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**DEVELOPMENT OF ENVIRONMENTAL EDUCATION
LABORATORY LESSONS ON A FRESH WATER
ECOSYSTEM IN A SCIENCE SUBJECT FOR
MATHAYOMSUKSA I STUDENTS**

NONGNART JINDAWATT,

ดุษฎีนิพนธ์ทางการ

จาก

บัณฑิตวิทยาลัย มหาวิทยาลัยมหิดล

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
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NONGNART JINDAWATT: DEVELOPMENT OF ENVIRONMENTAL
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This study was designed as an experimental research project. The purposes of the study were to develop and determine the efficiency of environmental education laboratory lessons of a fresh water ecosystem and to compare that to students' learning achievement before and after using environmental education laboratory lessons.

The sample comprised of 45 mathayomsuksa 1 students who were enrolled in the second semester of the academic year 2000 at Assumption College Thonburi, Bangkok. A simple random sampling method was employed for selection in the sample. The research instruments consisted of five lessons as follows:

- Lesson 1 - Let us explore the fresh water ecosystem
- Lesson 2 - The role of each organism in a fresh water ecosystem
- Lesson 3 - Interspecific relationships in a fresh water ecosystem
- Lesson 4 - Adaptation of organisms in a fresh water ecosystem
- Lesson 5 - Wise usage of a fresh water ecosystem

The findings of this study showed that environmental education laboratory lessons had an efficiency of 83.00 / 79.69 from the standard index 80 / 80 and the post-test achievement scores were significantly higher than the pre-test scores at a 0.05 level.

Therefore, the environmental education laboratory lessons had effectiveness in providing knowledge of a fresh water ecosystem. Environmental education laboratory lessons should be encouraged in science subject usage (Sc 102).

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นางนาถ จินดาวัฒน์ : การพัฒนาบทปฏิบัติการสิ่งแวดล้อมศึกษา เรื่อง ระบบนิเวศแหล่งน้ำจืด รายวิชา ว 102 วิทยาศาสตร์ สำหรับนักเรียนชั้นมัธยมศึกษาปีที่ 1 (DEVELOPMENT OF ENVIRONMENTAL EDUCATION LABORATORY LESSONS ON A FRESH WATER ECOSYSTEM IN A SCIENCE SUBJECT FOR MATHAYOMSUKSA I STUDENTS) คณะกรรมการควบคุมวิทยานิพนธ์ : ภัทรบุรณม์ พิชญ์ไพบุลย์ , Ed.D. , รัชชานนท์ สุภพงศ์พิเชฐ , พบ. ด. , ประกายรัตน์ สุขุมาลชาติ , M.S. 165 หน้า. ISBN 974-04-0358-1

การวิจัยครั้งนี้ มีวัตถุประสงค์เพื่อสร้างบทปฏิบัติการสิ่งแวดล้อมศึกษา หาประสิทธิภาพของบทปฏิบัติการ และเปรียบเทียบผลสัมฤทธิ์ทางการเรียนของนักเรียน ก่อนและหลังเรียนโดยใช้บทปฏิบัติการ กลุ่มตัวอย่างที่ใช้ในการวิจัยคือ นักเรียนชั้นมัธยมศึกษาปีที่ 1 โรงเรียนอัสสัมชัญธนบุรี ภาคเรียนที่ 2 ปีการศึกษา 2543 จำนวน 45 คน ซึ่งได้มาโดยการสุ่มตัวอย่างแบบง่าย โดยผู้วิจัยได้ดำเนินการสร้างบทปฏิบัติการเรื่อง ระบบนิเวศแหล่งน้ำจืด จำนวน 5 บท ดังนี้

บทปฏิบัติการที่ 1 - มาสำรวจแหล่งน้ำกันเถอะ

บทปฏิบัติการที่ 2 - ใครมีบทบาทอะไร

บทปฏิบัติการที่ 3 - สายใยสัมพันธ์

บทปฏิบัติการที่ 4 - แปลงร่าง-ปรับตัวของสิ่งมีชีวิต

บทปฏิบัติการที่ 5 - รู้รักษ์-ป้องกัน-พัฒนา

ผลการวิจัยพบว่า บทปฏิบัติการที่พัฒนาขึ้น มีประสิทธิภาพ 83.0 / 79.69 ซึ่งมีประสิทธิภาพตามมาตรฐาน 80 / 80 ที่กำหนดไว้ การเปรียบเทียบผลสัมฤทธิ์ทางการเรียน ก่อนเรียนและหลังเรียน โดยการทดสอบค่า t (t - test) ปรากฏว่าผลสัมฤทธิ์ทางการเรียนหลังจากเรียนบทปฏิบัติการสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05

จากผลการวิจัยนี้แสดงให้เห็นว่า บทปฏิบัติการสิ่งแวดล้อมศึกษาที่พัฒนาขึ้น มีประสิทธิภาพทำให้นักเรียนมีความรู้เพิ่มขึ้น ดังนั้นควรส่งเสริมให้นำบทปฏิบัติการนี้ไปใช้ในการเรียนการสอนวิชาวิทยาศาสตร์ (ว 102) เพิ่มมากขึ้น

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CHAPTER I

INTRODUCTION

1.1 Significance of the Problems

In today's world situation, change in technology has been quickly developed. This resulted in an accelerated program for human resource development in every country in order that they can survive and manage such change effectively and efficiently. Education is one strategy of human resource development which help create learning people, learning organization, and learning society. It is, therefore, mentioned in the 8th National Education Development Plan's objective that educational program will be developed in order to help pave the way for people's quality of life. To establish an educational program, learning method which follows people's life pattern should be focussed. Different fields of knowledge should be included that learners can have fully participation and self-learning. Wasana (1996 : 41) stated that a learner should have a good thought, good spirit, and morality to be a good citizen who has responsibility, learning enthusiasm, and be effective labor in each category of the new economics and social system.

In establishing an educational program, teachers play an important role in the teaching process. The more knowledge and ability in a certain field a teacher has, the better result in the works he gain (Jittima Taemboonprasert, 1981:2). Currently, learning and teaching arrangement does not reach its criteria because of several factors such as a teacher does not have a chance to teach the subjects he learned or, does not have good understand in learning objective, and cannot arrange all necessary activities

stated in the curriculum. Moreover, many teachers have a big load of teaching hours or has too many other special duty that causes low enthusiasm in teaching. Some teachers do not have teaching skills. Although there is an attempt to adjust the curriculum, teaching method is still the same. Many teachers prefer to give a descriptive lecture (Siriwan sripahol, 1982 : 140). Students are told to remember the lessons without participation. They become bored and do not pay good attention to the lessons. More importantly, the students are not able to apply what they have learned to every lives.

Learning and Teaching media is another factor that obstructs the students to get what has been designed for them in the curriculum. There is a few pieces of learning and teaching instruments. Each learning and teaching instrument is suitable for a certain subject or activity. Teacher is the one who should know how to use or apply which instrument and media for his/her work. Learning and Teaching media can help the learner to understand the subject easier in less time. It could help in transferring process of knowledge between teachers and students. Students will be aroused to do the activities, get more experiences, and can remember what they have learned. That creates an effective learning and teaching method.

The researcher believes that using lecture only will not help reach the goal objective of teaching. To solve this problem, teachers should select the right teaching method which is suitable for a subject. To teach the environmental education subject, there are many techniques such as outdoor learning, field operation, in class activities, demonstration, laboratory, games, discussion and debate, reporting or other innovative media to help learners to get and understand the lessons more easy and to have a good image of the learning process.

The researcher think that a teaching method should allow learners to have self learning and practice, directed experience, and encourage teachers to create learning atmosphere, using appropriate media to facilitate learners to learn the lessons and bring to the real life. This is compatible with the National Education Act, B.E.2542 (1999) section 24 : Learning Process Arrangement . To allow self learning, students must have a chance to participate in the learning process. A teacher must change their roles from a teller to a provider who sets a study scenario, prepare equipment , learning material , and giving suggestion. Phanorm Kaewkamnerd (1990:12) supported that teachers must cut off some parts of their roles and add them to the learners , give a chance for the learners to share their ideas, and experience with others, discuss and solve the problems among themselves.

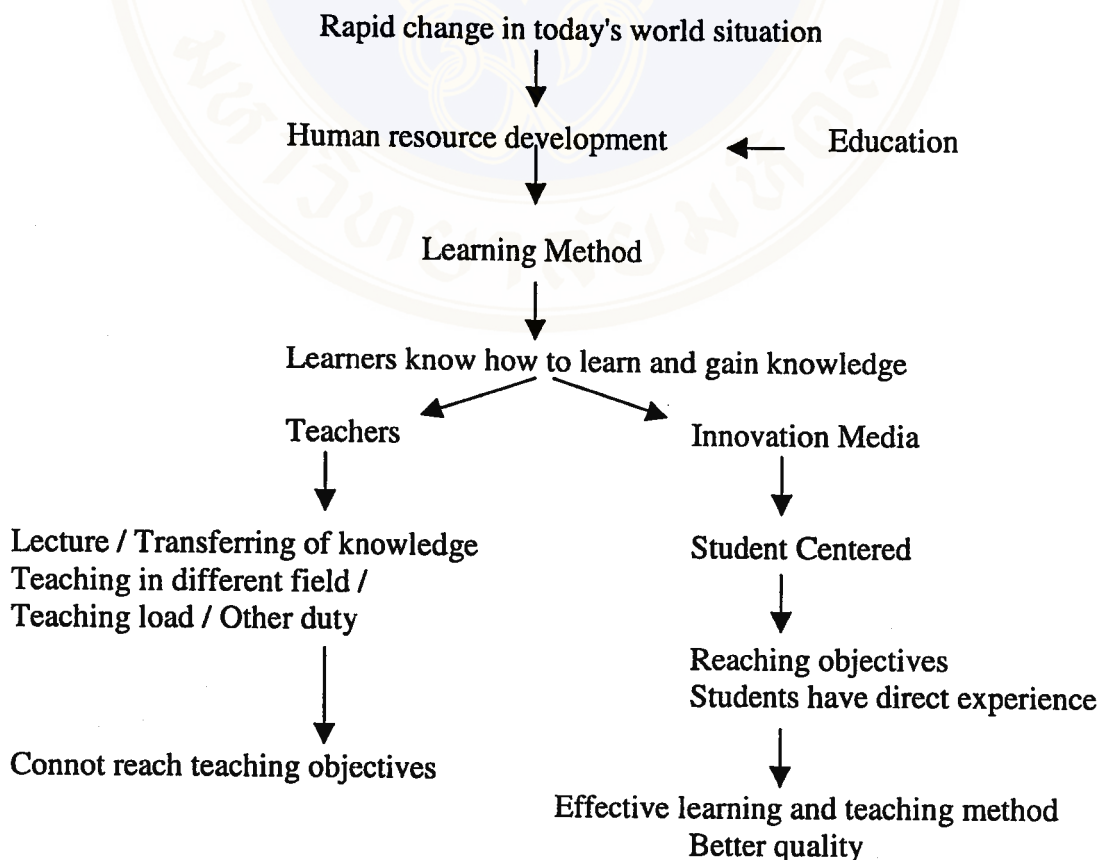


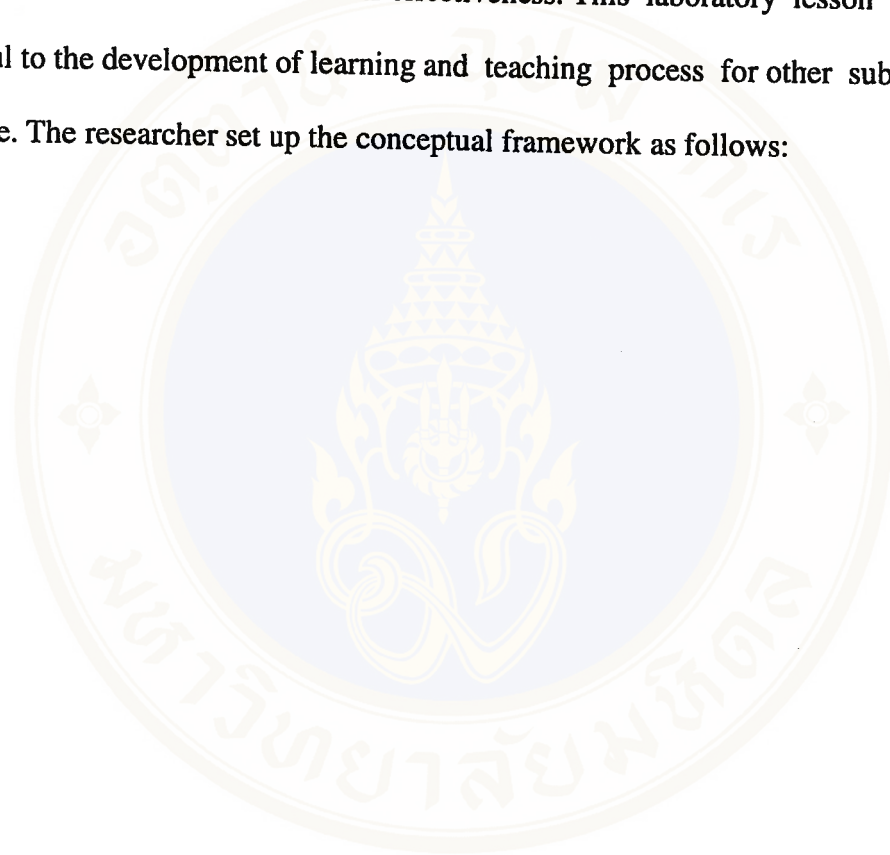
Figure 1 : Summarize of significance of the Problems

In the opinion of the researcher, one of a learning method which allow learners to have self learning is the laboratory method. Aree Kamplong (1993:2) stated that this learning method allows active participation. Students will enjoy studying, pay more attention to the lessons and remember, and can bring what they have learned to use in the real life. Teachers who provide learning activities can observed the students while they are practicing them. Teachers will have a chance to know the students better and can give support to each student appropriately. With the above reason. Researcher would like to introduce a laboratory lesson on fresh water ecosystem to be used for science 102 for Mathayomsuksa 1 students who start studying ecosystem and be able to analyze and develop creative thinking. When there are many people consume water carelessly, causing pollution to water creatures and to the society, teachers can use laboratory lesson of ecosystem to support the students to have good image and to participate in the conservation and sustainable development of local resource.

The studying of ecosystem will give learners basic knowledge for environmental education which is very important for existing. It will help people to realize their roles as parts of the ecosystem. Any activities done by human being could have an effect on the environment as well as to other living things included human itself. There are lots of things in the nature are appropriate for us to live happily. If we do not conserve them, this world heritage may be totally destroyed. We should realize that the use of natural resource for any development project may cause a problem of imbalance in the ecosystem. Therefore, it should be aware and assured that such development will not cause any effect to human being. To practice a laboratory lesson will also be useful for teachers to set a teaching plan because this method allows

students to have active participation and team working. Teachers can design various activities for the students to help them get through the lessons.

From empirical study, there is no research study about laboratory lessons in fresh water ecosystem. In this study, the researcher intend to develop a laboratory lesson for students and evaluate its effectiveness. This laboratory lesson may also be useful to the development of learning and teaching process for other subjects in the future. The researcher set up the conceptual framework as follows:



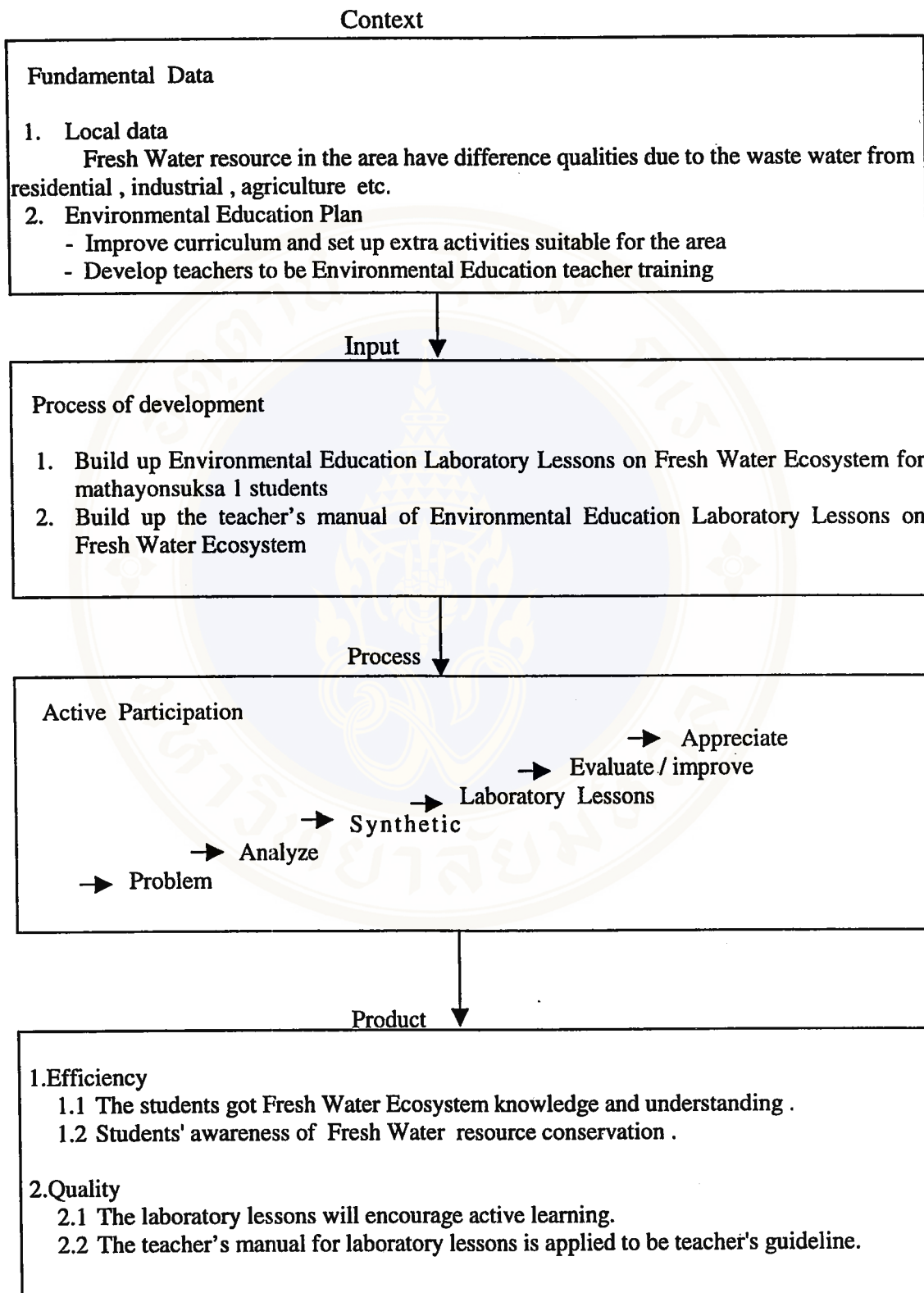


Figure 2: Conceptual Framework of the Research

1.2 Objectives of the Study

1. To study and build up laboratory lessons and teacher's manual on fresh water ecosystem on science subject (Sc 102) for mathayomsuksa 1 students .

2. To study the efficiency of laboratory lessons according to the standard index of 80 / 80 .

3. To study the learning achievement from the sample group of mathayomsuksa 1 students

1.3 Research Questions

1. Are the laboratory lessons on fresh water ecosystem for mathayomsuksa 1 students efficient for learning according to the standard index of 80 / 80 ?

2. Are the post-test achievement scores statistic significantly higher than the pre-test scores at the 0.05 level?

1.4 Hypotheses

1. The laboratory lessons on fresh water ecosystem for mathayomsuksa 1 students are efficient for learning according to the standard index of 80 / 80.

2. The post-test achievement scores statistic significantly higher than the pre-test scores at the 0.05 level.

1.5 Scope of the Study

1. In this study , the target population are 45 mathayomsuksa 1 students, During the second semester of the 2000 academic year , at Assumption College Thonburi , Bangkok. A simple random sampling method was employed for

selection of the samples.

2.The purposes of this research was to find the efficiency of laboratory lessons according to the standard index of 80 / 80 .

1.6 Definition of Terms

In order to understand the meaning of specific words, which were used in this study. The following terms were defined as follows:

Laboratory Lessons means a learning method which allow students to learn the lessons by themselves .(Siriporn Hongphan, 1997:130)

Teaching by Laboratory Lessons means to teach through experience, using experiment materials in an investigation (Brown,1982:93)

Work Sheet is the mean that the students practice their skills in class .

The Efficiency of Laboratory Lessons is the quality of laboratory lessons according to the standard index of 80 / 80 is accordance with

The first 80 is the students should not get the score of the exercises less than 80 percentages .

The other 80 is the students should not get the score of the test less than 80 percentages . (Saowanee Sikhabandith, 1985 : 294-295)

The Learning Achievement is the testing scores of the students after finishing the laboratory lessons on fresh water by doing the examination .

Ecosystem is any spatial or organizational unit which includes living organisms and nonliving substances interacting to produce an exchange of materials between the living and nonliving parts. (Southwick, C.H., 1972:104)

Fresh Water Ecosystem is a type of aquatic ecosystem that is very important to lives i.e. river, canal, swamp , marsh etc.

1.7 Contribution of the Study

1. There are the laboratory lessons on fresh water for teaching mathayomsuksa 1 students .
2. The laboratory lessons will encourage the students to be actively participated in learning activities .

CHAPTER II

LITERATURE REVIEW

This research study focused on development of environmental education laboratory lessons on fresh water ecosystem in science subject for mathayomsuksa 1 students. Literatures and studies related to this topic are stated under the following sections:

- 2.1 Theory and thought on education
- 2.2 The Concept of Environmental Education
- 2.3 The Concept of Laboratory Lessons
- 2.4 The Concept of Environmental Education Laboratory Lessons
- 2.5 The Concept of Ecosystem
- 2.6 The Review of the Related Research for this Study

2.1 Theory and thought on education

2.1.1 Knowledge

Meaning : According to the Dictionary of Education, knowledge is defined as the accumulated facts, truths, principles and information to which the human mind has access. (Good , 1973 : 325) Lexicon Webster defines it as the act, fact or state of knowing ; the body of facts accumulated by mankind. (The Lexicon Webster Dictionary, 1997 : 531) In addition, Prapapen Suwan (1997 :10) concluded that " knowledge " is the basic behavior of the learner which is accumulated through thinking, seeing, hearing or remembering. Knowledge in this sense concerns the definition or meaning of facts, principles, theory, law,

structure and methods of solving problems. Likewise, Bloom (1956 : 271) defines " knowledge " as the specific issue or general thought, which recognizes the method, process or situation through memory.

Therefore knowledge means all facts regarding events, principles, things or people in the mind of humans which has been accumulated , remembered , and expressed in the behavioral memory and can be observed or measured. (Prarop Kaoses, 2001 : 16)

Level of knowledge : Bloom's Taxonomy (Bloom, et al., 1956 : 122-205) has had a significant impact on the inventory of human learning experiences and on the methods by which they are assessed. The taxonomy categorizes cognitive behaviors into six hierarchical categories from simple to complex. These six ascending levels are as follow:

1. Knowledge is regarded as the recall of specifics and universals, the recall of methods and procedures, or the recall of a pattern, structure or setting.
2. Comprehension refers to the ability to understand non-literal statements (metaphors, symbolism, irony, and exaggeration) ; skill in translating mathematical verbal material into symbolic statements and vice versa ; the ability to grasp the thought of the work as a whole at any desired level of generality ; and skill in predicting continuation of trends.
3. Application, which theoretically requires more complexity than comprehension; application represents knowing an abstraction well enough to use it correctly when required.
4. Analysis is defined as the breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear

and/or the relations between the ideas expressed are made explicit, including ability to recognize unstated assumptions.

5. Synthesis involves the putting together of elements and parts from a whole, not clearly they are before; skill in writing, using an excellent organization of ideas and statements; ability to plan a unit of instruction for a particular teaching situation; and ability to formulate a theory of learning applicable to classroom teaching.

6. Evaluation includes the making of judgments about the value, for some purpose, of ideas, works, solutions, methods, and materials etc. The ability to indicate logical fallacies in arguments; the ability to evaluate health beliefs critically and skill in recognizing and weighing valued in alternative courses of action.

Knowledge Assessment : There are a number of instruments to measure knowledge depending upon the goals and objectives to be measured and the design of the user, but most of the instruments are tests which have been used widely.

(Boontham Kitpreedaborisuit, 1988 : 21-25)

There are three commonly used selected-response item formats : true-false, Multiple - choice, and matching. True-false and multiple choice are found extensively on commercially available tests, such as standardized tests, as well as on teacher-constructed tests. Matching items are used to a lesser extent, in part due to the complexity of the response. (Wiersma and Jurs, 1990 : 42)

1. True-false statements require the respondents to make a dichotomous choice either the statement is true or false; sometime the choice is between yes - no or right-wrong, but the format is the same.

2. Multiple choice items, which consist of plus two or more (usually more)

options, require the examinee to select the correct or best option. A variation on the multiple-choice item is to have the student select all correct options when there may be more than one. This variation is seldom used, however.

3. A matching item commonly consists of a two-column format and the task is to match the parts of the two columns.

Each of these item formats will be discussed individually and suggestions will be given for their construction. However, before doing so, we discuss the general characteristics of selected-response items that make them attractive for test use, as well as one characteristic considered to be a weakness.

In this study the Achievement Test in the form of a multiple-choice test is used to measure knowledge and cognition according to Bloom's principle.

2.1.2 Attitude

Meaning : According to the Dictionary of Education, attitude is a readiness to react toward or against some situation, person, or thing, in a particular manner, for example, with love or hate or fear or resentment, to a particular degree of intensity. (Good, 1973 : 48-49) Also, Thurstone (1967 : 77) stated that attitude is the total feeling of human prejudice, thinking, fear or resentment to a particular subject that is expressed in words. The attitude of an individual can be measured by asking opinions.

It can be concluded that attitude is a human behavior stemming from cognition of past experiences that he / she can express in term of acceptance or rejection.

Attitude is an element of the affective domain. Attitude is formed through emotions an individual has experienced since first touch and response and which has developed in value until it has become habit. Attitude is composed of three elements :

cognitive or belief component, feeling or evaluative component and behavior component.

Attitude can occur in the following two traits: positive attitudes and negative attitudes. Positive attitudes are readiness to respond in the traits of satisfaction, agreement, and causing a person to want to do, want to have, want to approach or want to do only good to such things. Negative attitudes are readiness to respond in the traits of dissatisfaction, disagreement, and causing a person to be bored, and stay away from such objects or conditions.

In conclusion, both education and experience are just the part of the source that creates the attitude. However, attitude has nothing to do with intrinsic skill and knowledge. The attitude could be something positive or negative and it has weight on thoughts and affective response of human.

Attitude measurement: The principle to measure the attitude of any individual should include the following components: (Boontham Kitpreedaborisuit, 1974: 222) content, direction and intensity. Instrument to measure attitude is Attitude Test, a test to measure the mental and emotional set or pattern of likes and dislikes held by an individual or group, often in relation to controversial issues, personal adjustment, etc. which is normally on a rating scale of opinion or response. The popular attitude tests are Thurstone's type scale, Likert scale, and Osgood scale. Every type of scale has weak and strong points. The Likert scale (Hopkins, Stanley, and Hopkins, 1941: 293) on which a statement is followed by the five category response continuum: strongly agree, agree, undecided, disagree, and strongly disagree. The Likert scale are very flexible and can be constructed more easily than most other types of attitudes scales. The Likert scale will be applied in this study.

2.1.3 Practices

Practice means to do something repeatedly in order to learn or acquire proficiency, mental or physical action for the purpose of learning or acquiring proficiency; the doing of something often as an application of knowledge and cognitive domain as well as attitude. The practical behavior can be measured if expressed in terms of action, but the process which stimulates the practical action requires time and many steps of decision-making. (Prapapen Suwan, 1977:20-21)

Practice measurement or practice test : A test primarily intended to afford practice or drill in the given field rather than to measure knowledge or achievement, commonly used in arithmetic, languages and other subjects; sometimes used as a measure of attitude for some purpose.

A practice test will be used in this study in the form of an experimental skill test concerning scientific process skills :

1. Observation
2. Measurement
3. Classification
4. Space / Space Relationship and Space/Time Relationship
5. Using Numbers
6. Organizing Data and Communication
7. Inferring
8. Prediction
9. Formulating Hypothesis
10. Defining operationally
11. Identifying and Controlling Variables

12. Experimenting
13. Interpreting Data Conclusion (IPST,1990 : 25-38)

2.2 The Concept of Environmental Education

2.2.1 Meaning of Environmental Education

According to the UNESCO (1977 : 75) Conference of the International Union for Conservation of Nature and Natural Resources, environmental education is defined as the process to develop awareness and attitude toward the value of the environment and its relationship to human lives including culture and biodiversity , with the aims of maintaining the quality of the environment. Also, Stapp (1981 : 1) stated that environmental education is the process to develop human awareness of the environment and related problems ; environmental education targets attitude, reinforcement, skills and practice in order to restore the environment through individual or group forces.

Laddaval Kunhasuwan (1991 : 2), Temduang Ratanathusnee and Waraporn Srisupan (1991 : 101) defined as the process to develop the conscientiousness of students and public in order to make them aware of environmental problems and have a sense of responsibility to join and solve the problems together. Environmental Education includes an emphasis on knowledge and understanding of the environment of the environment and the relationship to human life in order to develop the quality of the environment and better living of man. Likewise, Vinai Veeravatananond and Bancheun Sripanpong (1996 : 15) defined environmental education as an educational process that emphasis knowledge of the

physical environment and social environment, which can change the effects on human life , attitude, and behavior.

In conclusion , environmental education means an educational process that emphasizes the development of awareness of the students and the public toward environmental problems. Environmental Education encourages them to share responsibility and partnership and to participate in restoration and solve environmental problems together, hand in hand, in a sustainable manner.

2.2.2 Goals and Objectives of Environmental Education

Environmental Education Goals

According to the Belgrade workshop, the agreements had been set " to encourage each individual awareness in the environment and environmental problems and to promote knowledge, attitude and readiness to participate in and be in partnership for public problem-solving" (the Belgrade Charter, 1976:62)

Environmental Education Objectives

1. Awareness : To encourage awareness of individuals and society to heighten sensitivity to environmental problems.
2. Knowledge : To encourage knowledge and experience of the people toward the environment.
3. Attitudes : To encourage positive attitudes on the part of individuals and society towards the environment in order to promote co-operative effort to protect and improve the environment.
4. Skills : To encourage skills of individuals and society to analyze and solve environmental problems.

5. Evaluation ability : To encourage evaluation by the people to assess the environmental situation and study the function of projects in terms of ecology, politics, economics, social policy, ethics and education.

6. Participation : To encourage the people to co-operatively participate in community activities. (UNESCO, 1978: 20-27)

The Tbilisi Conference in 1977, the Belgrade Charter and the Rio Earth Summit in 1992 have confirmed these objectives. The Belgrade Charter Agenda 21 stated that " The aim of environmental education is to develop quality of life of the people in awareness, close relation with the environment and concerned problems, encourage knowledge, attitude. Reinforcement and co-operative work together either on an individual or group level in order to solve the social problems concerning the environment and prevent the development of new problems." The Tbilisi Conference in 1977 stated the objectives of environmental education as : (UNESCO,1980:26)

1. To encourage the global population to be aware of conditions and relations among economics, social, political, city and rural ecology.

2. To encourage the global population to develop knowledge, value, positive attitude and skills in order to protect and improve the environment and prevent environmental problems.

3. To build behavioral patterns toward the environment either on an individual or social level.

In conclusion, the objectives of environmental education are : development of environmental knowledge , understanding , attitude , skill and responsibilities; knowledge regarding how to analyze he problems related to the environment: develop and increase awareness of the people toward the environment and promote their ability

to effectively co-ordinate and participate in social problems in the present and future, The Belgrd Charter will be the main theme of this study.

2.2.3 Principles of Environmental Education

According to the Belgrade Charter, the principles of Environmental Education (Vinai Veeravatnanond & Banchaun Sripanpong, 1996 : 27-29) as follows:

1. Environmental Education must deal with all of the concerned natural or man-made environment, including ecology, politics, economics, technology, social policy, law, culture and aesthetics.
2. Environmental Education should be a lifelong process both formal and informal education.
3. Environmental Education should be interdisciplinary -approach.
4. Environmental Education should be active participation in environmental problem protection and problem solving oriented.
5. Environmental Education should be think globally but act locally.
6. Environmental Education should be present - future oriented.
7. Environmental Education should consider development , growth of all developments and their impact to the environment.
8. Environmental Education should promote people to realize a worth of the environment and necessity to cooperate in protection and solving the environmental problems including the national, regional and international levels.

The international environmental education workshop at Belgrade was the first environmental education workshop of the world so the eight principles were guideline for every country using suitable to the state of each country.

2.2.4 Strategies of Teaching of Environmental Education

Vinai Veerawatananont & Banchhun Sripanpong (1996 : 111-113)

recommended that the present popular teaching strategies of environmental education as follows:

1. Outdoor education : This is the learning by experience for example : field study, studying in the market, studying in a forest near their college or field trips.
2. Cinema or video : This makes students are very interested in the lesson.
3. Slide presentation : This is the strategy of teaching saver than field trip.
4. Transparency : This is a popular method because it is cheap, easy making and safe time.
5. Simulation and Games : Simulation is to suppose student in a situation and each learner discusses or students make decision about something. Games look like a simulation but it is a competition for example : students enter a competition for collecting garbage in their college, a competition for answering the questions , etc.
6. Inviting special lecture : Inviting special lecture who specialized in some content,lectures or discusses, students are more interested in environmental problems.
7. Laboratory : This is a better method for students to find problems.
8. Interview: Sometimes inviting special lecture is not comfortable

so the students must go to interview the specialist by themselves.

9. Special activities : The college or the club of environmental conservation might set special activities about the environment for students. And students always perceive the environment news.

10. Paper report : This method students can search and present an update information about the environment . They can work individual or group.

11. Debate : This method divides student into two groups for example one group is " promote using nuclear " and the other is " fight against to using nuclear" then each group must search many data promoting their ideas.

12. Role - playing : Learner plays a role of person who is in a story for example : a student play as a doctor and the other one is a patient , then they talk about air pollution causing some diseases.

13. Using opportunity : Sometime changing of attitudes toward environment has to wait suitable opportunity for teaching.

In conclusion, good teaching strategies of environmental education should use many methods and learner is active participation. Students have knowledge, attitudes and skills about the environment.

Nowadays , there are two specific types of environmental education established in the curriculum, they are : formal and informal environmental education. The formal environmental education is provided in kindergarten , primary and secondary school and, in the university while the later is done through mass media to general public.

Formal curriculum of environmental education currently used is the first part of level written in B.E. 2521 (1978) to be revised in B.E. 2533 (1990) by the

Educational Department, Ministry of Education. The objective of this curriculum is to develop an environmental characteristic to learners as stated in No. 8 of the curriculum's goal objectives that "to understand the situation and changes in the society, be able to propose community's development strategies and be proud of a role of good social members who try to promote and conserve national heritage of environment, region and , culture. In the B.E. 2533 (1990) adjustment of the curriculum, the Ministry of Education offered all educational institutes to propose their own appropriate curriculum to meet the community's needs. Especially in Science, it was designed to promote the learning of environment both directly such as doing group activities, forming up environmental groups , scientific project, conservative group and camping and indirectly such as adjustment of learning – teaching activities and laboratory lessons.

In this regards, the researcher then proposes the study of laboratory lessons for Mathayomsuksa 1 students which is one of a student – centered technique that the students have to do their own activities , learn and experienced the lessons by themselves, and then understand the concept and realize their responsibility towards the environment.

2.3 The Concept of Laboratory Lessons

2.3.1 Meaning of Laboratory Lessons

Laboratory Lessons means a learning method which allow student to learn the lessons by themselves. The students must have a direct learning and experience by doing an experiment. A teacher will set an activity plan in advance focusing on real situation

2.3.2 Definitions of Teaching by Laboratory Lessons

Teaching by Laboratory Lessons means to teach through experience, using Experimental materials in an investigation process. Both practicing and observing could be applied in either group teaching on individual studying. This concept is also supported by Kanchana Kietpravat (1981 : 86), Bamrung Kladcharoen and Chaweewan Kinawong (1984 : 191) who gave the meaning of teaching by laboratory lessons as a teaching process using directed experience in material using, investigation, studying test, observing, or applying to the real life.

Teaching by Laboratory Lessons can also means as the study process which allow students to have a self – learning under teacher monitoring. This is different from demonstration that a teacher works out an experiment and let the students observe or share some part of the test. Teaching by laboratory lessons might be divided into two types (Ob–Rom Sinpiban and Kunchalee Ongsiriporn, 1981 : 201 – 202):

1. Experimental type is a study method aimed for experimental skill such as investigating, analyzing strategy setting and problem solving.
2. Observation Type is a study method aimed for observational skill such as study visit to various places.

2.3.3 Learning Objective of Laboratory Lessons

Ob–Rom Sinpiban, Kunchalee Ongsiriporn, (1981 : 202)and Bamrung Kladcharoen , Chaweewan Kinawong (1984 : 192) stated that learning objective of laboratory lessons as following :

1. To give the students have directed experience through experiment and

observation and gain more knowledge.

2. To let the students have experimental skill that leads to more interest in the subject.

3. To let the students have equipment using skill.

Moreover, Kanchana Kietpravat (1981: 6) stated that laboratory lessons are useful in the following way :-

1. To learn a technique - that a teacher may demonstrate some part of the method and let the students do the rest of an experiment.

2. To practice laboratory skill in the students to be used in the next chance.

3. To explain rules and vocabularies used in the laboratory lessons.

4. To collect and interpret data, grouping and making conclusion.

5. To learn how to use the equipment.

6. To practice creative thinking strategy.

For skill- building, there are three interesting out of five from the following

To be practiced :

1. Acquisitive skills.

2. Organizational skills.

3. Creative thinking skills.

4. Manipulative skills

5. Communicative skills.

2.3.4 Learning – Teaching of Laboratory Lessons

There are three components in the learning – teaching process.

1. Role of a teacher.

2. Process of the learning – teaching of Laboratory Lessons.

3. Activities in the Laboratory Lessons

1. Role of teacher

Teacher takes a part of monitoring and helping students to get through an experiment. A teacher should be in an experimental room in a place where can be seen by student. Role of a teacher may be said in three sections (Pravit Choosilpa, 1981 : 5-6) :

Section 1 Pre lab – Discussion : A teacher has no stimulate the students to an experiment by asking some guiding question.

Section 2 Experiment Period : A teacher has to closely observed in an experiment to be able to give suggestion the students may need.

Section 3 Post – Lab Discussion : A teacher has to prepare some question to guide the students how to put together all information get from the experiment and making a conclusion.

2. Process the learning – teaching of Laboratory Lessons.

Process the learning – teaching of Laboratory Lessons may be said in three ways . (Kanchana Kietpravat, 1981 : 87 ; Ob – Rom Sinpiban and Kunchalee Ongsiriporn, 1981 : 203 ; Yupin Pipitkul, 1980 : 82)

1. Introductory step for orientation and motivation

2. Work period

3. Culminating activities

Nomrudee Chongpayuha, Somjai Ritsonthi and Payorm Tanmanee (1986 : 44-46) stated that Process the learning – teaching of laboratory lessons are in three

steps as following :

1. The leading and stimulating to an experiment process.
2. The experiment process.
3. The conclusion and presentation of result process.

3. Activities in the Laboratory Lessons

There are two forms of Activities in the Laboratory Lessons for the students (Spears and Zollman, 1977 : 34-35) as following :

1. Structured Laboratory is an old form of laboratory in which instruction and Orders are included.
2. Unstructured Laboratory is an inquiry method focussing an invest and analysis.

The laboratory lessons currently used in Thailand is the first one. This study also propose a structured laboratory for Mathayomsuksa 1 students.

2.3.5 Strength and weakness of the Laboratory Lessons

Learning-Teaching by laboratory lessons is a participatory learning method as if it was a real life. It is well accorded with the study's principal. Moreover, this kind of learning technique also fit to personality building. Suwat Yuthametha (1980: 190) concluded the benefit of the lab lessons as follow:

1. To implant in the students a fact finding skill.
2. To educate the students with scientific experimental skill.
3. To encourage the students to have an observational skill.
4. To educate the students in science subject by using a directed -experience method.

5. To draw student's attention in the laboratory lessons.
6. To develop the equipment using skill.
7. To apply what they have learned in everyday life.
8. To encourage the students to have more self-confident.

Chatree Kerdthum (2000:78-86) confirmed that laboratory lessons are useful for experimental learning-teaching, project, and group learning. However, there are also some weak points of this teaching technique such as material consuming and high expenses. Therefore, to avoid these problems, teacher should prepare learning activities included equipment and materials ready in advance. Demonstration may need in the first step to ease students to start an experiment. Teachers also take a role of conductor and helper in a laboratory.

2.4 The Concept of Environmental Education Laboratory Lessons

Environmental Education Laboratory Lessons means a teaching plan for environment subject which specifies that students must have a direct learning and experience by doing an experiment. (Siriporn Hongphan, 2540: 130) A teacher will set an activity plan in advance focusing on real situation which is appropriate for level the learners and accorded to the learning objectives as following :

1. Learning Objective means objectives of the laboratory lessons. First of all, a teacher should set up questions asking, what he/she wants the students to know.
2. Learning Place : Do not forget that different places may have different environment
3. Level of Students : The difficulty of laboratory lessons should be well fit to different levels of students. Practically, the teacher should divide the laboratory

lessons into two parts. The first part is a teacher manual for class monitoring and the second part is an exercise. In the manual, general objectives should be added together with specific objectives, study concept, activity plan, media, duration, and evaluation method to be used in the lessons.

2.4.1 The Characteristic of Environmental Education Laboratory Lessons

A laboratory lesson used in this research is aimed to help students understand the environmental subject and enjoy it. After studying, students will be able to determine cause and effect to environment's adversity and to save the environment. The laboratory lesson consists of the following contents :

1. A characteristic of inquiry approach : This allows students to find an answer to the question by themselves. There are some clues for students to find out the right answers after they have finish field study.
2. A problem approach : The students will learn how to find cause of a problem and how to solve it.
3. Sensory awareness : The students will be given right perception of the environment and how to conserve it.
4. Easy language to understand
5. Scientific base : Learning activities such as observation, classification, formulating hypothesis, organizing data and communication, defining - operationally, and interpreting data conclusion are used in this laboratory lesson.
6. After field operation, the students will be learned how to make a problem solving plan using a real situation.

7. Simple equipment is used in this laboratory lesson.

2.4.2 Environmental Education Laboratory Lesson Development Process

Teachers should start with the following steps :

1.Starting Process : Teachers should study basic data of the environment and surrounding areas where the lesson will be taken place in order to understand the ecosystem of such places and be able to write down the concept of the study. The following items should be done :

1.1 Set general objectives of the study

1.2 Explore the learning site, basic information of the surrounded area, and fix the study place. Teachers can set the study concept the students should gain from the laboratory lesson.

1.3 Set the specific objectives in three aspects : knowing and understanding, morality, and skill included time consuming for the program.

2.Establishing a laboratory lesson lesson : At this step, all details for each activity should be clearly set. Students should be informed about behavioral objectives, concept of the study, learning method, media and activities to be used. After this, teacher should be able to develop teaching method, exercises, teaching manual and evaluation tools.

3.Testing Step : After a study tool has been set , the laboratory lesson is ready to be tested in the class. Evaluation of this study method can be done both during the workshop or after finding it. Strength or weakness included suggestion could be found at this step.

Suggestions: A good laboratory lesson should include the following aspects:

1. Language used in laboratory lesson should be easy to understand. A complete sentence is recommended, avoid words or phrases and incomplete sentences.
2. Verifiable and up to date information is presented.
3. Supported by fact and true story and avoid order-form sentences.
4. Suitable for learners, both ages and study levels as well as their tradition and environment.

2.5 The Concept of Ecosystem

2.5.1 Definition of Ecosystem

An ecosystem is any spatial or organizational unit which includes living organisms and nonliving substances interacting to produce an exchange of materials between the living and nonliving parts. (Southwick, C. H .,1972 : 104)

An ecosystem includes population, communities, habitats and environments and it specifically refers to the dynamic interaction of all the parts of the environment , focusing particularly on the exchange of materials between the living and nonliving parts. (Southwick, C. H .,1972 : 105)

A population is a group of interacting individuals , usually of the same species , in a definable space. (Southwick, C. H .,1972 : 105)

A community , in the biologic sense , consists of the population of plants and animals living together in a given place. (Southwick, C. H .,1972 : 105)

Environment and habitat is a place where an organism lives, including both the physical and biologic features of the place. (Southwick, C. H .,1972 : 105)

In conclusion, an ecosystem is the interrelations of organisms with each

other and with their environment. There are both physical and biological conditions influencing the responses of organisms.

2.5.2 Types of Ecosystem

Ecosystems are divided into two systems as follows:

1. Natural Ecosystem

1.1 Terrestrial Ecosystem includes woods, grassland, field, desert etc.

1.2 Aquatic Ecosystem is divided into three parts as follows:

1.2.1 Fresh Water Ecosystem i.e. river, canal, swamp, marsh .

1.2.2 Marine Ecosystem i.e. sea , ocean , coral reef etc.

1.2.3 Estuarine Ecosystem i.e. estuary .

2.Human- made Ecosystem includes

2.1 Urban - Industrial Ecosystem

2.2 Agricultural Ecosystem

2.5.3 Roles of living organisms in Ecosystem

Ecosystem consists of three basic living organisms :producer organisms, consumer organisms and decomposer organisms .(Southwick,C.H.,1972 : 106-107)

Producer organisms are bacteria and plants which synthesize organic compounds . They are said to be autotrophic or self-productive, in that they take inorganic compounds and manufacture organic materials and living protoplasm from them.

Consumer organisms are animals which utilize the organic materials directly or indirectly manufactured by plants. Consumers are unable to produce their

own organic compounds . They are said to be heterotrophic, which means different or varied in nutritional source. Primary consumers or herbivores directly consume the organic compounds of plants. Secondary consumers may be omnivores or carnivores which depend partially or entirely on other animals for food. Tertiary and quaternary consumers may be the second or third-stage predator .

Decomposer organisms are bacteria and fungi which degrade organic compounds. Their nutrition said to be saprophytic, that is, associated with rotten and decaying materials . In a sense they are the digestive organisms of an ecosystem they reduce the complex organic molecules of dead plants and animals to simpler organic compounds which can be absorbed by green plants as vital nutrients. They provide the final essential link in the cycle of life. They are necessary for the renewal of life, for if decomposers were not active, organic compounds would become locked into complex insoluble molecules which could not be utilized as nutrients by plants.

Food chain is the nutritive series in which a group of organisms secures food in the same general way or the transfer of energy from plants through a series of other organisms. Food chain usually have 3 to 6 " links " or group of organisms which derive their nutrition in the same general way , for example : grass → grasshopper → frog → bird → man . In aquatic ecosystem , algae , phytoplankton and other aquatic plants occupy the same trophic level as grass , and herbivore animals including some crustacea , some insect larvae , and a few herbivorous fish occupy the same trophic level as the grasshopper . .(Southwick,C.H.,1972 : 137)

Food web is a very complex pattern of feeding relationship. For example :

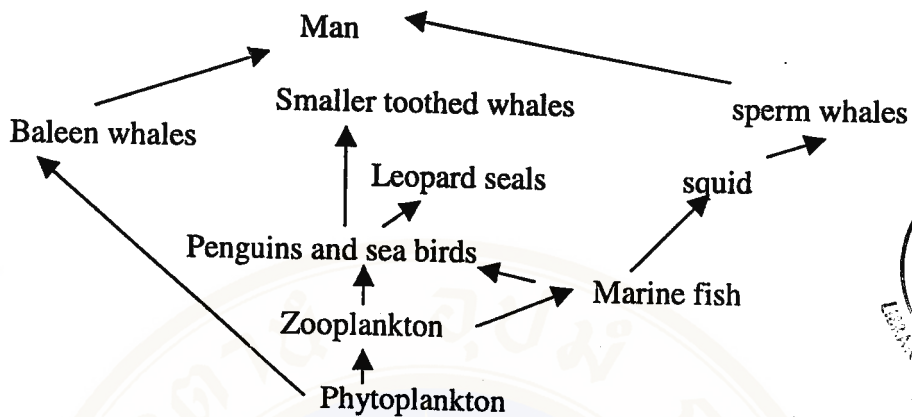


Figure 3 Food web for an aquatic ecosystem (Southwick,C.H. , 1972 : 139)

2.5.4 Interspecific relations

Interspecific relations of organisms are classified into two patterns . Some of them are cooperative and beneficial to one or more of the interacting population ; others are competitive . Cooperative interactions are represented by commensalism and mutualism, which are special types of symbiosis. Competitive interactions are represented by predation , parasitism , competition ,and amensalism or antibiosis .

Symbiosis means " living together " and in its broadest sense it refers to a relationship of any type between two or more living organisms . A symbiosis relationship may be beneficial or detrimental to the interacting organisms. However, symbiosis has come to mean primarily those relationships which are beneficial or stimulating to one or more of the interacting population. Two population interacting in such a way as to be beneficial to one and neutral to the other is referred to as commensalism; two population interacting in such a way as to be beneficial to both is termed mutualism.

2.5.5 Ecosystem Homeostasis

Ecosystem Homeostasis is a technical term for the balance of nature. In its broadest sense it refers not only to a balance of species, as for example, a balance between predator and prey or host and parasite, but also a balance of basic nutrient cycle and energetic pathways within an ecosystem. A homeostatic condition within an ecosystem implies that all aspects of ecosystem function are in balance. Thus, there would be a balance between production, consumption and decomposition, as well as between all species within the system.

2.6 The Review of the Related Research for this Studies

For this study, the researcher reviewed the study related to the learning - teaching process of environmental education as follows:

Wana Cholprawes (1983:79-83) who studied "A Study of Achievement in Science Skills of Mathayomsuksa I students using Game and Experimental Approaches." The sample group is 90 Mathayomsuksa I students of Klong Luang Pithayakom School, Pratum Thani Province. The group was divided into two 45 - student subgroups. One was an experimental group taught by using games. Another was a control group taught by experimental approaches. Each of the two groups was taught under the same content. The results of the study showed that both groups' achievement in Science Process Skills in Observation, Classification and Formulating Hypotheses was significantly different at the 0.05 level. Science Process Skills in Organizing Data and Communication showed a different at the 0.01 level as the experimental group achieved more average score than the control group. But the achievement in Science Process Skills in Space / Space Relationship and Space/Time

Relationship was different at 0.01 level as the control group gained more average score than the experimental group. For the rest of Science Process Skills in Measurement, Using Number, Experimenting and Interpreting Data and Conclusion, the achievement was not significantly different.

Krisana Boonkhum (1991:79-83) who studied "A Study on the Effects of an Instructional Approach Employing Environmental Survey upon Achievement, Science Process Skills and Attitude toward Environment of Prathom Suksa VI students. " The sample group was 31 in Prathom Suksa VI students of Wat Bampennuea, Bangkok. The results of this study indicated that the students learned by Environmental Survey had higher scientific achievement, science process skills, attitudes toward the environment than the expected criterion and was significantly at the 0.05 level.

Marasri Thaibounreang (1994:98-102) who studied "The Effects of Fieldtrip Experience and Combined Activities on Behavior and Decision Making of Preschool Children towards Natural and Environmental Conservation." Thirty of five to six years old preschool children were simple randomized sampling into two groups. The first experimental group was provided with fieldtrip experience activities. The second experimental group was provided with combined activities. The results of this study found that the preschool children's natural and environmental conservation behavior and decision of fieldtrip experience activities and combined activities after the experiment was higher than before the experiment at the 0.01 level.

Kwanjit Keawpan (1998 : 88) who studied ." The Effects of Organizing Science Camp by Environmental Survey upon Mathayomsuksa II students' Science Process Skills and Attitudes toward Environmental Conservation" The sample in this study were 60 Mathayomsuksa II students of Chaimongkol Pittaya School ,

Sukhothai. The experimental group was taught by the Environmental Survey. The control group was taught by the Teacher's manual. The results of this study indicated that the science process skills of experimental and control groups was not significantly different at the 0.05 level. The attitudes toward environmental conservation of experimental and control groups was significantly different at the 0.05 level.

Waleerat Supanunt (1998 : 90) who studied "The Development and Implementation of Field Trip Teaching Manual Titled "The Conservation of Natural Resource and Environment" for lower secondary school students." The experimental sample group was composed of one class of 45 students selected randomly from among the 14 lower Secondary School (Mathayomsuksa I) classes of Satri Phuket School, Phuket. The experimental group was taught using the Field Trip Teaching Manual. An achievement test was administered before and after the teaching program. The achievement scores of the experimental group from the post-program test were significantly higher than those of the pre-program test at the level 0.05.

Naviya Nantapanich (2000 : 99 - 104) who studied "The Development of Teacher's Manual of Environmental Education Activities for Grade Six Primary Education Regarding Mangrove Forest Conservation." The population of this study comprised Grade Six Pupils in schools under Prasamutjede District Education Office, Samut Prakan Province. The sample consisted of 42 Grade Six pupils selected from 727 with the simple random sampling technique. The research design of this study was the One Group Pre-test Post-test Design. Analysis results of data from the experiment showed that Grade Six pupils in the experiment group who had undertaken instructional activities as prescribed by the teacher's manual gained their knowledge

and comprehension of mangrove forest conservation , and increased their positive attitudes toward mangrove forest conservation significantly at the 0.001 level.

Thomas. R. Lord. (1999 : 22- 28) who studied "A Comparison Between Traditional and Constructivist Teaching in Environmental Science." Two instructional methods were compared in a non-laboratory-based environmental science course for college undergraduates. Students in 2 teacher-centered (traditional)classes(n = 46 and n = 45) were presented material in standard lecture fashion. Students in 2 student-centered (constructivist) classes (n = 48 and n =42) worked in small , heterogeneous groups on thought-provoking scenarios and critical thinking questions or constructed concept maps on the information of the day ; material was presented to the students in question - discussion fashion . Identical material , learning resources , student questionnaires, and examination were used for both populations . Students in constructivist classes performed significantly better on exams, rated the course higher , and participated more in campus and regional environmental support efforts than students in traditional classes.

This research studied the Development of Environmental Education Laboratory Lessons on Fresh Water Ecosystem in Science Subject for mathayomsuksa 1 students. The research's objective is to encourage the students to have directed experience through group processes. It is expected that students will get a good concept and realize their roles of conservation of the environment.

CHAPTER III

RESEARCH METHODOLOGY

This chapter presents four topics of methodology as follows : the target population and sample group , construction and development of the laboratory lessons , research design and the data analysis by suggesting the following :-

3.1 The target population and the sample group

3.1.1 The target population

In this study, the target population are mathayomsuksa 1 students of Assumption College Thonburi during the second semester of the 2000 academic year , in the class of science according to the educational curriculum with the number of 357 students devided into 8 rooms . (Table 1)

Table 1 Number of students in mathayomsuksa 1 of Assumption College Thonburi

Classroom	Number of students
M.1/1	44
M.1/2	43
M.1/3	45
M.1/4	45
M.1/5	44
M.1/6	45
M.1/7	44
M.1/8	47
Total	357

3.1.2 The sample group

The sample group consisted of two groups :- The first group had 9 students was designed by trying - out the laboratory lessons and the second

group had 45 students which was the main experimental sample group .

The first group was small group which a simple random sampling by drawing the lots from 3 classes , 3 students from each of them , 9 students in all .

The second group was 45 students from 1 class which taking by a simple random sampling from the other 5 classes .

3.2 Construction and Development of the Laboratory Lessons

Laboratory lessons are two sets ; laboratory lessons and teacher's manual .

They are :-

(1) Laboratory lessons

The content of laboratory lessons consisted of name , principle, experimental objectives , materials and instruments , experimental process , experimental reports , exercise and work sheet .

Procedure of construction and development laboratory lessons :-

1.1 Study the secondary curriculum in the year B.E.2521 (to be revised In B.E. 2533) to point out the subject matters , objectives , measurement and evaluation of laboratory lessons.

1.2 Analyze the purpose and activities of learning process.

1.3 The specific subject matters in each laboratory lessons ;
as follows

- The element of fresh water ecosystem
- The role of organisms in fresh water ecosystem
- The relationship of lives in fresh water ecosystem
- Adaptation of organisms in fresh water ecosystem

- Conservation and development of the fresh water ecosystem

1.4 Give the objectives of each laboratory lessons (Table 2)

1.5 Development of laboratory lessons 15 periods (3 periods for each laboratory lessons).

Lesson 1 : Let us explore the fresh water ecosystem

Lesson 2 : The role of each organisms in a fresh water ecosystem

Lesson 3 : Interspecific Relationships in a fresh water ecosystem

Lesson 4 : Adaptation of organisms in a fresh water ecosystem

Lesson 5 : Wise Usage of a fresh water ecosystem

1.6 Presentation to the thesis advisers committee , the experts and improvement of the laboratory lessons , respectively .

1.7 Re - experiment of the new laboratory lessons with the 9 mathayomsuksa 1 students (3 groups) in order to find out detail error such as language , interest , difficulty and the time proportion to improve it before application with the main experimental group .

Table 2 Concept , general and learning objectives of Laboratory Lessons

Lesson	Content	Concept	General objectives	Learning objectives
1. Let us explore the fresh water ecosystem	The element of fresh water ecosystem	Generally fresh water ecosysyem is both physical and biological Components different.The physical components of ecosystem have an influence on survival of living organisms such as tide, temperature, turbidity, gas mineral etc. The biological components of ecosystem can be found in their habitat and live together is a community.	Knowing and understanding of the element of fresh water ecosystem .	<ol style="list-style-type: none"> 1. Give the element of fresh water ecosystem . 2. Explain the meaning of community and habitat of organisms . 3. Explore to get the data of the element of fresh water ecosystem 4. Tell the kind of organisms in general fresh water ecosystem .

Table 1 (Continued)

Lesson	Content	Concept	General objectives	Learning objectives
2. The role of each of organisms in a fresh water ecosystem	The role of organisms in a fresh water ecosystem	In an ecosystem, there are many living organisms which can be differentiated by their habitats. They might be grouped as follows: Producer, Consumer, and Decomposer.	Knowing and understanding of the role of organisms in fresh water ecosystem.	<ol style="list-style-type: none"> 1. Tell the meaning of producer, consumer, decomposer and give the example of each. 2. Explain the relationship among producer, consumer and decomposer.
3. Interspecific relationships in a fresh water ecosystem	The relationship of organisms in a fresh water ecosystem	The relationship of organisms in fresh water ecosystem might be roughly discussed in two ways: Food chain, Food web and living relationship. Food chain is the nutritive series in which a group of organisms secures food in the same general way or transfer of energy from plants through a series of other organisms. Food web is a very complex pattern of feeding relationship. Living Relationship are classified into both get benefits, one gets and one loses, one gets and one does not get or does not lose.	Knowing and understanding of the relationship of organisms in fresh water ecosystem.	<ol style="list-style-type: none"> 1. Tell the meaning of food chain, food web and draw the diagram of them. 2. Give the relationship of organisms in fresh water ecosystem.
4. Adaptation of organisms in a fresh water ecosystem	Adaptation of organisms in a fresh water ecosystem	All living organisms have to adapt themselves to be able to survive in a condition which may change in time. Some plants have been taken to a new place, they will need some time to adapt themselves. There are two ways that living organisms can adapt themselves to the environment; Temporary adaptation and Permanent adaptation.	Knowing and understanding of adaptation of organisms in fresh water ecosystem.	<ol style="list-style-type: none"> 1. Tell the meaning and the cause together with the example in adaptation of organisms in the fresh water ecosystem..

Table 1 (Continued)

Lesson	Content	Concept	General objectives	Learning objectives
5. Wise Usage of a fresh water ecosystem	Conservation and development of the fresh water ecosystem	Wise used means to use water from any source, one should be careful and try every way to conserve as well as to develop such source of water to be clean useful to others. We should realize the prevention activities as well as giving knowledge about the contamination of water. At the same time, water sources should be renovated and keep clean.	Aware of the problems and suggest the way to conserve fresh water ecosystem.	<ol style="list-style-type: none"> 1. Explain the meaning of conservation and development . 2. Tell the necessary to conserve and develop the fresh water ecosystem. 3. Analyze the quality of water. 4. Analyze the problems of fresh water pollution and its effect to people . Find out the solution to that problems.

(2) Teacher's manual

Procedure of construction and development the teacher's manual :-

2.1 Study the secondary curriculum in the year B.E.2521 (to be revised in B.E.2533) and the teacher's manual (Sc 102) of the Institute for the Promotion of Teaching Science and Technology.

2.2 Point out the objectives of each laboratory lessons.

2.3 Development of teacher's manual 15 periods (3 periods for each laboratory lessons).

The content of teacher's manual consisted of name , learning objectives , experimental objectives , materials and instruments , preparation period , pre - lab discussion , experimental results , post - lab discussion and guidelines of answer to the exercise .

2.4 Submit the teacher's manual to the experts to check its reliability of the subject matters and details.

2.5 Apply this teacher's manual with the main experimental group.

Then use the developed laboratory lessons to all the main experimental group to find out the efficiency according to the standard index of 80/80. The researcher had constructed teaching plan and evaluating method :-

- Teaching plan

Table 3 Time table

Time	No. of periods	Content	Evaluation
1	3	The element of fresh water ecosystem. Lab 1 : Let us explore the fresh water ecosystem.	Exercise of Lab 1
2	3	The role of organisms in a fresh water ecosystem. Lab 2 : The role of organisms in a fresh water ecosystem.	Exercise of Lab 2
3	3	The relationship of organisms in a fresh water ecosystem. Lab 3 : Interspecific relationships in a fresh water ecosystem..	Exercise of Lab 3
4	3	Adaptation of organisms in a fresh water ecosystem. Lab 4 : Adaptation of organisms in a fresh water ecosystem.	Exercise of Lab 4
5	3	Conservation and development of the fresh water ecosystem. Lab 5 : Wise Usage of a fresh water ecosystem.	Exercise of Lab 5

- Evaluating method , there are three types :-

1. The knowledge tests
2. The experimentation skill tests
3. The attitude tests

1. The knowledge tests

Procedure of construction ; as followed

1.1 Study the process from text books and evaluating materials.

1.2 Analyze contents and objectives in according to Benjamin S. Bloom

(Table 4)

1.3 Construct 30 items of multiple choices (4 choices)

1.4 Submit to the thesis advisers committee , the experts, respectively to improve it .

1.5 Apply this test to the mathayomsuksa 1 students was designed to try - out the pretest and also to analyze the discrimination power , difficulty level by using 27 percentages technique , reliability of Kuder – Richardson (KR – 20) to improve it .

1.6 Apply this test to the main experimental group .

Table 4 Analysis of contents and learning objectives according to Bloom's taxonomy

This table was created according to Bloom's taxonomy (Bloom and colleagues, 1956: 90-109), which compose of knowledge , comprehension, application, analysis, synthesis and evaluation as follows :

Details	Know- ledge	Compre- hension	Applica- tion	Analysis	Synthesis	Evalua- tion	Total
1. The element of fresh water ecosystem	1 item (2)	2 items (1,5)	1 item (4)	2 items (3,6)	-	-	6 items

Table 4 (Continued)

Details	Know- ledge	Compre- hension	Applica- tion	Analysis	Synthesis	Evaluat- ion	Total
2.The role of organisms in a fresh water ecosystem.	3 items (7,9,10)	1item (8)	-	-	-	-	4 items
3.The relationships of lives in a fresh water ecosystem	-	4items (11,13, 14 , 18)	-	4items (15,16 17,20	2 items (12,19)	-	10 items
4. Adaptation of organisms in a fresh water ecosystem.	2 Items (26,27)	3 items (21,22, 23)	-	3 items (24,25, 28)	-	-	8 items
5. Conservation and development of the fresh water resource	-	-	-	-	-	3 items (29,30)	2 items
Total	6	10	1	9	2	2	30

2. The experimentation skill tests

2.1 Study some documents and researchs

2.2 Analyze the subject matters' objectives

2.3 Construct 20 items of multiple choices (4 choices)

2.4 Submit to the thesis advisers committee, the experts respectively to improve it .

2.5 Apply this test to the mathayomsuksa 1 students was designed to try - out the pretest and also to analyze the discrimination power , difficulty level by using 27 percentages technique , reliability of Kuder – Richardson (KR – 20) to improve it .

2.6 Apply this test to the main experimental group .

3. The attitude tests

3.1 Study the process of attitude according to Likert method

3.2 Construct 20 items of the attitude tests towards the learning - teaching by using the rating scale 5 levels.

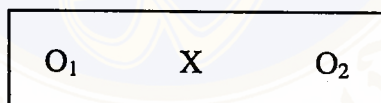
3.3 Submit to the thesis advisers committee , the experts, respectively to improve it .

3.4 Apply this test to the main experimental group .

3.5 Analyze the students ' attitude towards the learning-teaching.

3.3 Research Design

This study was experimental research : one group pre-test and post-test 29 design , has the following form (A. Srisopa, 1984 : 107)



O_1 is the pre-test scores

O_2 is the post-test scores

X is learning and teaching with the laboratory lessons

Procedure of learning and teaching :

1. The students have done the pre-test that composed of the knowledge tests and the experimentation skill tests for 1 period . (50 minutes)

2. The students worked out laboratory lessons .

3. The students have done the post-test that was the same as the pre-test and then they would have the attitude tests .

4. Collect the data and analysis with the statistics.

3.4 Data analysis

1. Analysis of the quality of research instruments

1.1 Analysis of the discrimination power (r) and difficulty level of the achievement tests in each items using 27 percentages technique

(Kitpreedaborisut, B., 1991 : 86-89)

$$\text{Difficulty level (p)} = \frac{P_H + P_L}{2n}$$

$$\text{Discrimination power (r)} = \frac{P_H - P_L}{N}$$

When p is difficulty level

r is discrimination power

P_H is the number of the students who got right answer in high score

P_L is the number of the students who got right answer in low score

n is all of the samples

The acceptable difficulty level in this study was at 0.2 - 0.8

The acceptable discrimination power in this study was at 0.2 up.

1.2 Analysis of the reliability of the achievement tests by

Kuder – Richardson's formula (KR –20 in Taweerat, P.,1995 : 123)

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

When r_{tt} is the reliability

n is the number of the items

p is the proportion of the students who got the right answer in each item

q is the proportion of the students who got the wrong answer in each item

S_t^2 is total of variance

The acceptable reliability of this achievement tests was 0.6 up.

1.3 Analysis of the reliability coefficients for the attitude tests was computed by using the most commonly used available package computer program "Statistical Package for the Social Sciences (SPSS / PC)" reliability subprogram or the Cronbach Alpha Model (Cronbach, In Taweerat, P., 1995 : 125) The formular showed that

$$\alpha = \frac{n}{n-1} \left\{ 1 - \frac{\sum S_i^2}{S_t^2} \right\}$$

When α is α - coefficient

n is the number of items

S_i^2 is the score of variance for each item

S_t^2 is the score of variance for all items

The acceptable reliability coefficient of this attitude scale was 0.6 up.

2. Analysis of opinion's scores from the experts about laboratory lessons and the teacher's manual by using basic statistics : Percentage and Mode .

3. Analysis of the efficiency of laboratory lessons

To find the efficiency of laboratory lessons according to the standard index of 80 / 80, the formula of E_1 / E_2 showed that (S. Sikhbandith , 1985 : 294)

$$E_1 = \frac{(\sum X / N) \times 100}{A}$$

$$E_2 = \frac{(\sum Y / N) \times 100}{B}$$

When E_1 is the efficiency of the exercises' evaluation among learners in percentage

E_2 is the efficiency of the achievement tests among learners
in percentage

A is total scores of the exercises

B is total scores of the posttest

ΣX is summation of doing the exercises scores

ΣY is summation of doing the achievement tests

N is number of students

4. Comparison of the learning achievement

The learning achievement scores were compared by using the t-test.

$$t = \frac{\Sigma D}{\sqrt{\frac{N \Sigma D^2 - (\Sigma D)^2}{N-1}}}$$

When t is the t-test

D is the different of the pretest and posttest scores

D^2 is the square of D

N is the number of the sample group

CHAPTER IV

RESULTS

The purposes of this study were to develop and determine the efficiency of environmental education laboratory lessons on fresh water ecosystem in science subject for mathayomsuksa 1 students according to the standard index of 80 / 80 and to find the learning achievement before and after using the laboratory lessons at the 0.05

4.1 Results from Development of the Learning Achievement Test (Pre-test and Post-test)

The researcher created the learning achievement test (50 questions) with four choices in each question . The test was divided into 2 sections ; section 1 was the knowledge test (30 questions) and section 2 was the experimentation skill test (20 questions). The test was examined by the thesis advisor committee and the experts , before trying out by 40 students. After that analysis for the difficulty level, its discrimination power were done. The results were shown in Table 5.

Table 5 The Results of the Difficulty level and the Discrimination power of the Learning Achievement Test in each item

Item	P_H	P_L	$P_H + P_L$	$P_H - P_L$	p	r
1	9	6	15	3	0.68	0.27
2	7	4	11	3	0.50	0.27
3	10	6	16	4	0.72	0.36
4	7	4	11	3	0.50	0.27
5	5	2	7	3	0.32	0.27
6	8	5	13	3	0.59	0.27
7	6	1	7	5	0.32	0.45
8	10	6	16	4	0.72	0.36

Table 5 (Continued)

Item	P_H	P_L	$P_H + P_L$	$P_H - P_L$	p	r
9	9	5	14	4	0.64	0.36
10	11	6	17	5	0.77	0.45
11	10	6	16	4	0.72	0.36
12	7	4	11	3	0.50	0.27
13	7	2	9	5	0.41	0.45
14	11	6	17	5	0.77	0.45
15	9	6	15	3	0.68	0.27
16	7	3	10	4	0.45	0.36
17	7	4	11	3	0.50	0.27
18	9	4	13	5	0.59	0.45
19	8	5	13	3	0.59	0.27
20	5	2	7	3	0.32	0.27
21	6	3	9	3	0.41	0.27
22	6	2	8	4	0.36	0.36
23	8	5	13	3	0.59	0.27
24	8	5	13	3	0.59	0.27
25	9	3	12	6	0.54	0.54
26	8	3	11	5	0.50	0.45
27	10	6	16	4	0.72	0.36
28	7	4	11	3	0.50	0.27
29	9	6	15	3	0.68	0.27
30	7	2	9	5	0.41	0.45
31	8	5	13	3	0.59	0.27
32	10	7	17	3	0.77	0.27
33	8	5	13	3	0.59	0.27
34	6	1	7	5	0.32	0.45
35	7	2	9	5	0.41	0.45
36	6	3	9	3	0.41	0.27
37	10	5	15	5	0.68	0.45
38	8	4	12	4	0.54	0.36
39	8	5	13	3	0.59	0.27
40	6	2	8	4	0.36	0.36
41	6	3	9	3	0.41	0.27
42	5	2	7	3	0.32	0.27
43	11	5	16	6	0.72	0.54
44	10	6	16	4	0.72	0.36
45	8	5	13	3	0.59	0.27
46	5	2	7	3	0.32	0.27
47	8	5	13	3	0.59	0.27
48	7	3	10	4	0.45	0.36
49	5	2	7	3	0.32	0.27
50	7	4	11	3	0.50	0.27

From Table 5, The difficulty level was between 0.32 - 0.77 and the discrimination power was 0.27 up . After that analysis for the reliability was done from the proportion of the students who got the right and wrong answer in each item (Table 6) and total scores in each student (Table 7)

Table 6 Analysis of the proportion of the students who got the right and wrong answer in each item.

Item	Right answer	Wrong answer	p	q	pq
1	28	12	0.70	0.30	0.2100
2	24	16	0.60	0.40	0.2400
3	30	10	0.75	0.25	0.1875
4	25	15	0.62	0.38	0.2356
5	14	26	0.35	0.65	0.2275
6	25	15	0.62	0.38	0.2356
7	20	20	0.50	0.50	0.2500
8	31	9	0.78	0.22	0.1716
9	22	18	0.55	0.45	0.2475
10	28	12	0.70	0.30	0.2100
11	24	16	0.60	0.40	0.2400
12	21	19	0.52	0.48	0.2496
13	18	22	0.45	0.55	0.2475
14	27	13	0.68	0.32	0.2176
15	25	15	0.62	0.38	0.2356
16	19	21	0.48	0.52	0.2496
17	24	16	0.60	0.40	0.2400
18	23	17	0.58	0.42	0.2436
19	18	22	0.45	0.55	0.2475
20	15	25	0.38	0.62	0.2356
21	17	23	0.42	0.58	0.2436
22	14	26	0.35	0.65	0.2275
23	24	16	0.60	0.40	0.2400
24	17	23	0.42	0.58	0.2436
25	27	13	0.68	0.32	0.2176
26	19	21	0.48	0.52	0.2496
27	24	16	0.60	0.40	0.2400
28	22	18	0.55	0.45	0.2475
29	26	14	0.65	0.35	0.2275
30	19	21	0.48	0.52	0.2496
31	24	16	0.60	0.40	0.2400
32	31	9	0.78	0.22	0.1716
33	21	19	0.52	0.48	0.2496

Table 6 (Continued)

Item	Right answer	Wrong answer	p	q	Pq
34	14	26	0.35	0.65	0.2275
35	15	25	0.38	0.62	0.2356
36	18	22	0.45	0.55	0.2475
37	27	13	0.68	0.32	0.2176
38	23	17	0.58	0.42	0.2436
39	21	19	0.52	0.48	0.2496
40	16	24	0.40	0.60	0.2400
41	17	23	0.42	0.58	0.2436
42	11	29	0.28	0.72	0.2016
43	27	13	0.68	0.32	0.2176
44	25	15	0.62	0.38	0.2356
45	22	18	0.55	0.45	0.2475
46	16	24	0.40	0.60	0.2400
47	27	13	0.68	0.32	0.2176
48	19	21	0.48	0.52	0.2496
49	11	29	0.28	0.72	0.2016
50	20	20	0.50	0.50	0.2500

Table 7 Total Scores of the Learning Achievement Test of the Students

No.	X	$X - \bar{X}$	$(X - \bar{X})^2$	No.	X	$X - \bar{X}$	$(X - \bar{X})^2$
1	38	11.15	124.32	21	28	1.15	1.32
2	36	9.15	83.72	22	25	-1.85	3.42
3	34	7.15	51.12	23	22	-4.85	23.52
4	28	1.15	1.32	24	28	1.15	1.32
5	37	10.15	103.00	25	18	-8.85	78.32
6	35	8.15	66.42	26	20	-6.85	46.92
7	27	0.15	0.02	27	27	0.15	0.02
8	33	6.15	37.82	28	20	-6.85	46.92
9	17	-9.85	97.02	29	25	-1.85	3.42
10	35	8.15	66.42	30	17	-9.85	97.02
11	27	0.15	0.02	31	18	-6.85	46.92
12	35	8.15	66.42	32	19	-7.85	61.62
13	28	1.15	1.32	33	17	-9.85	97.02
14	36	9.15	83.72	34	26	-0.85	0.72
15	28	1.15	1.32	35	25	-1.85	3.42
16	27	0.15	0.02	36	28	1.15	1.32
17	19	-7.85	61.62	37	33	6.15	37.82
18	17	-9.85	97.02	38	25	-1.85	3.42
19	28	1.15	1.32	39	26	-0.85	0.72
20	25	-1.85	3.42	40	37	10.15	103.02

From Table 6 and Table 7 , Analysis of the reliability was done by using Kuder - Richardson's formula (KR - 20) . The result was 0.75.

4.2 Results from Evaluations of Environmental Education Laboratory Lessons by the experts

The three experts evaluated the quality of laboratory lessons. An application of 5 rating scales questions for the level of opinion was selected. The continuum of 1 to 5 were: 1 = Lowest, 2 = Low , 3 = Moderate , 4 = High , 5 = Highest

The results were shown in Table 8

Table 8 Percentage and Mode from Evaluation of Environmental Education Laboratory Lessons by the Experts

Evaluation List	Level of opinion (%)					Mode
	5	4	3	2	1	
1. Laboratory Lessons	-	-	-	-	-	
1.1 The principle was accorded with Laboratory Lessons	33.3	66.7	0.0	0.0	0.0	High
1.2 Laboratory Lessons were appropriated with the grade	33.3	66.7	0.0	0.0	0.0	High
1.3 Objectives were clear	0.0	33.3	66.7	0.0	0.0	Moderate
1.4 Objectives can be evaluated	0.0	33.3	66.7	0.0	0.0	Moderate
1.5 The activities of testing were sequential	33.3	66.7	0.0	0.0	0.0	High
1.6 Time use was appropriate	33.3	66.7	0.0	0.0	0.0	High
1.7 The Difficulty was suitable for student in this grade	33.3	66.7	0.0	0.0	0.0	High
1.8 Laboratory Lessons encouraged students' experimentation skills	33.3	66.7	0.0	0.0	0.0	High
1.9 Laboratory Lessons encouraged students' thinking skills	33.3	66.7	0.0	0.0	0.0	High
1.10 Each student was active participation in learning activities	33.3	66.7	0.0	0.0	0.0	High
1.11 Students got the concepts	0.0	100	0.0	0.0	0.0	High
1.12 Language used was also clear	33.3	66.7	0.0	0.0	0.0	High
2. The experimental reports and exercises	-	-	-	-	-	
2.1 The experimental reports were appropriate	33.3	66.7	0.0	0.0	0.0	High

Table 8 (Continued)

Evaluation List	Level of opinion (%)					Mode
	5	4	3	2	1	
2.2 The exercises after lessons were harmoniously agreed with the experiments	33.3	66.7	0.0	0.0	0.0	High
2.3 The exercises after lessons were harmoniously agreed with the objectives	33.3	66.7	0.0	0.0	0.0	High
2.4 Number of question was suitable	33.3	66.7	0.0	0.0	0.0	High
2.5 The experimental reports and exercises encouraged students' skills and use	33.3	66.7	0.0	0.0	0.0	High
3. Work sheets	-	-	-	-	-	
3.1 The contents followed objectives	33.3	66.7	0.0	0.0	0.0	High
3.2 The contents were continuous	33.3	66.7	0.0	0.0	0.0	High
3.3 The contents were complete	33.3	66.7	0.0	0.0	0.0	High
3.4 The contents were appropriated with the time	33.3	66.7	0.0	0.0	0.0	High
3.5 Details of contents were appropriate	0.0	100	0.0	0.0	0.0	High
3.6 The examples of contents were clear	33.3	66.7	0.0	0.0	0.0	High
3.7 The pictures of contents were appropriate	33.3	66.7	0.0	0.0	0.0	High
3.8 Language used was easy to understand	0.0	100	0.0	0.0	0.0	High
4. The teacher's manual	-	-	-	-	-	
4.1 Learning objectives were clear	33.3	66.7	0.0	0.0	0.0	High
4.2 Experimental objectives were clear	33.3	66.7	0.0	0.0	0.0	High
4.3 Chemical substances and instruments were appropriate	33.3	66.7	0.0	0.0	0.0	High
4.4 Suggestions for advance preparation were appropriate	33.3	66.7	0.0	0.0	0.0	High
4.5 Suggestions of Pre- lab discussions were appropriate	33.3	66.7	0.0	0.0	0.0	High
4.6 Post- lab discussions were appropriate	33.3	66.7	0.0	0.0	0.0	High
4.7 Pictures of the experimental results were appropriate	33.3	66.7	0.0	0.0	0.0	High
4.8 Language used was easy to understand	0.0	100	0.0	0.0	0.0	High
4.9 Guide line for exercises was clear	0.0	100	0.0	0.0	0.0	High
4.10 The teacher's manual was useful	0.0	100	0.0	0.0	0.0	High

From Table 8, data analysis about opinion's scores from the three experts in each part of laboratory lessons was at high level except objectives of laboratory lessons were at moderate level, but the highest level was as follow : students got the concepts from laboratory, language used was easy to understand of work sheet and teacher's manual , guide line for exercises was clear and the teacher's manual was useful. The experts agreed that the Environmental Education Laboratory Lessons and Teacher 's Manual are suitable for the learning - teaching process at the high level. Their suggestions were as followed :

1. Environmental Education Laboratory Lessons : learning objectives should have clear criteria for evaluation easily and the pictures of living organisms in fresh water resources should be at Appendix .

2. Experimental Reports and Exercises : some questions should be open - ended for several answers.

3. Work Sheets : number of pictures should be increased to draw students's attention .

4. Teacher 's Manual : some answers of the exercises were not clear and suggested to add some details.

After that the researcher has improved and developed them to test its efficiency.

4.3 Results from Studying the Efficiency of Environmental Education

Laboratory Lessons by the Small Sample Groups.

The researcher applied these laboratory lessons and teacher's manual with 3 groups of mathayomsuksa 1 students (3 students in each group) at

Assumption College Thonburi , Bangkok .

The learning - teaching process were as follows :

1. The students were asked to do the pre-test .
2. After learning 15 periods of the lab-direction, they had to answer all the questions.
3. Read additional information from the work sheets.
4. The students had to finish the post-test after finished all of them.

From observation , it was found that the students did not understand every step of the lab - direction. To solve this problem, the researcher has collected all information and improved the lab-direction to be more easy understanding . After that the students were interviewed about the learning - teaching process on the laboratory lessons. It found that the laboratory lessons were useful,help the students understand the subject matters , get the direct experience and skills , everybody had an active participation in the lab - testing and broadly expressed their opinions , and could understand the important of fresh water resource towards the living organisms.

From the achievement testing to the small sample group of 9 students, it was found that : Mean of the pre-test = 28.3 and Mean of the post-test = 39.9 , the results were shown in Table 9

Table 9 The Results of the Exercises' Scores, the Pre-test and Post-test Scores of the Small Sample Group

No	Pre-test (X)	Post-test (Y)	D = (Y-X)	D ²	Scores of exercises
1	30	41	11	121	45
2	38	45	7	49	47
3	22	34	12	144	38
4	25	38	13	169	43
5	37	45	8	64	47.5
6	20	36	16	256	37
7	36	45	9	81	46.5
8	28	39	11	121	44
9	19	36	17	289	33
N=9	$\sum X=255$ $\bar{X} = 28.3$	$\sum Y= 359$ $\bar{Y} = 39.9$	$\sum D = 104$	$\sum D^2=1294$	381

From Table 9 , The obtained data was analyzed by the t - test technique was 10.21 but the statistic standard table of the t - test at the 0.05 level is 1.86 ($t_{8(0.95)}$) Analysis for the efficiency of laboratory lessons was 84.67/ 79.78 from the standard index of 80 / 80 . (Appendix B)

4.4 Results from Studying the Efficiency of Environmental Education

Laboratory Lessons by the Main Experimental Group

The researcher improved the laboratory lessons after testing to the small sample groups. Then it was applied to the 45 students who were the experimental group and never studied these laboratory lessons. The results of the exercises' scores, the pre-test and post-test scores were shown in Appendix B, and analyzed by the efficiency of laboratory lessons was 83.0 / 79.69 from the standard index of 80 / 80 (Table 10)

Table 10 The Efficiency of Laboratory Lessons to the Main Experimental Group

Statistics value	Pre-test	Scores of exercises	Post-test
Mean	30.69	41.5	39.84
Percentage	61.38	83.0	79.69

4.5 Results from the Comparison of the Learning Achievement Test

(Pre-test and Post- test)

According to the score analysis from the learning achievement test of the 45 students of the main experimental group it was found that : Mean of the pre - test was 30.69 and Mean of the post - test was 39.84 , the post-test achievement scores were significantly higher than the pre-test at the 0.05 level (Table 11).

Table 11 Comparison of the Learning Achievement Test of the Main Experimental Group (45 students)

Test	N	$\sum D$	$\sum D^2$	df	t
Pre-test	45	413	4483	44	15.52
Post-test	45				

Note : Scores of the exercises , the pre-test and the post-test , total scores of each student were presented in Appendix B

From Table 11 , the t - test from calculation was 15.52, the statistic standard table of the t - test was 1.684 ($t_{44(0.95)}$). This showed that the post-test achievement scores were significantly higher than the pre-test at the 0.05 level which followed the hypotheses. Therefore , the conclusion stated that the students had higher knowledge.

Evaluation in each Laboratory Lessons

From the analysis of scores in each laboratory lesson of the experimental group, it was found that : Mean = 7.8 , Percentage = 78.0 in Lab 1 ; Mean = 8.3 , Percentage = 83.0 in Lab 2 ; Mean = 8.2 , Percentage = 82.0 in Lab 3 ; Mean = 9.1 , Percentage = 91.0 in Lab 4 ; Mean = 8.1 , Percentage = 81.0 in Lab 5 ; and Mean of total scores followed the standard value of 80 % (Table 12)

Table 12 Evaluation of the scores from exercises

Evaluation	Scores of exercises				
	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5
Total scores (45 students)	351	374.5	367.5	408	364
Mean	7.8	8.3	8.2	9.1	8.1
Percentage	78.0	83.0	82.0	91.0	81.0

4.6 Results from Measurement of Attitude towards the Learning - Teaching

From analysis of the reliability coefficient for attitude test by using the most commonly used available package computer program " Statistical Package for the Social Science (SPSS/PC) " reliability subprogram or the Cronbach Alpha Model , the reliability coefficient value was 0.79 . To analyze the level of students' attitude towards the learning - teaching of laboratory lessons on fresh water ecosystem by rating scales of 1 - 5 , the result was as followed :

	<u>Positive Attitude</u>	<u>Negative Attitude</u>
Strongly agree	5 scores	1 scores
Agree	4 scores	2 scores
Uncertain	3 scores	3 scores
Disagree	2 scores	4 scores

Table 13 (Continued)

	Statements	Attitude scores					Mode
		5	4	3	2	1	
15.	Students had a lot of knowledge about environment.....	35.6	60.0	4.4	0.0	0.0	4
16.	Students were interested in the environment and participated in environmental problem solving..	24.4	66.7	8.9	0.0	0.0	4
17.	Students awared to conserve the environment.....	15.6	73.3	11.1	0.0	0.0	4
18	In lessons should have a lot of experimental activities	31.1	55.6	13.3	0.0	0.0	4
19.	This laboratory lessons were appropriate to use in learning-teaching.....	31.1	66.7	2.2	0.0	0.0	4
20.	The environmental knowledge can be useful to their real life.....	24.4	68.9	6.7	0.0	0.0	4

Note : * negative questions

CHAPTER V

DISCUSSION



The study of environmental education laboratory lessons on fresh water ecosystem in science subject (Sc.102) for Mathayomsuksa 1 students could be discussed in 7 sections as follows.

5.1 Quality of Pre-test and Post-test

Pre-test and Post-test were qualitatively analyzed and found that p value of difficulty level was between 0.32 - 0.77 within the established standard (p value between 0.20 - 0.80). It revealed that none of the constructed Pre & Post -Test is too difficult ($p < 0.20$) or too easy ($p > 0.80$). Discrimination power (r value was 0.27 upwards, indicated that Pre & Post -Test were able to differentiate between high and low intelligence of students. Reliability of the Test was 0.75, closed to 1 explicit high level of reliability. Test were qualified and being accepted as Pre-test and Post-test.

5.2 Qualitative Evaluation by Experts

There were 4 parts of laboratory lessons be evaluated and found that :

1. The lessons were good and the principle was accorded with laboratory lessons. Language used was also clear while activities of testing were sequential. Difficulty level was suitable for student in this grade and time use was appropriate. Lessons promoted student's skill of practice and created conceptual thinking. It was participatory learning process with fair objectives. There were some suggestions that objectives of lessons should have clear criteria for evaluation. The researcher has

reviewed the lessons according to suggestions before using them.

2. The report and exercise after lessons were harmoniously agreed with the experiment and its objectives. Number of question was suitable. It promoted skill and implementation. A suggestion for change and improvement by experts was to use an open-ended questions to allow different answers.

3. The work sheet was good. Content was easy understanding and well synchronized with objectives. However, it was suggested that number of pictures should be increased to draw student's attention.

4. The teacher's manual was good and useful for teaching. Objectives of learning and testing were clear. Chemical supply, instrument, and suggestion for advance preparation were appropriate. Discussion before and after testing were also appropriate to time limited. It was suggested that answers of questions after testing should be clear and concise before using with the experimental group.

In conclusion , the experts had strongly agreed that the constructed environmental education laboratory lessons on fresh water ecosystem was appropriate to be used in learning and teaching process.

5.3 The Efficiency of Environmental Education Laboratory Lessons in testing with the Small Sample Group

The testing was done with small sample group and found that the efficiency was 84.67 / 79.78 within established standard of 80 / 80. Lessons could be used for learning and teaching with modifications of guidelines and directions of experiment lessons. However, it was suggested that there were some unclear parts of the lab-lessons which should be completed before using with the experimental group. The

researcher, then, improved them to be more easy understanding.

5.4 The Efficiency of Environmental Education Laboratory Lessons in testing with the Main Experimental Group

The study revealed that efficiency of lessons in the main experimental group was 83.0 / 79.69 within established standard of 80 / 80. This indicated that environmental education laboratory lessons on fresh water ecosystem for Mathayomsuksa 1 students was effective as hypothesized.

5.5 The Comparison of the Learning Achievement by Pre-test and Post-test.

Mean score of pre-test was 30.69 from total 50 score and post-test was 39.84. This indicated that the students gained more learning achievement after practicing the laboratory lessons. Mean score of pre-test and post-test was statistical significant difference ($p > 0.05$).

Similarity Waleerat Supanun (1999:90) who developed and implemented the use of a Field Trip Teaching Manual Titled " Conservation of Natural Resources and Environment" for lower secondary school students , found that mean score of knowledge of student after undergoing a teaching manual was higher than mean score of prior study with statistical significant difference ($p > 0.05$).

Naviya Nantapanich (2000 : 99-104) found that Grade Six pupils in the experiment group who had undertaken instructional activities as prescribed by the teacher's manual gained their knowledge and comprehension of mangrove forest conservation , and increased their positive attitudes toward mangrove forest conservation with statistical significant difference ($p > 0.001$).

Using of laboratory lessons on environment is ,therefore, effective for the development of learning & teaching process in achieving the goal and objectives.

5.6 Attitude towards the learning - teaching of laboratory lessons

After the students finished the learning environmental education laboratory lessons on fresh water ecosystem completely, they were asked to answer a set of questions on attitude towards learning and teaching process . Most of the students answered "strongly agree" and "agree " in positive questions and answered " disagree " and "strongly disagree " in negative questions. This shown that most of students had agreed with the learning - teaching of laboratory lessons on fresh water ecosystem , which indicated that the students developed an attitude towards the constructed lessons at satisfactory level.

5.7 Environmental Education Laboratory Lessons used in this study created a high learning achievement due to:-

Laboratory Lessons were evaluated by Thesis Committee and Experts , remedial action was made according to suggestions. Lessons were pre-test with three small groups of three students each in Mathayomsuksa 1 class. Improvement of lessons was done before using with the main experimental group.

In carrying out planned learning and teaching activities, emphasis was made on the learning - teaching process using a student -centered to allow creative thinking and self - directed experiment . The students recorded the results of the experiment and drew conclusion by themselves and through group process. After practicing the experiment the students gained their knowledge and skill in science. As

said by the learning and producing of educational equipment development committee on science, University Affairs (1982:116) stated that experiment is the fundamental of learning by searching and attributing for skill.

After studying the developed lessons the students can used appropriate equipment in an experiment process that the experiment was conducted smoothly and the result was valid. The students were anxious to learn.

It indicated that in learning activity from the developed laboratory lessons which included sorts of media, the researcher could notice that the students were stimulated. This might be that the students did not have many chances to touch the real situation and gained direct experiences. The students enjoyed learning and could increase the level of learning achievement. They gained knowledge on fresh water ecosystem attributed to the realization of the value of fresh water resource. It envisaged that the students would be able to help disseminate the knowledge, the facts, and would draw more public attention to participate in the problem solving in the future, the researcher hopes that the environmental education laboratory lessons would be widely used .

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Fresh Water Ecosystem is critical for survival of living organism especially human. Human use water for drinking and supply, agriculture, industry, waste disposal etc. Fresh water resource is the source of plant and animal. Nature create a suitable environment to human needs but human use environment inefficiently. These attribute to pollution with affect living organism including human. Human search for methods to prevent and correction but it is only solve problem at the end of the cause. Due importance has to be devoted to the origin of cause by implant knowledge and correct fact and enhance awareness of people for the sustainability of fresh water reservoir. Student is part of soceity and being a future of the nation. Therefore the best way is to pave the foundation in student from now on.

6.1 Conclusions

The researcher developed environmental education laboratory lessons on fresh water ecosystem in science (Sc.102) for Mathayomsuksa I. To begin with the content of ecosystem. This study was experimental research and pre-test & post-test one group designed . Study revealed that

1. Efficiency was 83.0/79.69 which was acceptable within standard index of 80 / 80.
2. Learning achievement between prior and after using of lessons was statistical significant difference ($p > 0.05$).
3. Learning activities in this lessons has helped student to be vigilance to

ascertain the cause and effect from environment and enabling them to adjust environment. Student received direct experiences through sensory nerve and long memory. Student has excitement and enjoy in the experiment and gain their skill in using of equipment and process of experiment. Student gained responsibility and able to work as a group. Student know to solve problem and ready to face the real situation. Learning with Environmental Education Laboratory Lessons, therefore, is the method To develop process of learning on environment from subject to abstract. It is the organized process to focus on student. Let student discover and learn by practicing themselves, later on student will understand, remember of knowledge and utilize knowledge in daily life. Construction and development of environmental education laboratory lessons should be supported and promoted extensively.

6.2 Recommendations from this Study

From the study of laboratory lesson in mathayomsuksa 1 students, it was found that the students gained more testing score after using the laboratory lesson with a statistical significance at 0.05 level. This method allows students to discover and learn by practising that students will have direct experiences. Therefore, it should be promoted for the science subject teaching extensively.

Result from this experimental research revealed that the efficiency of the study was 83.0 / 79.69 which was acceptable within the standard index of 80 / 80. Therefore, teachers can adjust this laboratory lesson to be used for other schools to be well fit with different environment.

Constraints

1. Majority of students could not use equipment correctly or has never Been used some kind of equipment before. Teacher needs to demonstrate the use of

equipment which is time consuming.

2. Students do not accustom to the learning with real environment which need many equipments. Moreover there is a need to transport equipment from laboratory to fresh water reservoir and after finishing the testing they could not clean equipment within the stipulated time. They need to clean equipment in leisure time.

3. In laboratory lesson 2, student has to collect water sample from reservoir and examining by microscope in laboratory which is time consuming.

4. School has several activities during December to mid of February and student has to participate in such activities. Thus student in experimental group were unable to attend class. Experiment had to be postponed.

6.3 Recommendations for Further Research Studies

1. As it was shown that learning achievement between prior and after using the lesson was significantly different, therefore, it is suggested that this laboratory lesson should be tested in other group of students such as students in public schools for further improvement.

2. This research studied the fresh water ecosystem in a lentic community where there was no circulation of water and natural resources were well balance. To promote the study of fresh water ecosystem, it is recommended that the study is done in a lotic community where are pool zone and rapid zone. It is also recommended to study in different areas such as in estuarine ecosystem or marine ecosystem where there are beach, rocky shore, and coral reef communities.

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APPENDIX A

1. ENVIRONMENTAL EDUCATION

LABORATORY LESSONS

2. TEACHER'S MANUAL FOR

LABORATORY LESSONS

3. THE LEARNING ACHIEVEMENT TESTS

ENVIRONMENTAL EDUCATION

LABORATORY LESSONS

FRESH WATER ECOSYSTEM



Nongnart Jindawatt

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Laboratory Lesson I

Let us explore the Fresh Water Ecosystem

Principle : Generally water source is both physically and biologically different. This laboratory lesson is designed to study the physical part of a reservoir by means of its capacity to illuminate sunlight into the water. Starting by putting a *sechi-disc* into the reservoir. If the water is clean and clear enough, it will allow maximum ray of light into the bottom of the reservoir so that we can see the *sechi - disc* easily in the deepest level. This means that plants will be able to synthesize the light for survival and produce oxygen in the water. The study also intends to find out acid and base value (pH value) of the water source. It could be done by dipping a stirring-rod into the water and put it on a universal indicator paper. The water will cause the paper to be different color. The experiment should be done several times at different points of the reservoir and compare the new colors with the standard color available at the box of the testing paper, read and record the pH values. Next step of the study is to test the temperature of the water. Again, the test should be done several times to compare the result and find out mean value. The process is to simply put a thermometer about 5 -6 cm. in the water. Wait until the temperature is stable, read and record the result . To measure the temperature in deeper level, we can put a bottle into an established level, bring up some water and make a measurement. To study the biological part of the reservoir, it could be done easily by using observational technique and record what have been found.

Experimental Objectives

1. To draw a map or chart showing the water source, what have been discovered and record the result
2. To explain the environment around the water source.
3. To tell the characteristic of the water source such as its color, smell, how clear or how polluted it is.
4. To measure the illumination capacity of sunlight in the water.
5. To tell the temperature of the water at surface level and at 20 cm. depth.
6. To tell the pH value of the water at surface level and at 20 cm. depth.
7. To tell kinds of visible organisms in fresh water reservoir.

Materials and Instruments

1. Secchi-disc
2. Water-sample bottle
3. Universal indicator paper
4. Thermometer 0-100 c
5. Sterring-rod

The Experimental Process

1. Divide the students into small groups to survey the reservoir, explain its environment, and draw a map showing what have been discovered.
2. Observe the color, smell, how clear, turbid, and polluted of the water.
3. Measure the capacity of sunlight to illuminate into the water by using a sechi-disc. Tie a string which has been marked for its length to a piece of paper and put them deep into the water until the sechi-disc could not be seen. Record the depth

of the water from the marked string. Ease the string further into the water for a few cm. and slowly pull the string upwards until the sechi-disc can be seen. Record the depth of the water. Calculate the average value of the two depth values, then record the result. That is the capacity of the sunlight to shine into the water.

4. Measure the temperature of the water at surface level and at 20 cm. depth.

4.1 At the surface of the water, put the thermometer into the water about 5-6 cm. depth, wait until the temperature is stable, then record the result.

4.2 At the 20 cm. depth, tie a string to a bottle and let them go into the water, jerk the string to let the water fill in the bottle, pull the string upwards to measure the temperature of the water in the bottle. Read and record the result.

5. Measure the pH value of the water at the surface level and at 20cm. depth.

5.1 At the surface of the water, dip a stirring-rod into the water then put it on a piece of universal indicator paper, read the value of the color from the paper box and record the result.

5.2 At the 20 cm. depth, put a stirring - rod into a bottle, put the bottle into the water at 20 cm. depth. Bring the bottle up and measure the pH value of the water as done in 5.1 and record the result.

Note To measure the temperature and pH value, it should be done not less than 3 times in several points of the reservoir so that the mean values could be calculated.

6. Observe the visible organisms around the reservoir that could be found.

(To examine their types from Appendix)

Experimental Report

Lab 1 Let us explore the Fresh Water Ecosystem

Date / Month / Year

Group.....

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

Experimental Objectives

.....

.....

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Experimental Results

Area to explore

To draw a map or chart showing the water source

To explain the physical environment around the water source.

.....

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.....

.....

.....

.....

.....

Table of physical environment of water source

List	Result
Smell of water	
Color of water	
Turbidity of water	
Contaminated substance in water source	
Illumination capacity of sunlight in water source	
Temperature of water at surface level	
Temperature at 20 cm.depth	
PH of water at surface level	
pH at 20 cm.depth	
Visible organisms in fresh water source	

Conclusion

.....

.....

.....

Exercise

1. What is the physical condition of the study water source? (1.5 marks)

.....

.....

2. From 1, what do you think is the cause of such condition? (1.5 marks)

.....

.....

3. What is the characteristic of clean water? (1.5 marks)

.....

.....

4. What tools should be used to measure (3 marks)

- the capacity of the sunlight to shine into the water.....
- water temperature.....
- pH value.....

5. What are the community? (1 marks)

.....

6. What are the organic substances found at the reservoir? (1.5 marks)

.....

.....

Worksheet for Laboratory Lesson I

The Element of Fresh Water Ecosystem

Fact : Water source in general is different in size such as pond, creek, canal, river, sea, and ocean. They are different in their compositions even fresh water, brackish or salty water. Apparently, clean water has no color, no smell, no suspension or pollution, light can be shone in at a certain depth and temperature is about 25–30 c. In deeper level the temperature will be lower, standard pH value is about 5-9 . Other water source which has a bad smell, unclear, some suspension or rubbish, light cannot be easily passed, and temperature is higher than clean water both at surface and deeper level. The pH value of polluted water is actually lower than 7 . This is the result of people who has no responsibility to the environment. In any reservoir, there are many organic substances. The system where those living organisms are together as a community, have a relationship among themselves and with other environment is called an *Ecosystem*. There are two types of such relationship: physical relationship between living organisms and their environment and biological relationship which happens among living organisms.

The physical components of ecosystem which have an influence on survival of living organisms in fresh water reservoir are as follows:

- * Temperature which is rather stable and is a very important factor for every living organisms in water source.

- * Tide brings about sediment that makes water to be unclear and makes possible for living organisms to be spread out in water.

- * Turbidity level of water has an influence on light to be illuminate into water.

- * Quantity of gas in water makes different in oxygen in water and resulted

in the capacity of light to shine into water.

* Mineral in water such as calcium, magnesium, sodium, and potassium.

Biological components in fresh water source can be found in their *habitat* and live together in a *community* . These living components might be classified in two types:

1. To divide by the transferring of energy characteristics

Producer are animals and plants that can produce their own food such as fern, and other plants.

Consumer are those who could not produce their own food such as plankton, insects etc.

Decomposer are bacteria and fungus that destroy and digest the dead body of animals and plants.

2. To divide by living place

They are plants and animals that live in different places such as

- on the surface of the soil eg. Shellfishes
- hanging on plants leaves eg. Seaweed
- floating on the water eg. Plankton, neuston, duckweed, water lettuce
- nekton that swim in the water eg. frogs, fish

Laboratory Lesson II

The role of organisms in Fresh Water Ecosystem

Principle To study about lives in water, we should study how those living organisms live and what are their relationship at the same time. The study can be done by bring samples of living organisms to the laboratory and use a magnifying glass or a microscope to observe them closely.

Experimental Objectives

1. To tell types of living organisms in water or at 20 cm. depth.
2. To tell types of plankton found and be able to tell the method of the study.
3. To know what are the food of those living organisms.
4. To classify type of each living organism by its food.
5. To know the roles of each member in the water source.

Materials and Instruments

1. Magnifying glass
2. Simple net
3. Plankton net
4. Aluminium tray
5. Plastic-Box
6. Slide and cover-glass
7. Water-sample bottle
8. Dropper
9. Microscope

The Experimental Process

Section 1

1. Observe types and number of living organisms in water.
2. Collect samples of those animals and plants by using a plankton net. Bring to wash and clean in Aluminium tray, record number and drawing of the samples.
3. Bring some water sample from different places, pour it into plastic-boxes, observe some living things in water then record the result.

4. Bring some water sample from 20 cm. depth of the reservoir by using a water-sample bottle and do as No.3.
5. Use a plankton net to pick up some plankton, put them in a box, observe them by using a magnifying glass, record the result.
6. Take some sample from 5 to be observed by a microscope.
7. Bring those samples back into the water source.
8. Note the roles of those living organisms.

Section 2

Note types of food of the following living organisms: frog, grasshopper, butterfly, worm, snail, gouramy, pilot fish, cap, field crab, half beak, duck, and crane.

Experimental Report

Lab 2 The role of organisms in Fresh Water Ecosystem

Date / Month / Year

Group.....

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

Experimental Objectives

.....

Experimental Results

Section 1 Table show that living organisms in water resource

List	Name of living organisms	Number	Drawing	Roles and Duties
Organisms at the surface of water				
Organisms at 20 cm.depth				
Visible plankton				
Plankton from the microscope				
Organisms hanging on plants leaves				

Section 2 Table show types of food that organisms eat

Type of animal	Food	The source of food		
		Vegetable	Animal	Dead vegetable and animal
Frog				
Grasshopper				
Butterfly				
Worm				
Snail				
Gouramy				
Pilot fish				
Cap				

Section 2 (Continued)

Type of animal	Food	The source of food		
		Vegetable	Animal	Dead vegetable and animal
Field crab				
Half beak				
Duck				
Crane				

Conclusion

.....

.....

.....

Exercise

1. What types of living organisms in water did you find? (1 mark)
.....
2. Who takes the role of producer and why? (1 mark)
.....
3. Tell the name of consumers in three following levels: (3 marks)
 - Consumer No. 1
 - Consumer No. 2
 - Consumer No. 3
4. Who takes both roles of predator and prey? (1 mark)
.....
5. Who do you think is the decomposer? (1 mark)
.....
6. Is it possible that there is no decomposer in a water source, why? (1 mark)
.....
7. Are those living organisms in the water have any relationship, how? (1 mark)
.....

Worksheet for Lesson II

The Roles of Organisms in Fresh Water Ecosystem

Fact In an ecosystem, there are many living organisms which can be differentiated by their habitats. They might be grouped as follows:

1. **Producer** is a group of living organisms who can produce their own food such as green plants and seaweed.

2. **Consumer** is a group of living organisms who survive by eating other plants or animals. In a fresh water resource there are four groups of consumer:

2.1 consumer who eats plants such as shrimp, fish, hydra, and plankton. (Herbivores)

2.2 consumer who eats meat such as frog and piranya. (Carnivores)

2.3 consumer who eats both plants and meat such as bird, duck, and goose. (Omnivores)

2.4 consumer who eats a dead body or dead plants such as catfish and oyster. (Detritivores or Scarvengers)

The consumer level 1 is a group of living organisms who directly eats plants or both plants and animals, and consumer level 2 are those who eats the first group.

All animals cannot produce their own food. They are *predator* who eat the *prey* for food. Some animals are both predator and prey.

3. **Decomposer** are living organisms who cannot produce food. They get food from digestion process such as bacteria and fungus. This group of living organisms give a balance to the world. What has been digested will be back to the nature and come back to mankind in a form of mineral.

Laboratory Lesson III

Interspecific relationships in a Fresh Water Ecosystem

Principle : The relationship of living organisms in the ecosystem might be roughly discussed in two ways: *Food Chain, Food Web Relationship* and *Living Relationship*.

This laboratory lesson discusses about four activities of relationship.

Experimental Objectives

1. To explain the meaning of food chain, food web, predator, and prey.
2. To draw a diagram of food chain, food web, and fresh water ecosystem.
3. To explain the relationship between lives in fresh water ecosystem.

Materials and Instruments

1. String or Knitting wool 1 roll
2. Information cards of the relations
3. Information cards of the components of fresh water resource
4. The pictures of relations i.e. Predation, Parasitism, Mutualism , etc.

The Experimental Process

First Activity : Draw a Food Chain and a Food Web

1. Ask the students to draw at least three Food Chains from information gained in Laboratory Lesson II .

2. From 1. draw a Food Web.

Second Activity : How food web connects to each other.

1. Divide the students into groups, 10 each. The teacher gives information cards to a group representative to distribute to the group members, one card each. The

students put a card on their breasts.

2. Each group stand in a circle, about 2 feet apart from each other.

3. The rest of the students, 2-3 each, stand in the middle of a circle holding a piece of knitting wool.

4. Each student study an information card, see how each card relate to the other, then make a food web by connecting the knitting wool together.

5. The students discuss about the relationship of their cards and record the result.

Third Activity : “ Predator ”

1. Show the students a picture of predator and prey in an ecosystem “a cap tries to get a baby fish”.

2. Let one of the students act as a cap, the other as a baby fish.

3. Let the two students play their roles until one lose.

4. Let more students play the roles of predator and prey.

5. The students discuss what they have learn from the play and record the result.

Fourth Activity : A pair of relationship

1. Ask for thirteen volunteer students.

2. The teachers gives information cards about three types of relationship in an ecosystem to the first three students : the first type is that both sides get a benefits, the second type is that one gets and one loses, and the third type is that one side gets a benefit while the other does not get or does not lose.

3. The teacher gives other volunteers one card each.

4. The volunteers study their cards to see what type of relationship cards

they have got and join the group they belong to.

5. The rest of the student check the right clues and correct the answers.

6. All the students discuss the relationship of members of an ecosystem and record the result.



Experimental Report

Lab III Interspecific relationships in a Fresh Water Ecosystem

Date / Month / Year

Group.....

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

Experimental Objectives

.....

Experimental Results

Activity 1

Activity 2

Activity 3

Activity 4

Both get benefits (+,+)	One gets and one loses (+,-)	One gets a benefit and the other does not get or does not lose.(+,0)

Conclusion

.....

Exercise

1. Draw a food chain of the following living organisms: atemia, phytoplankton, a crane and a prawn. (2 marks)

2. Draw a food web of the following living organisms : an apple snail, a serpent-head fish, a baby shrimp, a heron, atemia, red worm, and phytoplankton. (3.5 marks)

3. Put a number in front of the following clues in the blank in front of the name lists.

- | | |
|----------------------------|--|
| 1. Both get benefits. |a cap – a baby fish |
| 2. One gets and one loses. |a morning glory – a water hyacinth |
| 3. One gets and one does |a water leech - a fish |
| not get or does not lose. |a snail – a worm |
| |a frog - a lotus leaf |
| |a dragonfly's larva – an aquatic herb |
| |water fern - blue-green algae |
| |a bee - a lotus flower |
| |millipede – water lettuce |

Worksheet for Lesson III

The Relationship of Organisms in Fresh Water Ecosystem

Fact : Living organisms do not have only physical relationship to their environment , but they also have a relationship among themselves such as being a shelter to other or being food to others. In this way they have a transferring of energy called a *Food Chain*.

For example : Phytoplankton --> Snail

Phytoplankton --> gouramy --> serpent-head --> crane

Phytoplankton --> red worm --> serpent-head --> crane

Algae --> baby shrimp --> serpent-head --> heron

Within the food chain they also have a complicated food web.

Food Web is a very complex pattern of feeding relationship, for example:

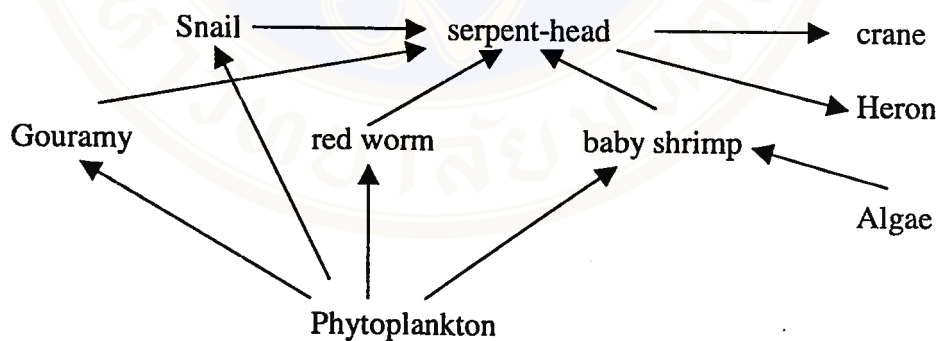


Figure 1 : Food Web in Fresh Water Ecosystem

In an ecosystem, each member has different roles such as a producer, a consumer, and a decomposer. These living organisms live together with the following relationships:

1. Both get benefits

1.1 Protocooperation (+,+) means that both sides get benefits together, but this will happen only in a short period. Although they are apart, each can still survive such as a flower and an insect, a black ant and a weevil, a myna bird and a buffalo.

1.2 Mutualism (+,+) means that both sides get benefits the whole period that they are together, if one is away the other cannot be survive such as blue - green algae and red duckweed or water fern, lichens which consists of fungus and algae.

2. One gets and one loses

2.1 Parasite (+, -) is a relationship between a host and a parasite that the parasite get food from the host such as a water leech and a fish, a shellfish and a worm.

2.2 Predation (+, -) is a relationship between a predator and a prey such as a frog and an insect, a big fish and a small fish.

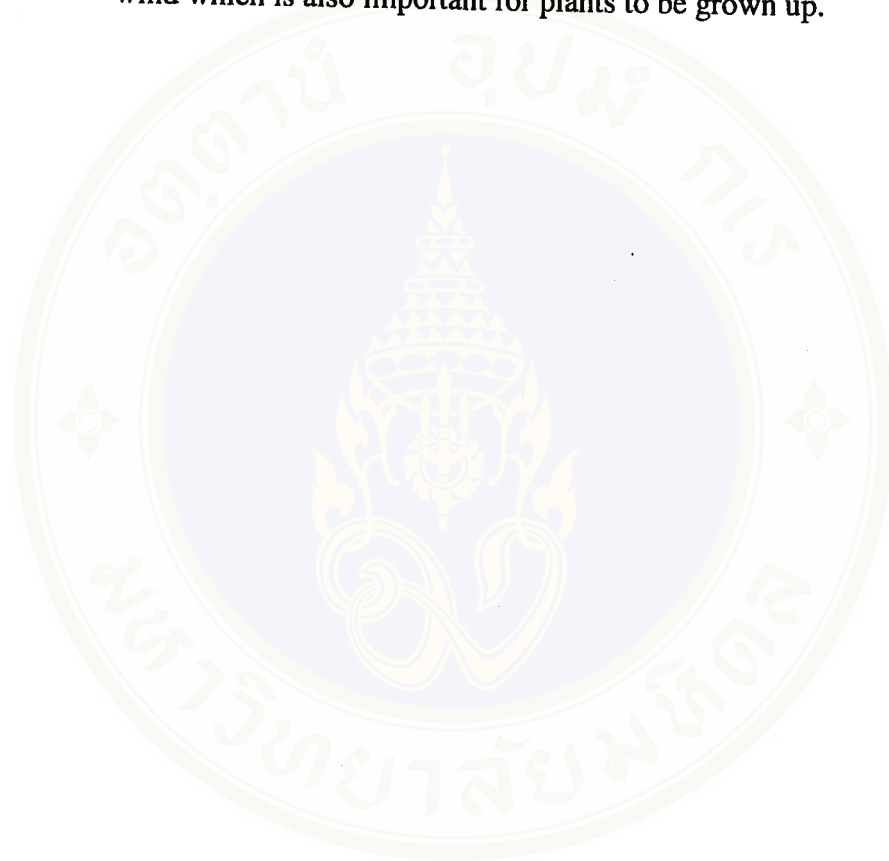
3. One gets and one does not get or does not lose

3.1 Commensalism (+, -) means a relationship between two components that one get benefit while the other does not get or lose anything such as a frog or a toad on a lotus leaf.

There are also the relationship between living things and other environment such as sunlight, temperature, tide, wind, gas, mineral, acid or base quality of the water as follows:

- light or sunlight which has an influence on plants to synthesize and to make flowers bloom.
- temperature has an effect on quantity of oxygen in water which is important for living organisms to be survive.
- carbon dioxide at an appropriate quantity is useful for plants and fishes.

- oxygen for living creature to breathe in.
- mineral at high level means high fertility of plants.
- pH value of water that each kind of plant need different values.
- water which is necessary for all living things.
- wind which is also important for plants to be grown up.



Laboratory Lesson IV

Adaptation of Organisms in a Fresh Water Ecosystem

Principle : All living organisms need to adapt themselves to be able to survive in the changing environment. There are two types of adaptation : temporary adaptation and permanent adaptation.

Experimental Objectives

- 1.To explain the meaning of the words : temporary adaptation and permanent adaptation and give some examples of the two words.
2. To tell the reasons that living organisms have to adapt themselves.
- 3.To draw a picture show the parts of plants or animals that have been adapted.

Materials and Instruments

- | | |
|---------------------|---------------|
| 1. Aluminium tray | 2. Razor |
| 3. Magnifying glass | 4. Text books |

The Experimental Process

1. Let the students observe plants or animals in a school pond or at a nearby water source. Each student should be able to explain at least five items of plants or animals they found in the water and could draw a picture and give reasons why those living organisms have to adapt themselves and how. (If necessary the students may bring parts of plants to a laboratory and use a blade to cut out the plants into pieces and use a magnifying glass to observe each part of the plants.)
2. Ask the students to have more study about this topic in the library.

Experimental Report

Lab 4 Adaptation of Organisms in a Fresh Water Ecosystem

Date / Month / Year

Group.....

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

Experimental Objectives

.....

Experimental Results

Type of living organisms	Drawing	Characteristic of adaptation	Reason to make an adaptation

Conclusion

.....

Exercise

1. Why must living things adapt themselves ? (1 mark)

.....
.....

2. What does temporary adaptation mean ? (1 mark)

.....
.....

3. Give the two examples for temporary adaptation(1 mark)

.....
.....

4. What does permanent adaptation mean ? (1 mark)

.....
.....

5. Give the three examples for plants' permanent adaptation (3 marks)

.....
.....

6. Give the three examples for animals ' permanent adaptation (3 marks)

.....
.....

Worksheet for Lesson IV

Adaptation of Organisms in a Fresh Water Ecosystem

Fact : All living things have to adapt themselves to be able to survive in a condition which may change in time. Some plants have been taken to a new place, they will need some time to adapt themselves. There are two ways that living organisms can adapt themselves to the environment

1. Temporary adaptation is usually happens in a short period and can be change into a former condition

Plants	Animals
1. Plants always face to the light. 2. Plants have long stems to be able to get sunshine. 3. If it is in an open space, plant will adapt its shape in to a bush.	1. A lizard tries to adapt its color to look closely to the wall paint. 2. A frog or a toad hide itself from others when there is no food.

2. Permanent adaptation will take more time to happen and some parts of plants or animals may be adapted and changed to new forms from one generation to another. The reason why those living organisms have to adapt themselves is to survive and to safe their races. This process lakes a longer time than the first one.

Plants	animals
1. Water hyacinth has a tube – like stem to float on the water. 2. Water mimosa has a cushion to float on the water. 3. Seaweed has slim – shape leaves to reduce force from water tide. 4. Duckweed - has a very flat body to float on water. 5. Morning glory - has an air bulb to be able to floating on water.	1. A grasshopper adapts its color to look like a plant stem to hide from its enemy. 2. A larva adapts its color to look much like a tree leaves. 3. A green snake adapts its color to cope with its environment. 4. A fish has a slim shape to help swim quickly in water. 5. A frog have fascia claws to help swimming in water and has long legs to help jumping on land.

Laboratory Lesson V

Wise Usage of a Fresh Water Ecosystem

Principle : The increasing number of population has an effect on the increase in consuming of water resources. If people do not think carefully, it might be harmful to water ecosystem such as:

1. Shortage of water
2. A flood
3. Water pollution

To use water from any source, one should be careful and try every way to conserve as well as to develop such source of water to be clean useful to others.

Experimental Objectives

1. To tell at least one problem of water source
2. To tell the cause of such problem.
3. To plan and find a solution of such problem.
4. To analyze the quality of water in a water source.

The Experimental Process

Part 1

1. Ask the students to find an example of problem of a water source in the community.
2. Each group of the students tell the class about the problem they found.
3. The students plan together how to solve such problems:
 - 3.1 Try to quote out what is the real problem.
 - 3.2 Find the cause of such problem.

3.3 Study more information to solve the problem.

3.4 Make a conclusion

3.5 Give a suggestion about the problem which could be done at district level.

4. The students present their study to the class.

Part 2

1. Divide the students into different groups to study a water quality investigating table to see if there is any problem or what is the cause of the problem and record the result.

2. Each group present to the class what they have found or want to suggest and record the result.

Samlee's house is on the bank of a river. Her parents are agriculturists. Samlee went to study in Bangkok for four years. After came back home Samlee found that the river has been changed. There were many boats and manufacturing plants. Samlee brought some water samples from different places in the river to study. She found that:

Water Source	Oxygen (mg/litre)		BOD (mg/litre)		Coliform Bacteria (cell/100ml.)	
	Mean	Standard Value (not 1 Lower than)	Mean	Standard Value (not 1 Lower than)	Mean	Standard Value (not 1 Lower than)
Below	1.0	2.0	3.5	4.0	224,000	-
Middle	2.6	4.0	3.4	2.0	2,137,000	20,000
Upper	5.4	6.0	3.2	1.5	530,000	5,000

Source : Bancha Santhavee, et. al. (1998) Environmental Science.

Bangkok: Watthanapanich

Experimental Report

Lab 5 Wise Usage of Fresh Water Ecosystem

Date / Month / Year

Group.....

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

Experimental Objectives

.....

.....

.....

.....

Experimental Results

Section 1

1. The real problem

2. The cause of such problem

3. Study more information to solve the problem

4. Conclusion

5. Suggestion about problem-solving

Section 2

Samlee's house is on the bank of a river. Her parents are agriculturists.

Samlee went to study in Bangkok for four years. After came back home Samlee found that the river has been changed. There were many boats and manufacturing plants.

Samlee brought some water samples from different places in the river to study. She found that:

Water Source	Oxygen (mg/litre)		BOD (mg/litre)		Coliform Bacteria (cell/100ml.)	
	Mean	Standard Value (not 1 Lower than)	Mean	Standard Value (not 1 Lower than)	Mean	Standard Value (not 1 Lower than)
Below	1.0	2.0	3.5	4.0	224,000	-
Middle	2.6	4.0	3.4	2.0	2,137,000	20,000
Upper	5.4	6.0	3.2	1.5	530,000	5,000

1. What is the difference of the quality of water near Samlee's house and the standard value and what is the cause of such difference?
2. From the table, if there is any effect to the ecosystem and the community on the banks of the river, if there is, how, and how do you think can solve this problem?
3. How do we protect and keep the water clean and in good condition?

Exercises

1. What is the serious problem to water source in general? (1 mark)

2. What kind of resource is water? (1 mark)

3. Explain how you can keep water resource to be free from pollution. (2 marks)

4. What is the principle of how to manage the water source? (1 mark)

5. What is the meaning of water conservation and how to do that? (3 marks)

6. What behavior shows how to develop water source? (2 marks)

Worksheet for Lesson V

Conservation and Development of the Fresh Water Ecosystem

Fact : Among any water sources in the world, fresh water source is the most important one for human beings. In these days there is an increasing need for fresh water whereas the fresh water is limited. When the number of population is increased, the need for water is also increased. Some people do not use water thoughtfully. This leads to shortage of water in several parts of the world. It is worse when quality of water in natural water sources is lower, especially where water ways are in a community or passed through a town. Quality of water may be shown by the following factors:

1. Quantity of Dissolved Oxygen (DO) which is counted by milligram per one liter of water. In general, clean water should have $DO = 5 - 7 \text{ mg/liter}$. Dirty water has less than 3 mgDO/liter . The quantity of DO in water is always changed depending on temperature and organic substances in water. If the temperature is high or if there is a lot of organic substances, DO will be low.

2. Biological Oxygen Demand (BOD) is a quantity of oxygen that microbes use for digestion of organic substances in water. If BOD in water is higher than 100 mg/liter , that means the water is not clean.

3. Coliform Bacteria is a biological measurement for dirty water. If there is a high number of coliform bacteria that means the water is not clean.

At present there are many problems about water supply. They are :

1. Shortage of water supply which is difficult to be solved. Suggestion is that we should try to collect as much water as we could by building a dam or an irrigation.

To try to reduce the use of water is another way to help solve this problem.

2. A flood which is a natural disaster affected by human behavior.

3. Water pollution that resulted from people throwing rubbish and sewage into water sources.

To help solve the problem of water pollution, it might be done by using high technology, recycling the used water from manufacturing or managing a sewage system as following :

1. **Physical water treatment** This is a very simple way by using a net to take out rubbish or leaving water in a well to be precipitated.
2. **Chemical water treatment** The chemical to be use is chlorine to let the water be precipitated and have a moderate value of acid or base. This method is rather costly.
3. **Biological water treatment** This is another basic way to treat the water by using microbes in water to get rid of dirty substances naturally. This method is cheap and give a very good result.

Those are solutions to the end of the problem. To prevent water pollution problem, one should start at the cause of the problems. That is human behavior.

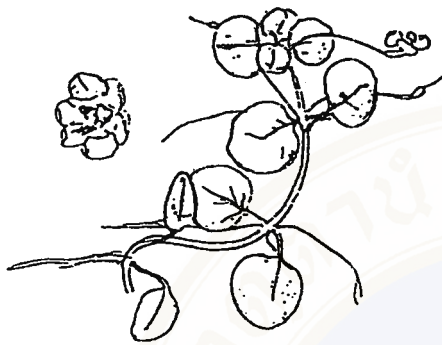
Water is one of natural resources, which can be circulated. To conserve and keep water for supplying people needs, we should realize the prevention activities as well as giving people knowledge about the contamination of water.

The method of conservancy of water should be call for:

1. To keep water clean.
2. To arrange sewage system in households, manufacturing, and hospitals.
3. To manage good methods for getting rid of rubbish in households.
4. To propose water consuming laws to be enacted.

At the same time, water sources should be renovated and keep clean.

Living Organisms in Fresh Water Resource



Hydrocharis morsustranae
(Frogbit)



Chara



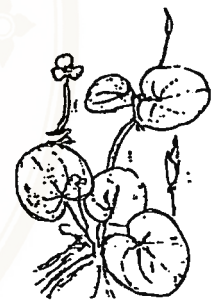
Nitella



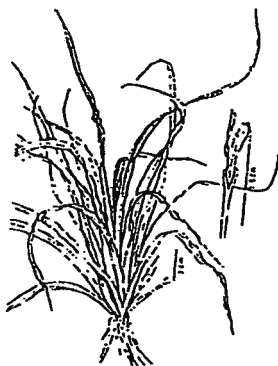
Cyperus pulcherrimus
(elephant cyperus)



Scirpus articulatus
(bulrush)



Sagittalia guayanensis
(arrowhead, swamp-potato)



Blyxa echinosperma



Eleocharis dulcis
(spike-rush)



Cyperus difformis
(Small flower umbrella plant)



Cyperus iria
(umbrella sedge, rice flatsedge)



Ottelia alismoides



Monochoria vaginalis
(monochoria, picherel weed)



Fimbristylis miliacea
(Grass-like-fimbristylis)

Fimbristylis dichotoma
(tall-fringe rusa)



Najas graminea
(busby pond weed)



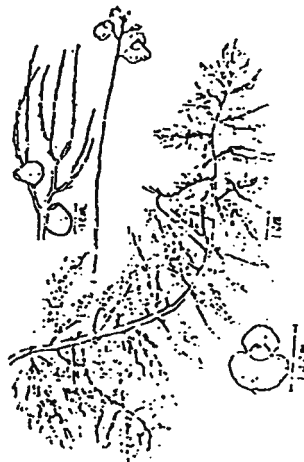
Blyxa japonica



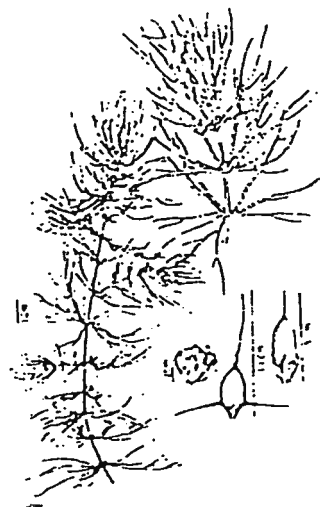
Hydrilla verticillata
(hydrilla)



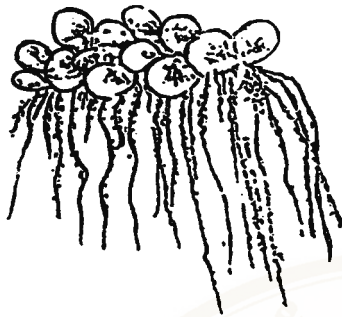
Linnophylla heterophylla



Utricularia aurea
(Common bladderwort)



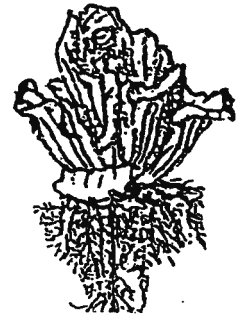
Ceratophyllum demersum
(hornwort)



Salvinia cucullata
(Floating moss)



Jussiaea repens
(creeping waterprimrose)



Pistia stratiotes
(water lettuce)



Amoeba



Paramecium



Euglyna



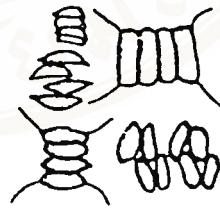
Anabaena



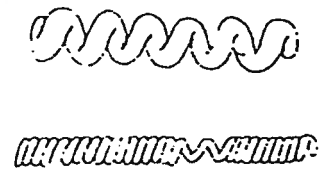
Chroococcus



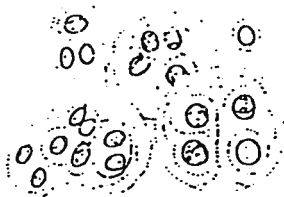
Diatom



Scenedesmus



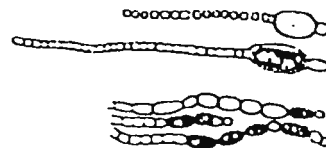
Spirulina



Gloeocapsa



Chlorella



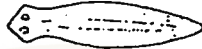
Cylandrospermum



Zylop



Leech



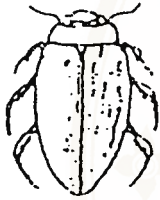
Planaria



Daphnia



Rotifer



Predaceous diving beetle



Larva of predaceous diving beetle



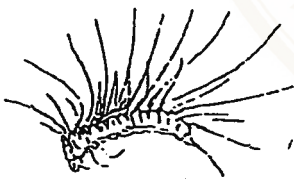
Larva of mayfly



water measures or marsh treader



Creeping water bug



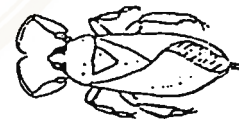
Larva of crawling water beetle



Water boatman



Larva of dragonfly



Giant water bug



Dragonfly



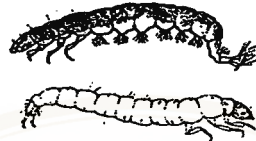
Crawling water beetle



Mayfly



Hydra



Caddisfly



Crane fly



Dixid midges



Black fly



Midges

Flower fly



Spring tails



Antlion



Waterscorpion



Water scavenger beetle



Larva of water scavenger beetle



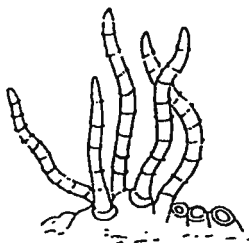
Water strider



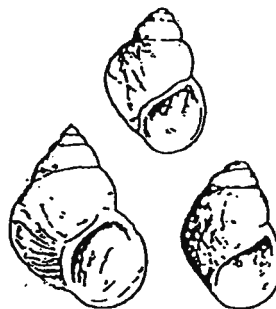
Riffle bug or Broad-shouldered Water striders



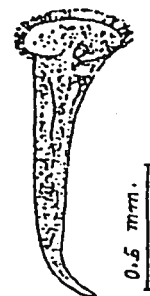
Backswimmer



pipe worm



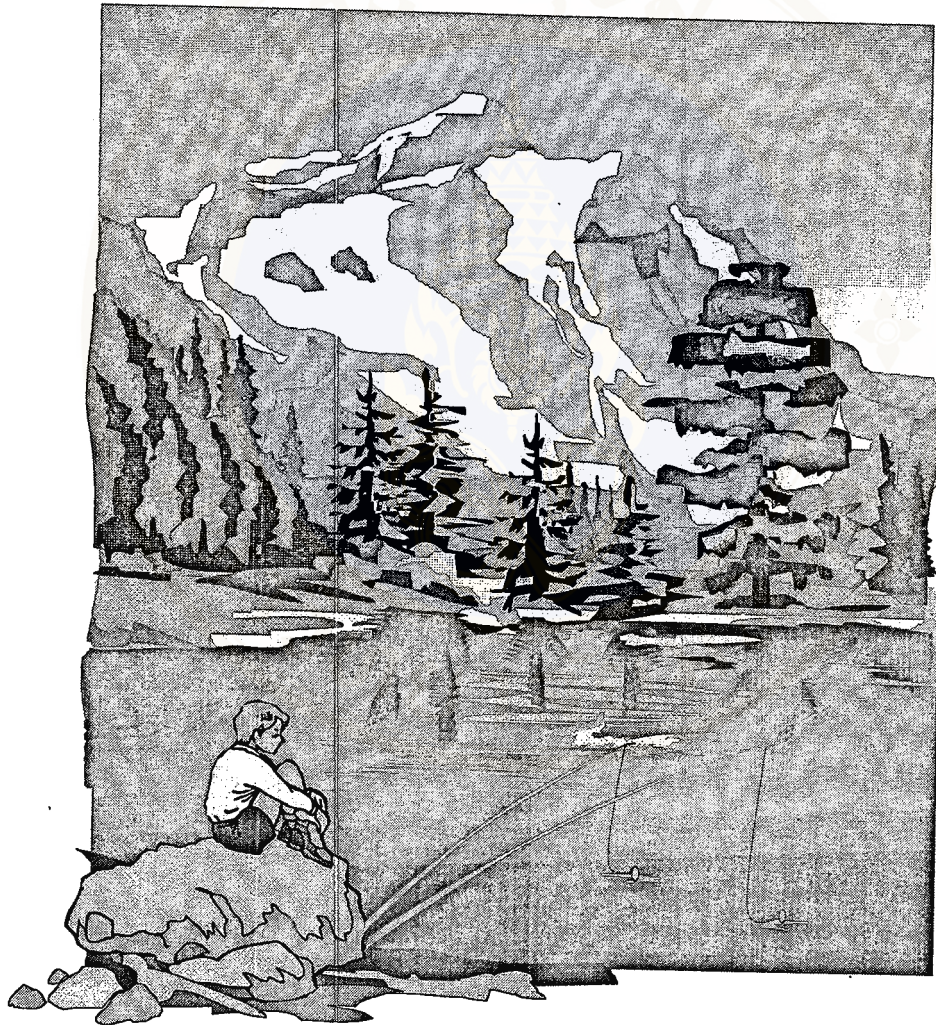
Pond snail or River snail



Stentor

**TEACHER'MANUAL
FOR ENVIRONMENTAL EDUCATION
LABORATORY LESSONS**

FRESH WATER ECOSYSTEM



Nongnart Jindawatt

Copyright by Mahidol University

Concept , general and learning objectives of Laboratory Lessons

Lesson	Content	Concept	General objectives	Learning objectives
1. Let us explore the fresh water ecosystem	The element of fresh water ecosystem	Generally fresh water ecosystem is both physical and biological Components different. The physical components of ecosystem have an influence on survival of living organisms such as tide, temperature, turbidity, gas mineral etc. The biological components of ecosystem can be found in their habitat and live together is a community.	Knowing and understanding of the element of fresh water ecosystem .	<ol style="list-style-type: none"> 1. Give the element of fresh water ecosystem . 2. Explain the meaning of community and habitat of organisms . 3. Explore to get the data of the element of fresh water ecosystem 4. Tell the kind of organisms in general fresh water ecosystem .
2. The role of each of organisms in a fresh water ecosystem	The role of organisms in a fresh water ecosystem	In an ecosystem, there are many living organisms which can be differentiated by their habitats. They might be grouped as follows: Producer, Consumer, and Decomposer.	Knowing and understanding of the role of organisms in fresh water ecosystem.	<ol style="list-style-type: none"> 1. Tell the meaning of producer, consumer , decomposer and give the example of each . 2. Explain the relationship among producer, consumer and decomposer .
3. Interspecific relationships in a fresh water ecosystem	The relationship of organisms in a fresh water ecosystem	The relationship of organisms in fresh water ecosystem might be roughly discussed in two ways: Food chain, Food web and living relationship. Food chain is the nutritive series in which a group of organisms secures food in the same general way or transfer of energy from plants through a series of other organisms. Food web is a very complex pattern of feeding relationship. Living Relationship are classified into both get benefits, one gets and one loses, one gets and one does not get or does not lose.	Knowing and understanding of the relationship of organisms in fresh water ecosystem.	<ol style="list-style-type: none"> 1. Tell the meaning of food chain , food web and draw the diagram of them . 2. Give the relationship of organisms in fresh water ecosystem.

Table 1 (Continued)

Lesson	Content	Concept	General objectives	Learning objectives
4. Adaptation of organisms in a fresh water ecosystem	Adaptation of organisms in a fresh water ecosystem	All living organisms have to adapt themselves to be able to survive in a condition which may change in time. Some plants have been taken to a new place, they will need some time to adapt themselves. There are two ways that living organisms can adapt themselves to the environment; Temporary adaptation and Permanent adaptation.	Knowing and understanding of adaptation of organisms in fresh water ecosystem.	1. Tell the meaning and the cause together with the example in adaptation of organisms in the fresh water ecosystem..
5. Wise Usage of a fresh water ecosystem	Conservation and development of the fresh water ecosystem	Wise used means to use water from any source, one should be careful and try every way to conserve as well as to develop such source of water to be clean useful to others. We should realize the prevention activities as well as giving knowledge about the contamination of water. At the same time, water sources should be renovated and keep clean.	Aware of the problems and suggest the way to conserve fresh water ecosystem.	<ol style="list-style-type: none"> 1. Explain the meaning of conservation and development . 2. Tell the necessary to conserve and develop the fresh water ecosystem. 3. Analyze the quality of water. 4. Analyze the problems of fresh water pollution and its effect to people . Find out the solution to that problems.

Teacher' s Manual for Laboratory Lesson I

The element of fresh water ecosystem

In this lesson, the students study about physical components of fresh water ecology. Those are color, smell, clear, clean, turbid, pH value and temperature of the water. The students also study the biological components of water sources which can be easily observed.

Learning Objectives

1. To give the element of fresh water ecosystem .
2. To explain the meaning of community and habitat of organisms .
3. To explore to get the data of the element of fresh water ecosystem.
4. To tell the kind of lives in general fresh water resource .

Lab I Let us explore the Fresh Water Ecosystem

Experimental Objectives

1. To draw a map or chart showing the water source, what have been discovered and record the result
2. To explain the environment around the water source.
3. To tell the characteristic of the water source such as its color, smell, how clear or how polluted it is.
4. To measure the illumination capacity of sunlight in the water.
5. To tell the temperature of the water at surface level and at 20 cm. depth.
6. To tell the pH value of the water at surface level and at 20 cm. depth.
7. To tell kinds of visible organisms in fresh water reservoir.

Time	Pre-Lab Discussion	15	minutes
	Experiment Period	85	minutes
	Post-Lab Discussion	40	minutes
	Total	140	minutes

Materials and Instruments

List	Number / group
1. Sechi-disc	1
2. Water-sample Bottle	1
3. Universal indicator paper	1
4. Thermometer 0-100 c	1
5. Sterring-rod	1

Preparation Period

1. The students should be asked to study the laboratory lessons before starting the activities.
2. The teacher tell the established work sites which should consist of every component that students need to study. Safety regulations of students must be mentioned.
3. Each student should be assigned to prepare tools and material for the study.

Pre-Lab Discussion

1. The teacher tells the student to prepare themselves to work as a team. Each student should be clear about their roles in this study.
2. The teacher suggests how to use tools and equipment for the experiment such as a sechi-disc, a net, bottle for sample articles etc. The students are well informed what, where, when, why, and how to observe things and make a record. Suggestion for keep some water sample to test the temperature and the pH value is to put a bottle into the water at a set level and bring the bottle up to test by a thermometer and a universal

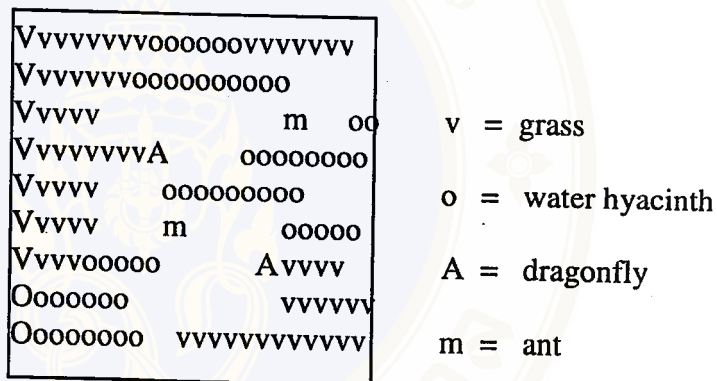
indicator paper.

3. The students are well informed about any hazard or venomous animals such as bees, caterpillars, scorpion, and snakes to be aware of.

4. Any student who is not good at drawing may use symbols for animals or what have been found.

Experimental Results is up to the environment of the work site.

For Example : A map or chart showing water source



Post-Lab Discussion

1. The teacher discusses with the students, using information from the experiment and try to make a conclusion about:

A. The Physical Condition of the Water Source which may be different in two ways:

- a clean water source
- a dirty water source with many suspension, rubbish, high temperature, pH value is lower than 7, where light cannot easily pass through.

B. There are many living organisms found in the water source, such as

- Plants at surface level: duckweed, water lettuce, water mimosa, and morning glory.

- Plants under water: various types of seaweed.
- Plants which some parts are under water, some are above water level: lotus
- Plants on the banks of the river, water source: water hyacinth, reed.
- Animals and other living organisms: grasshoppers, dragonflies, butterflies, water striders, water scorpions, water bugs, backswimmers, mayflies, water beetles, water boatman, amoeba, water mites, shellfishes, frogs, toads, and catfishes.

Living organisms that live together in the same area called a *Community* and their living places called a *Habitat*.

After finish discussion, students have to answer questions at the end of the experiment.

Suggestions See what kind of water source did the students found.

Answer to the Exercises

1. and 2. Try to find causes of the problem and the reasons either it is a dirty water source or a clean one.
3. All clean water sources will have no color, no smell, no suspension, or rubbish, and light can be easily illuminated through the water, temperature is around 25 – 30 C
4. Equipment to be used for testing the quantity of light to pass through the water is sechi-disc, equipment to test the temperature is a thermometer, and equipment to see the pH value is universal indicator paper.
5. Living things that live together called a *Community*.
6. The teacher should examine the result from what the students have found.

Teacher's Manual for Laboratory Lesson II

The role of organisms in fresh water ecosystem

In this topic the students will study number and characteristics of each living organism that can be easily found in any water source included its roles in the community.

Learning Objectives

1. To tell the meaning of Producer, Consumer, Decomposer and give the example of each.
2. To explain the relationship among Producer, Consumer and Decomposer.

Lab II The role of organisms in Fresh Water Ecosystem

Experimental Objectives

1. To tell types of living organisms in water or at 20 cm. depth.
2. To tell types of plankton found and be able to tell the method of the study.
3. To know what are the food of those living organisms.
4. To classify type of each living organism by its food.
5. To know the roles of organisms in fresh water ecosystem

Time	Pre-Lab Discussion	15	minutes
	Experiment Period	85	minutes
	Post-Lab Discussion	40	minutes
	Total	140	minutes

Materials and Instruments

List	Number / group
1. Magnifying glass	1
2. Water-sample Bottle	1
3. Simple net	1
4. Plankton net	1
5. Aluminium tray	1
6. Plastic Box	1
7. Slide and Cover glass	1
8. Dropper	1
9. Microscope	1

Preparation Period

1. The students should be asked to study the laboratory lessons before starting the activities.
2. The work sites should be the same place as did in lesson one.
3. Each student should be assigned to prepare tools and material for the study.

Pre -Lab Discussion

1. The teacher tell the students what type, which characteristics, and what number of living organisms to be observed either by eyes only or by using a magnifying glass.
2. The students have to record what they have found at the water source, if the number is more than 10 = many, if less than 10 it is = a few.

If the students do not know the thing they found, draw or sketch a picture of that thing and record some of its important information. They may ask other who may know or read more information from a book. The teacher may ask the students to collect some small living organisms in a bottle and bring back to the class. Other equipment to be used is a microscope.

Experimental Results

Section 1 Results of an experiment is up to the environment of the work site

Section 2 Record the food of those living organisms.

Type of animal	Food	The source of food		
		Plants	Animals	Dead plants and animals
Frog	Insects		/	
Grasshopper	Leaves, grass	/		
Butterfly	Nectar on the stigma of flowers	/		
Worm	Leaves, vegetables	/		
Apple snail	Detritus			/
Gouramy	Grass, moss	/	/	
Pilot fish	Phytoplankton, Zooplankton, moss, grass		/	/
Cap	Larva of aquatic animals, detritus	/		/
Field crab	Rice, detritus	/	/	
Half beak	Grass, moss		/	
Duck	Duck weed, prawn, shell, crab, fish		/	
Crane	Prawn, shell, crab, fish			

Post-Lab Discussion

The teacher discusses with the students, using information from the experiment and try to make a conclusion about type, number, characteristics and living habits of the living organisms:

1. Living organisms in clean water are such as wood louses, water bugs, reeds, red weeds, morning glory, and water hyacinth.
2. Living organisms on surface of the water are such as fishes and seaweed.
3. Living organisms at 20 cm. depth are fishes, prawns, lotus, and weeds.
4. Plankton in water are such as water mite, *Euglena*, *Paramecium*, *Rotifer*.

The teacher tell what are the eating habit of the said animals and plants .

The one who get other's life is called *a Predator* and the one who lose its life to other is called *a Prey*.

The organism who eats the producer is *the first consumer*.

The one who eats the first consumer is *the second consumer (carnivores)*.

The consumer who takes both plants and animals for food is *the first, the second, or the third consumers*.

The consumer who takes only dead things for food is called *the last consumer*.

Living organisms who are the most important producer to the world are **PLANTS**.

After the students understand the roles and relationship between living organisms in the community, the teacher asked questions at the end of an experiment.

Answer to the Exercises

No. 1 – 4 see information from the experiment.

No. 5 the decomposer is bacteria , fungi, microorganisms.

No.6 The bad point if there is no decomposer is that there will be a big pile of rubbish and dead body. The environment will be in worse condition.

No.7 The relationship of living organisms in water sources are the producer can produce their own food, consumer cannot produce their own food. When the producer and consumer are dead , decomposer will give a balance to the world by digestion process. What has been digested will be back to the nature and come back to mankind in a form of mineral.

Teacher's Manual for Laboratory Lesson III

The relationship of organisms in fresh water ecosystem

In this topic, the students will have four activities to finish. They are : drawing food chain and food web, combining the food web, who is predator, and making a pair of relationships.

Learning Objectives

1. To tell the meaning of food chain, food web and draw the diagram of them.
2. To give the relationship of organisms in fresh water resource.

Lab III Interspecific Relationship in Fresh Water Ecosystem

Experimental Objectives

1. To explain the meaning of food chain, food web, predator, and prey.
2. To draw a diagram of food chain, food web, and fresh water ecosystem.
3. To explain the relationship between organisms in fresh water ecosystem.

Time	Pre-Lab Discussion	20	minutes
	Experiment Period	80	minutes
	Post-Lab Discussion	40	minutes
	Total	140	minutes

Materials and Instruments

Activities	Lists	Notes
1	The data from Lab II , work sheet	
2	String 1 roll or 1 ball of knitting wool, Word cards telling different components of fresh water resource i.e. sun , algae, phytoplankton, zooplankton, larva of insects, frog ,bird, fish, duck weed , snail , etc.	More names are suggested.
3	A chart showing an activity between a predator and a prey.	Other charts showing the relationship between living things are also encouraged.
4	Word cards telling a pair of the relationships such as a frog - a lotus leaf, an insect - a frog , a lotus - a bee, a snail - water hyacinth , a dragon fly -reed , a snail-a lotus, a butterfly-a waterhyacinth flower , a water leech – a fish , red duck weed - blue green algae , morning glory - water lettuce etc.	There should be three types of relationship <ul style="list-style-type: none"> - both get benefits - one gets one loses - one gets, the other neither get nor lose

Preparation Period

1. The students should study the laboratory lessons before starting the activities.
2. Work site might be a school ground, school back yard, a basket – ball ground, or a school botany garden.
3. There should be a preparation for all equipment and material needs.

Pre – Lab Discussion

The teacher tell the students to do the activity thoughtfully.

Try to understand what they have found and give reasons for every event.

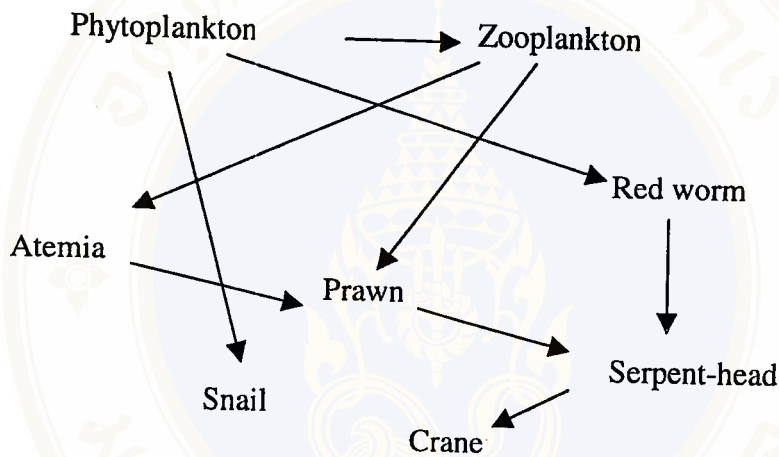
Experiment Results

The First Activity

Food chain in fresh water ecosystem , for example ;

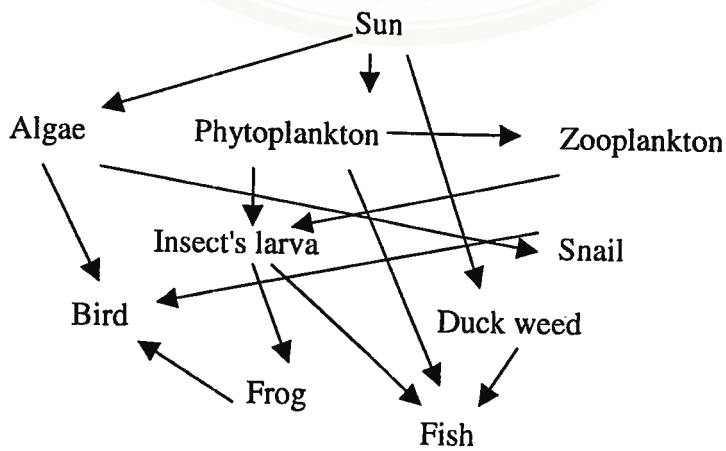
1. Phytoplankton → Zooplankton → Atemia → prawn → Serpent-head
2. Phytoplankton → Red worm → Serpent-head → Crane
3. Phytoplankton → Snail

Food web in fresh water ecosystem from Food chain 1, 2, 3



The Second Activity

Food web in fresh water ecosystem



The Third Activity " Predator "

When the number of caps increases, the baby fish are less.

When there are less baby fish, caps number becomes decrease because of shortage of food

When the number of caps is less, baby fish increase.

The Fourth Activity A pair of relationships

Both get benefits (+ , +)	One gets, one loses (+ , -)	One get, the other neither get nor lose (+ , 0)
Red duck weed - blue green algae A lotus flower - a bee A butterfly – a water hyacinth flower	Morning glory - water lettuce A snail - a worm A frog – an insect A water leech – a fish a cap – a baby fish	A frog – a lotus leaf A snail - water hyacinth A snail – a lotus A dragon fly – a reed plant

Post-Lab Discussion**The First Activity**

Teacher and students make a discussion Using information from the result of Laboratory Lesson Two. The students should be able to draw a strength line of food chain and a food web of living creatures in the fresh water source as following:
phytoplankton → zooplankton → water mite → small fish → big fish → human being
(The head of an arrow always goes to a consumer.)

Several food chains can make a food web, just like a spider web.

The Second Activity

As in the first activity, the food relationship of living organisms in a fresh water ecosystem will start firstly from the sun that transfer energy to living organisms to produce food. The transferring of energy will go on and on from one to another. If it is in the same line, that is called a food chain.

The Third Activity

From the first and second activities, it is possible to classify who are predators and who are preys. The activity may start with catfishes and a baby fishes. Some living organisms can be both a predator and a prey.

The Fourth Activity

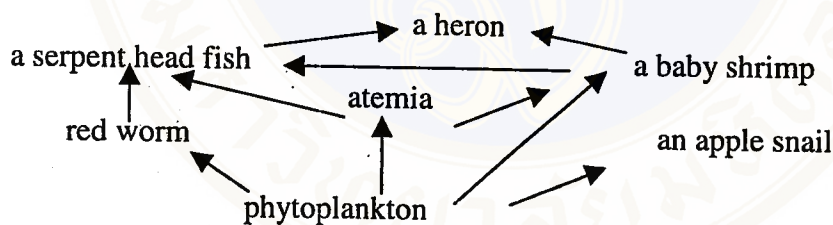
The teacher and students try to make a conclusion of the different types of relationship between living organisms in fresh water ecosystem and finish the questions at the end of the experiment.

Answer to the Exercises

1.

Phytoplankton → atemia → prawn → crane

2.



3.

- | | |
|---|---|
| 1. Both get benefits (+, +) | <u>3</u> a cap – a baby fish |
| 2. One gets, one loses (+, 0) | <u>3</u> a morning glory – a water hyacinth |
| 3. One get, the other neither get nor lose (+, -) | <u>3</u> a water leech – a fish |
| | <u>3</u> a Snail – a worm |
| | <u>2</u> a frog - a lotus leaf |
| | <u>2</u> a dragon fly's larva – an aquatic herb |
| | <u>1</u> water fern - blue green algae |
| | <u>1</u> a bee – a lotus flower |
| | <u>2</u> millipede- water lettuce |

Teacher's Manual for Laboratory Lesson IV

Adaptation of organisms in a fresh water ecosystem

This topic is about how livery creatures adapt and adjust themselves to be able to survive in a fresh water ecosystem.

Learning Objectives

Tell the meaning and the cause together with the example in adaptation of lives in the fresh water resource.

Lab IV Adaptation of organisms in a fresh water ecosystem

Experimental Objectives

Experimental Objectives

- 1.To explain the meaning of the words : temporary adaptation and permanent adaptation and give some examples of the two words.
- 2.To tell the reasons that living things have to adapt themselves.
- 3.To draw a picture show the parts of plants or animals that have been adapted.

Time	Pre-Lab Discussion	15	minutes
	Experiment Period	85	minutes
	Post-Lab Discussion	40	minutes
	Total	140	minutes

Chemical substances and Instruments

List	Number / group
1. Magnifying glass	1
2. Razor	1
3. Aluminium tray	1
4. Text books	1







Preparation Period

1. The students should be asked to study the laboratory lessons before starting the activities.
2. The Work site might be a fish bowl.
3. Borrow books about aquatic animals and ecosystem from a library to study.
4. Prepare enough material for an experiment.


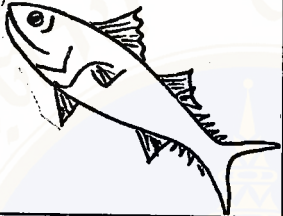



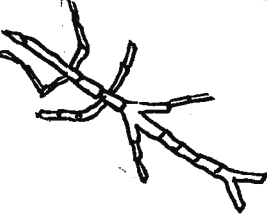
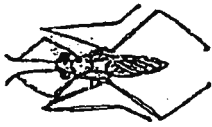
Pre-Lab Discussion

The teacher tell the student how to observe living organisms in a fresh water source and record what they think is interesting. Some may draw pictures of what they have found.

Experimental Results

Type of living organisms	Drawing and label	Characteristics of adaptation	Reason to make adaptation
Water cress and water mimosa		Has cushion to cover its stem.	To be able to float on water
Algae or seaweed		With slim leaves	To help forcing to water tide
Duck weed		Has a very flat body	To float on water
Water lettuce , water hyacinth		Has an air bulb	To be able to float on water

Experimental Results (Continued)

Type of living organisms	Drawing and label	Characteristics of adaptation	Reason to make adaptation
Morning glory		Has a tube – like stem	To help floating on water
A fish		With a slim shape	To help swim quickly in water
A frog		Have fascia claws and has long legs	To help swimming in water and to help jumping on land.
A prawn or a shrimp		Has two types of legs: swimming legs and walking legs	to help survive in water and at the bottom of the water source
A duck		<ul style="list-style-type: none"> - Has fascia legs - Mouth has big tip and flat 	<ul style="list-style-type: none"> - To swim in water - Eating small fish and plants in water
An insect		Adapt its color to look as much like plants or stems a tree	to hide from its predators.
A water strider		Small body and long legs	To help movement quickly on the surface of water or leaves

Post – Lab Discussion

Teacher and students try to make a conclusion and living creatures in the fresh water source have to adapt and adjust themselves as follows :

There are two types of adaptation

1. Temporary adaptation happens in a short period and once there is a change it is possible to change back to the former situation.

Plants	animals
1. Plants always face to the light. 2. Plants have long stems to be able to get sunshine. 3. If it is in an open space, plant will adapt its shape in to a bush.	1. A lizard tries to adapt its color to look closely to the wall paint. 2. A frog or a toad hide itself from others when there is no food.

2. Permanent adaptation means to change a structure or shape from one generation to another. This process takes a longer time than the first one.

Plants	animals
1. Water hyacinth has a tube – like stem to float on the water. 2. Water mimosa has a cushion to float on the water. 3. Seaweed has slim – shape leaves to reduce force from water tide.	1. A grasshopper adapts its color to look like a plant stem to hide from its enemy. 2. An insect’s larva adapts its color to look much like a tree leaves. 3. A green snake adapts its color to cope with its environment. 4. A water strider has small body and long legs to help movement quickly on the surface of water or leaves

Answers to the Questions

1. Living things must adapt themselves to be able to survive in the environment.

2. Temporary adaptation is a change in a short period and once there is a change it is possible to change back to the former situation.

3. Examples for temporary adaptation are such as plants always face to the

light, plants have long stems to be able to get sunshine, a lizard tries to adapt its color to look closely to the wall paint, a frog or a toad hide itself from others when there is no food.

4. Permanent adaptation is a change in a structure or shape of things and may happen from one generation to another. This process takes a longer time than the temporary one.

5. Examples for permanent adaptation of plants are such as

5.1 Water hyacinth has a tube – like stem to float on the water.

5.2 Water mimosa has a cushion to float on the water.

5.3 Seaweed has slim – shape leaves to reduce force from water tide.

6. Examples for permanent adaptation of animals are such as

6.1 A grasshopper adapts its color to look like a plant stem to hide from its enemy.

6.2 An insect's larva adapts its color to look much like a tree leaves.

6.3 A green snake adapts its color to cope with its environment.

Teacher's Manual for Laboratory Lesson V

Conservation and Development of the fresh water ecosystem

In this topic, the students will study some information and ideas about how to conserve and develop water source to be useful and be a supplying resource for all mankind.

Learning Objectives

1. To explain the meaning of conservation and development.
2. To tell the necessary to conserve and develop the fresh water resource.
3. To analyze the quality of water
4. To analyze the problems of fresh water pollution and its effect to people

and to find out the solution to those problem

Lab V Wise Usage of a Fresh Water Ecosystem

Experimental Objectives

1. To tell at least one problem of water source
2. To tell the cause of such problem.
3. To plan and find a solution of such problem.
4. To analyze the quality of water in a water source.

Time	Pre-Lab Discussion	15	minutes
	Experiment Period	85	minutes
	Post-Lab Discussion	40	minutes
	Total	140	minutes

Preparation Period

The students should study the laboratory lessons before starting the activities.

Pre-Lab Discussion

Each group of student find examples of problem of a water source in the community, discuss the cause of the problem they found, study the area of the problems and plan together how to solve such problems:

Result of the Activity

Section 1 :The students use a transparency to present the result of the study.

For Example

1. Problems

There are rubbish in a pool at the east of the school. The rubbish becomes stagnant and causes a bad smell when it rains

2. The causes of the problems

There might be some manufacturing around the school that let their waste water and sewage into the water source such as

2.1 Waste water and sewage from community.

2.2 Waste water and sewage from industry.

2.3 Waste water and sewage from agriculture.

3. Study more information to solve the problems

Students observe the site and get more information that

3.1 There is a community and shops standing around the pool.

A lot of rubbish and used water go into that pool.

3.2 There are also manufacturing nearby that let off their sewage which have both organic and non-organic substances into water source.

3.3 Moreover, rubbish from agriculture and cattle's dung are also left in the water source.

4. Conclusions

Water in the pool is dirty and decay from community's rubbish which has an effect to the water source:

- There are a lot of water hyacinth that grow well in decay water which has some quantity of detergent solution.
- There are a lot of organic substances that microbes have to digest caused a lack of oxygen in water.
- Hot water from the manufacturing is not good for living things in water as well as caused a lack of oxygen.

4. Suggestion about the problems – solving

How to solve the problems.

5.1 Ask for community participation in keeping the water clean.

5.2 Strengthening the community activities in preventing water from unclean situation, such as to get rid of water hyacinth and renovate the water source.

5.3 Ask for a cooperation from manufacturing in managing their sewage system.

5.4 Give education to the community about how to recycle the rubbish, how to make use of cattle's dung for plant fertilizer, and to grow revolving plants.

Post- Lab Discussion

The group representatives give a presentation to the class using a transparency.

Each group discusses the result of other groups.

Making a conclusion of the causes of the problems and how to solve them.

To study the Work Sheet for Lesson V

Section 2 : Analyzing of Result from the table

1. Quality of water nearby Samlee's house is different from water in the river. The amount of DO is lower than the standard value. This may be caused by many organic and non-organic substances from manufacturing that consume quite an amount of oxygen for their digestion process. The BOD value as well as quantity of bacteria are over than standard values. That means the water is not good for people to consume.

2. The bad quality of water leads to negative effects of the ecosystem.

Suggestions for Problem Solving

1. By physical water treatment. This is a very simple way by using a net to take out rubbish or leaving water in a well to be precipitated.

2. By chemical water treatment. The chemical to be used is chlorine to let the water be precipitated and have a moderate value of acid or base. This method is rather costly.

3. By biological water treatment. This is another basic way to treat the water by using microbes in water to get rid of dirty substances naturally. This method is cheap and gives a very good result.

3. To prevent water pollution problem, a good strategy has to be in action. Sewage system should be applied to every manufacturing and there should be a regular test for water quality.

Answers to the Exercises

1. The serious problem to water source in general is human bad behavior and bad habits are main causes of water pollution from both agricultural and manufacturing waste.
2. Water is one of the circulating resources.
How to manage water resources one should:
 - 2.1 Prevent and control water pollution from both agricultural and manufacturing waste.
 - 2.2 Give knowledge about how to treat water or how to make it clean to the public.
 - 2.3 Purpose water-consuming laws to be enacted.
3. The principle of how to manage the water source is conservation and keep water.
4. The meaning of water conservation is to use water economically and prevent from pollution, one should:
 - 4.1 arrange sewage system in households, manufacturing, and hospitals
 - 4.2 manage good methods for getting rid of rubbish in householdspropose water consuming laws to be enacted.
5. Behavior shows how to develop water sources should be regularly renovated, keep clean, and prevent from pollution. That will help conserve our natural resources for all mankind. Give education to the community about how to develop water sources. Persuade or ask for community participation in keeping the water clean and make yourself an exemplariness.

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THE LEARNING ACHIEVEMENT TESTS

FRESH WATER ECOSYSTEM

Class Mathayomsuksa 1 50 items 50 marks 50 minutes

- Directions :**
1. This achievement tests is categorized into 2 main parts .
 2. Choose the best answer . Please mark X on answer sheet .
-

Part I : Number 1 to 30

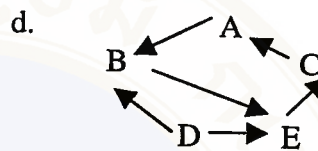
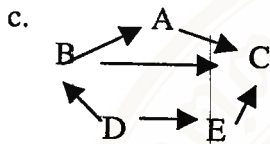
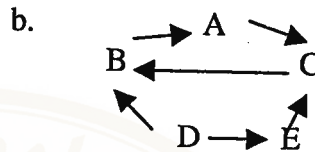
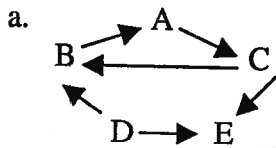
1. Which one is community ?
 - a. Fifty warblers in the cage.
 - b. Cranes eat fish in the rice field.
 - c. Thirty - five chipmunks on the roof.
 - d. A lot of cockroaches in the pond.
2. Which one is the correct definition of ecosystem ?
 - a. The adaptation in many ways of community.
 - b. The natural condition of community.
 - c. The relationship between community in every way.
 - d. The area where community lives.
3. From surveying a pond , in the morning we found many aquatic animals on the surface. At midday they are less. The difference probably come from ?
 - a. temperature
 - b. light
 - c. humidity
 - d. pressure
4. Which one shows the best relationship between organisms and habitat ?
 - a. Mole cricket has two big forelegs for digging.
 - b. Butterflies live in the deep forest and there's a lot of water all year.

- c. Flies help pollination and nectar sucking.
- d. Some grasshoppers look like brances.
5. The factor of ecosystem consists of organisms and inorganisms, which one shows the factors of ecosystem ?
- a. producer , decomposer , habitat
- b. producer , consumer , habitat
- c. producer , consumer , decomposer
- d. habitat , producer , consumer , decomposer
6. From the following list. Which one is the cause that makes the community in the water resources change ?
1. the community which lives in the same area
2. the intensity of light and heat
3. the quality of water
4. pH
- a. 1 and 3
- b. 2 , 3 and 4
- c. 1 , 3 and 4
- d. 1 , 2 , 3 and 4
7. Which one is the producer in the fresh water resource?
- a. reed , water bug , duck weed
- b. lotus , algae , water lettuce
- c. shell , worm , morning glory
- d. water hyacinth , lady bird , dragon fly
8. Which one is the important thing in photosynthesis of producer?
- a. water , light , chlorophyll , carbondioxide
- b. light , water , temperature , oxygen

From the following list, answer the question number 19 to 20

A = snake , B = rat , C = owl , D = rice , E = rabbit

19. Which one shows the food web correctly ?



20. From number 19 which level of consumer is C ?

- a. the first and the second
 - b. the second and the third
 - c. only the second
 - d. the first , the second and the third
21. What is the reasons for adaptation of the living organism in the environment ?
- a. To beauty according to the environment
 - b. To be different from the natural
 - c. To growing
 - d. For survival
22. Why do fish have strong and dark color at the back ?
- a. To find food easily
 - b. Difficult for the enemies to see
 - c. To move easily
 - d. Protect it from the light
23. Why do plants have bigger leaves in the water than on the land ?
- a. Leaves of plants in the water can absorb a lot of water.
 - b. Water pressure is more than air pressure.

- c. To adapt to the environment.
- d. For the habitat of aquatic animals.
24. Why do some plants in the water have something like spongy around their trunk in order to adapt themselves ?
- a. To reduce the resistance of current b. For floating
- c. To protect them from enemies d. For attracting the insects
25. What is the fresh green of leaf - grasshopper for ?
- a. eating food b. mating
- c. feeding embryo d. escaping from enemies
26. Which one is adaptation of living thing ?
- a. Europeans have blue eyes.
- b. The trunk of morning glory is hollow.
- c. Seals mate at night.
- d. Worms like to live in dirty food.
27. Which plants like to grow in the water ?
- a. Trunk is long and hollow , stoma are under leaves.
- b. Thick bark with a lot of branches.
- c. There is air in the internode and stoma are upper leaves.
- d. There are torns around the trunk which is hard wood against the current.
28. Which one shows unadaptation in the environment ?
- a. Falling of leaves in summer
- b. Hibernation is in winter and summer.
- c. Fresh water fish cannot live in the salt water.
- d. Morning glory grows both on the land and in the water.

29. Which one is not the cause of water's problem ?
- Increasing of population is rapidly.
 - Development of country to NIC
 - New technology in agriculture development.
 - Use the foreign water polluted treatment
30. What is the affected first when waste water with much organic substances is thrown to the water resource ?
- Decreasing of oxygen
 - Less population of aquatic animals
 - Better circulation of water
 - Some aquatic plants will grow rapidly.

PART II : Number 31 to 50

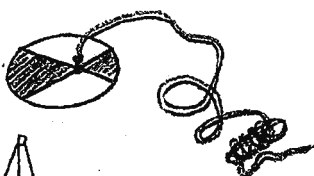
31. When the teacher let the students have the lab test, what should the students orderly do ?
- Count to know that there are enough equipments → plan for the lab test → arrange the area on the table → start the lab test
 - Count to know that there are enough equipments → immediately start the lab test → arrange the area on the table → wash the equipments
 - Count to know that there are enough equipments → wash the equipments → pick up all the equipments and put them on the table → immediately start the lab test
 - Pick up the equipments and put all of the chemical substances on the table → immediately start the lab test → count to know that there are enough equipments → wash the equipments

32. In the lab testing , what should we do in spending time ?
- Try to be the first.
 - Do it carefully and finish it in the limited time.
 - Do it carefully although cannot finish in the limited time.
 - Do it carefully and finish it at the same time as the other.
33. In the lab testing , which one is the least important ?
- Choose the right size of the equipments , put it firmly , not fall to the ground.
 - Keep the area clean , keep the unused things tidy.
 - Ask one of your friends to be the person who pick up chemical substances or equipments every time you do the test.
 - When you finish , wash the equipments, keep them tidy.
34. In noticing the test or anything else , what would you do , if you want the notice to be exacting ?
- continue in noticing.
 - Now and then in noticing.
 - Testing and notice it several times.
 - Notice it by using nerve in touch as much as you can.
35. From the exacting noticing , what is the first step it will bring you to ?
- Problem
 - Hypotheses
 - Fact
 - Conclusion and Application
36. In specification the scientific problem , what should be the main to hold ?
- Hypotheses
 - Fact
 - Idea
 - Study

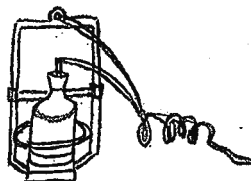
37. What is the best way to collect the data ?
- Ask to see the data from the other group.
 - Try to express your idea in the data.
 - Collect the desired data.
 - Collect the data from the testing.
38. What are the good conclusions like ?
- Try to conclude it the same as your friends.
 - Need the knowledge and former experience to conclude.
 - Need your friends' idea to conclude
 - Need a lot of data from the testing.
39. In the case that one group of students had done the experiment and had got the difference data from the other group. What should he do ?
- Correct the data to be similar to his friends.
 - Change the whole equipments.
 - Change the method of experiments.
 - Re-experiment many times to get the correct solution.
40. If the students wants to measure the transperence of the light through the water.

Which equipment should he use ?

a.



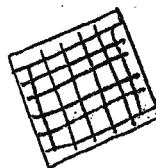
b.



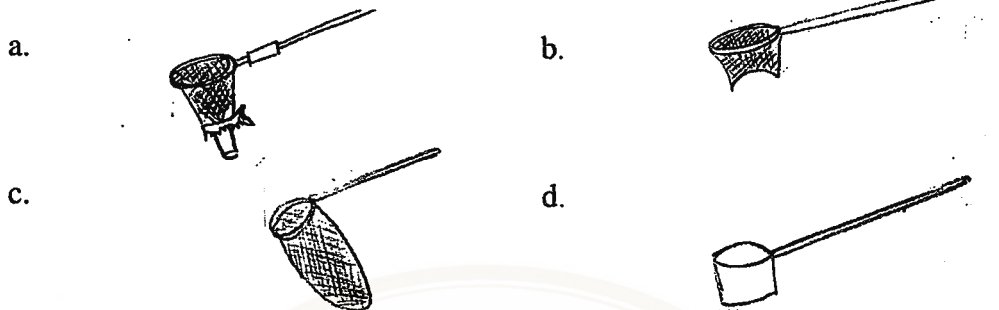
c.



d.



41. Which equipment use to keep plankton sampling ?



42. Which equipment should we use to check the unseen plankton?

1. Magnifying glass 2. Microscope 3. Slide 4. Dropper 5. Cover glass

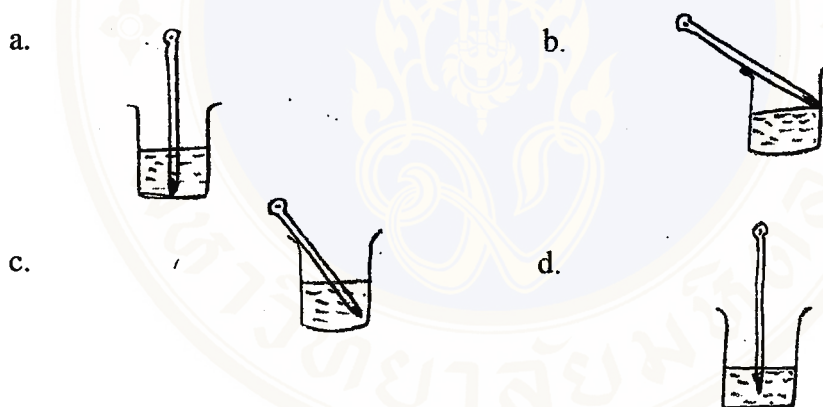
a. 1, 3, 4

b. 2, 3, 5

c. 1, 3, 5

d. 3, 4, 5

43. Which one shows the correct of using thermometer?



44. Which one shows the incorrect of using the thermometer?

a. The measurement of the thermometer of any substances should let the bulb of the thermometer touch that thing.

b. When reading temperature, you should read it at eye level.

c. If you want to use the thermometer to measure the temperature of substances which very different from each other, you should leave it for a while.

d. The thermometer which is used to measure the temperature of any substances should be sure that the level of liquid inside does not change when you read it.

45. What should we do when using the litmus paper test liquid in the test tube?
- Use forceps to hold the litmus paper dip in liquid.
 - Drop the litmus paper into the test tube.
 - Incline the test tube and bring the litmus paper to touch at the edge of the test tube.
 - Use stirring-rod dip into liquid in the test tube then bring it to touch the litmus paper which put on the glass.
46. In testing that the liquid in the test tube is acid or base. What should we do ?
- Bring the universal indicator paper to put on the edge of the test tube → use the clean stirring-rod to touch that paper → demote it into the test tube and touch the liquid → observe and note
 - Bring the universal indicator paper to put on the crucible → use the clean stirring-rod dip into the liquid → touch that paper → observe and note
 - Bring the universal indicator paper to put on the edge of the test tube → incline the test tube until the liquid flow to that paper → observe and note
 - Incline the test tube until the liquid flow to its edge → bring the universal indicator paper to touch the liquid → observe and note
47. In measuring the temperature and the pH of water , we should do the experiment many times in order to fine what reason ?
- To fine the certainly of the data
 - To fine the deficiency of the experiment
 - To get the experience of the experiment
 - To add the experience in the experiment

48. Which one is incorrect according to the method of using the microscope?
- Arrange the Body Tube to defend the objects ' flowing
 - Turn the lowest power objective lens to straighten the Body Tube
 - Use the highest power objective lens to fine the image
 - Open two eyes while look through the microscope, not close one's eye
49. When the eyes are looking at the image in the microscope, what is the forbidden thing you should not do ?
- Use the clip of slide
 - Adapt the mirror under the stage to get the most light
 - Incline the microscope while you look at the slide of the cell
 - Turn the coarse adjustment to adjust the clearness of image
50. Which one is incorrect in using the dropper ?
- When you have already sucked the liquid, you should not turn the dropper up.
 - Slowly squeeze the dropper in order to let the liquid dip one by one
 - When dipping the liquid, you should in cline the dropper to touch the edge of the container so the liquid will not splash.
 - The cleaning of the dropper, you should take off the stopper every times.

Key of the Achievement Tests

Part I : Number 1-30

- | | | | |
|-----|---|-----|---|
| 1. | b | 2. | c |
| 3. | a | 4. | b |
| 5. | d | 6. | d |
| 7. | b | 8. | a |
| 9. | b | 10. | c |
| 11. | a | 12. | c |
| 13. | d | 14. | c |
| 15. | a | 16. | d |
| 17. | b | 18. | a |
| 19. | c | 20. | b |
| 21. | d | 22. | b |
| 23. | c | 24. | b |
| 25. | d | 26. | b |
| 27. | c | 28. | c |
| 29. | d | 30. | a |

Part II : Number 31-50

- | | | | |
|-----|---|-----|---|
| 31. | a | 32. | b |
| 33. | c | 34. | d |
| 35. | a | 36. | b |
| 37. | c | 38. | d |
| 39. | d | 40. | a |
| 41. | a | 42. | b |
| 43. | d | 44. | b |
| 45. | d | 46. | b |
| 47. | a | 48. | c |
| 49. | d | 50. | c |

APPENDIX B

Table 14 **Scores of the Learning Achievement Test in
each Item**

Table 15 **The Results of the Exercises' Scores, the Pre-
test & Post-test Scores of the Main
Experimental Group**

Table 16 **The Results of the Exercises' Scores of the
Students in each Laboratory**

Table 14 Scores of the Learning Achievement Tests in each item (Student No. 1-15 , Item No. 1-50)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1
2	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1
3	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	1
4	1	0	1	1	0	1	1	0	0	1	1	1	1	1	0	0	1	0	1	0	1	1	0	1
5	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	0	1	1	0	1	0	1	1	1
6	1	0	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1
7	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	1	1	0	1	0	1	1	0	1
8	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	0	0	1
9	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0
10	1	1	1	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	1
11	1	1	1	0	0	1	1	0	0	1	1	0	1	0	0	1	1	0	0	1	1	1	0	0
12	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	1	1	0
13	1	0	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1
14	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1	1	1	0
15	1	1	1	0	0	1	1	1	1	0	0	0	1	0	1	1	1	1	0	1	0	0	0	1
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1	1	1	1	0	1	1	0	1	1	0	1	0	1	1	0	1	1	1	1	1	0	1	1	1
2	0	1	1	0	1	1	1	0	1	0	1	1	1	0	1	0	1	1	1	0	1	1	0	0
3	1	1	0	1	1	0	1	1	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0	1
4	1	0	1	1	0	1	0	0	0	0	1	1	0	1	0	1	1	1	0	0	1	1	0	1
5	1	1	1	0	1	1	1	0	1	0	1	1	0	1	1	0	1	0	1	1	1	0	1	1
6	1	1	1	1	1	1	1	0	1	0	1	0	0	1	1	0	1	1	1	0	0	1	0	1
7	0	0	1	1	0	1	1	0	0	1	1	1	0	0	0	1	1	1	0	0	1	0	1	1
8	1	1	1	1	0	1	0	0	1	0	1	1	1	0	1	1	1	1	0	1	1	1	0	0
9	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	1	0
10	0	1	0	1	1	1	1	1	0	1	1	1	0	1	0	0	1	1	1	1	1	1	0	0
11	0	1	0	1	1	1	1	0	1	0	1	1	1	0	0	1	1	1	1	0	0	1	0	1
12	1	1	1	1	1	1	0	0	1	0	1	1	1	0	1	1	1	1	0	1	1	1	0	0
13	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0	1	0
14	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	1	1	1	0
15	1	1	1	0	0	1	1	1	1	0	0	0	1	0	1	1	1	1	0	1	0	0	0	1

Table 14 (Continued), (Student No. 16-30 , Item No. 1-50)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
16	1	1	0	1	0	1	0	1	0	1	0	1	0	0	1	1	1	0	0	1	0	0	0	1
17	1	1	1	0	0	1	0	1	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1
18	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	1	0
19	1	1	1	0	0	1	1	0	0	0	1	0	1	1	1	1	0	0	0	1	0	1	0	1
20	0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0
21	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1	0	0	1
22	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0	1	0	1	0	0	0	1	0	1
23	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1	0	0	0	1	0	0
24	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	0	0
25	1	0	1	0	1	0	1	1	1	1	0	0	1	1	1	0	0	0	1	1	0	1	0	1
26	0	0	1	1	0	1	0	1	1	1	1	0	1	1	0	0	1	0	0	1	0	0	1	0
27	1	0	1	1	0	1	1	0	1	1	1	0	1	1	1	0	1	1	0	0	1	1	0	1
28	1	1	1	0	0	1	0	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	1	0
29	1	1	0	1	0	1	1	0	1	1	0	1	0	1	1	0	0	0	0	1	1	1	0	1
30	1	0	0	1	1	0	1	0	1	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
16	1	0	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	1	1	0	0	0	0
17	0	0	1	1	1	1	0	0	0	0	0	1	1	0	1	0	0	1	0	0	1	0	0	0
18	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0
19	0	0	1	0	1	1	0	0	1	1	1	1	1	1	1	0	1	0	0	0	0	1	0	0
20	1	0	1	1	0	1	1	0	1	1	1	0	0	1	1	0	1	0	0	0	1	0	0	1
21	0	1	0	1	1	1	0	0	0	1	1	0	1	0	0	1	1	0	1	0	1	0	0	1
22	1	0	1	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0
23	1	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	1	0
24	0	1	0	1	0	1	1	0	1	1	1	0	1	0	0	0	0	1	0	0	1	1	0	1
25	0	1	1	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1
26	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1
27	0	0	1	0	1	1	1	1	0	1	0	0	1	0	0	0	0	1	0	1	1	0	0	0
28	0	1	0	1	0	1	1	0	1	0	1	1	1	0	0	0	0	1	0	1	1	1	0	0
29	1	0	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
30	1	0	0	0	1	0	0	0	1	1	0	1	0	0	1	0	0	1	1	0	1	0	0	0

Table 14 (Continued), (Student No. 31- 40 , Item No. 1-50)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
31	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0
32	1	0	0	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0	1
33	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1	0	0	0	1	0	0
34	0	1	1	0	1	0	0	1	0	1	1	1	1	0	1	0	1	0	0	1	0	0	1	0	1
35	0	0	1	1	1	0	1	0	0	1	0	1	1	0	0	0	1	1	0	1	0	1	0	1	1
36	0	1	1	1	1	1	0	0	1	1	1	0	0	1	1	0	1	0	0	1	0	0	1	1	1
37	1	0	1	1	0	0	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	0	0	1	1
38	1	1	1	1	0	0	1	1	0	1	1	0	0	0	0	1	1	0	0	0	1	0	1	0	1
39	0	0	1	1	1	0	0	1	0	1	1	1	1	0	1	0	1	1	0	0	1	0	0	1	1
40	0	1	1	0	1	1	0	1	0	1	1	1	0	1	0	1	1	1	0	1	0	1	1	1	1

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
31	0	0	1	0	1	0	1	1	0	1	0	0	1	0	0	1	0	1	0	1	0	1	0	0	1
32	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1	1	0	1	1	0	1	0	1	0
33	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	1
34	0	1	0	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0	1	1	1	1	1	0	1
35	0	1	1	1	0	1	0	1	0	1	0	1	0	0	1	0	0	0	1	0	1	1	1	0	0
36	1	0	0	0	1	1	1	0	1	0	0	1	1	0	0	1	0	1	1	1	1	1	1	0	0
37	1	0	1	1	0	1	1	1	1	1	1	0	0	1	0	0	1	1	1	1	0	1	0	1	1
38	0	1	0	1	0	1	1	0	0	1	1	0	1	0	1	0	1	0	0	1	0	1	0	0	1
39	0	0	1	1	1	0	1	1	1	0	1	0	0	1	0	1	0	1	0	0	1	0	1	0	0
40	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1

Table 15 The Results of the exercises' scores, the Pre-test and Post-test Scores of the Main Experimental Group

No.	Pre-test (X)	Post-test (Y)	D = (X - Y)	D ²	Scores of exercises
1	31	41	10	100	45.5
2	28	38	10	100	41.5
3	29	40	11	121	39.5
4	27	42	15	225	46
5	33	38	5	25	39
6	29	37	8	64	44
7	31	41	10	100	40.5
8	34	40	6	36	40
9	32	40	8	64	36.5
10	37	40	3	9	46.5
11	31	38	7	49	38.5
12	37	44	7	49	44
13	30	40	10	100	37.5
14	29	36	7	49	41
15	25	35	10	100	43
16	32	40	8	64	42.5
17	24	37	13	169	40
18	29	37	8	64	40
19	32	44	12	144	39
20	33	37	4	16	37.5
21	27	37	10	100	44
22	22	37	15	225	35.5
23	31	37	6	36	43
24	35	45	10	100	46.5
25	32	42	10	100	40
26	37	39	2	4	38
27	28	42	14	196	42.5
28	27	38	11	121	44.5
29	31	43	12	144	35
30	31	48	17	289	46.5
31	24	40	16	256	47
32	39	44	5	25	41
33	34	41	7	49	34.5
34	35	40	5	25	45
35	29	45	16	256	44.5
36	36	45	9	81	45.5
37	34	46	12	144	46
38	28	40	12	144	40.5
39	27	36	9	81	40.5
40	31	41	10	100	36
41	29	42	13	169	40
42	37	39	2	4	46
43	33	34	1	1	38.5
44	28	32	4	16	39
45	23	36	13	169	45.5
N = 45	$\Sigma X=1381$ $\bar{X} = 30.69$	$\Sigma Y= 1793$ $\bar{Y} = 39.84$	$\Sigma D = 413$	$\Sigma D^2=4483$	1867 Mean = 41.5

To find the t – test

$$\begin{aligned}
 t &= \frac{\sum D}{\sqrt{\frac{N \sum D^2 - (\sum D)^2}{N - 1}}} \\
 &= \frac{413}{\sqrt{\frac{45 (4483) - (413)^2}{45 - 1}}} \\
 &= 15.518
 \end{aligned}$$

From the standard table :

The level of significance at 0.05 , df = 44 , $t_{44(0.95)} = 1.684$

Conclusion stated that the post-tset scores were significantly higher than the pre-test scores at the 0.05 level . Those means the laboratory lessons are efficient for providing knowledge to the students .

The analysis of the efficiency of the laboratory lessons according to the standard index of 80 / 80 , the formula of E_1 / E_2

$$E_1 = \frac{(\sum X / N) \times 100}{A}$$

$$E_2 = \frac{(\sum Y / N) \times 100}{B}$$

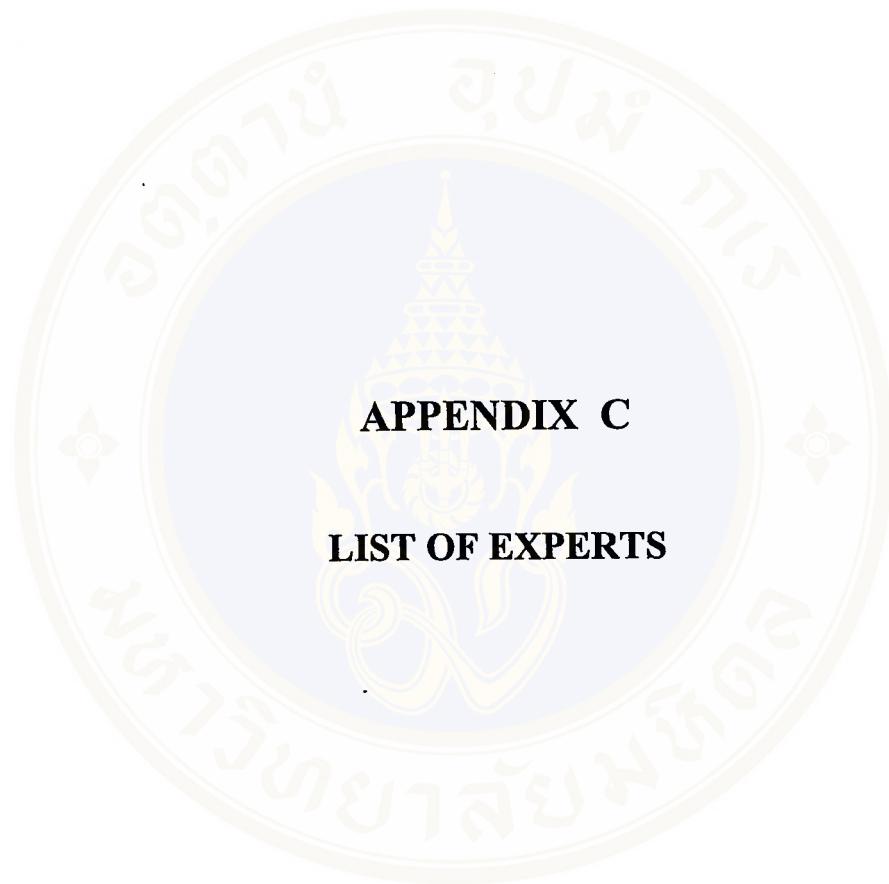
$$\begin{aligned}
 E_1 &= \frac{1867 / 45 \times 100}{50} \\
 &= 83.0
 \end{aligned}$$

$$\begin{aligned}
 E_2 &= \frac{1793 / 45 \times 100}{50} \\
 &= 79.69
 \end{aligned}$$

The efficiency of the laboratory lessons $E_1 / E_2 = 83.0 / 79.69$

Table 16 The Results of the Exercises' Scores of the Students in each Laboratory Lessons

No.	Scores of exercises					Total (50 marks)
	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	
1	8.5	9	8	10	10	45.5
2	8	8	8	9.5	8	41.5
3	8	9.5	7.5	7	7.5	39.5
4	8	10	9	10	9	46
5	7	7	7.5	10	7.5	39
6	8	9.5	8.5	10	8	44
7	7.5	7.5	9	7	9.5	40.5
8	7	7	9.5	9	7.5	40
9	7	7.5	6.5	8.5	7	36.5
10	9	8	9.5	10	10	46.5
11	7	7	7.5	9.5	7.5	38.5
12	7.5	9.5	8	10	9	44
13	7.5	7	8.5	7.5	7	37.5
14	7	10	7.5	8.5	8	41
15	7	9	8	10	9	43
16	7	8.5	8.5	9.5	9	42.5
17	8.5	9.5	8.5	7	6.5	40
18	7.5	8	8.5	8	8	40
19	8.5	9.5	9	6	6	39
20	8	7	6.5	10	6	37.5
21	8.5	8	8.5	10	9	44
22	7.5	7	7	8	6	35.5
23	8	6	9	10	10	43
24	8.5	8.5	9.5	10	10	46.5
25	7.5	9	6.5	10	7	40
26	6	8.5	8.5	8	7	38
27	8	7	7.5	10	10	42.5
28	8.5	10	8	10	8	44.5
29	5.5	6	8.5	10	5	35
30	9	10	8.5	10	9	46.5
31	9.5	10	8.5	10	9	47
32	9	9	9	7.5	6.5	41
33	9	8	7.5	5	5	34.5
34	8	9.5	8	10	9.5	45
35	7.5	9.5	8.5	10	9	44.5
36	8	9.5	9	10	9	45.5
37	9	9.5	8.5	10	9	46
38	8	7.5	8.5	8	8.5	40.5
39	7	8.5	8	9.5	7.5	40.5
40	6.5	7	8.5	7	7	36
41	7.5	8	8.5	8	8	40
42	8	8.5	9.5	10	10	46
43	7	7	7.5	10	7	38.5
44	7	6.5	7.5	10	8	39
45	9.5	8.5	7.5	10	10	45.5
Total	351	374.5	367.5	408	364	1867
Mean	7.8	8.3	8.2	9.1	8.1	41.5
Percentages	78.0	83.0	82.0	91.0	81.0	83.0



APPENDIX C

LIST OF EXPERTS

List of Experts

1. Mr. Kanon Somrang
Education Supervisory unit office of the
Private Education Commission
Ministry of Education
2. Miss Wanaporn Siripala
Education Supervisory unit office of the
Private Education Commission
Ministry of Education
3. Mrs. U-sa Katelure
Teacher C. 9
Mathayom Wat Nongkheam School,
Nongkheam , Bangkok

BIOGRAPHY



NAME Mrs. Nongnart Jindawatt

DATE OF BIRTH 26 September 1960

PLACE OF BIRTH Rayong, Thailand

INSTITUTIONS ATTENDED Prince of Songkla University, 1978-1981:
Bechelor of Science (Biology)
Mahidol University, 1999-2001:
Master of Education
(Environmental Education)

POSITION&OFFICE 1984-Present, AssumptionCollegeThonburi,
Bangkhae,Bangkok 10160
Position : Teacher