

THE DEVELOPMENT OF AN E-LEARNING MODULE ON THE SANDY SHORES ECOSYSTEM FOR GRADE-8 SECONDARY STUDENTS

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Abstract

The research objective was to develop an e-learning module on the sandy shores ecosystem for grade-8 secondary students. The module development was divided into four stages: Stage 1 Studying and analyzing basic information, Stage 2 Developing the e-learning module and investigating its efficiency, Stage 3 Test piloting the e-learning module, and Stage 4 Improving the e-learning module. The pilot testing ran from November to December, 2006. The sample groups, derived by means of purposive sampling, included three classes of grade-8 secondary students at Sunthonphu Pittaya Secondary School in Klang District, Rayong Province, Thailand, studying in the second semester of the academic year 2006. The measurement and evaluation for the students had three parts: student achievement assessment, ICT skills assessment, and assessment of attitudes towards the sandy shores environment. It was found that the students' academic achievement and ICT skills in each sample group after using the module were significantly higher than prior to using the module. On the other hand, the students' attitudes towards the sandy shores environment in each sample group after using the module were found not to be higher than previously. Their academic achievement and ICT skills after using the module were not related to their level of science learning outcomes. The academic achievement and ICT skills, of the three sample groups after using the module were found to be no different than their level of achievement recorded before studying the module. The research findings revealed that the e-learning module on the sandy shore ecosystem was effective and could be used for grade-8 secondary students, as one of the vehicles fostering the development of the cognitive abilities and ICT skills.

Keywords: *e-learning; sandy shores ecosystem; module development; grade-8 secondary students*

Introduction

Thailand has developed a master plan for Information and Communication Technology (ICT) usage in education for

2004-2006 (National Education Commission, Office, 2002: 14). ICT is a diverse range of technologies, which is

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continually growing (e.g., the growth of multimedia, the Internet, and the talking word processor). Each technology offers something unique and of interest to education (Ratcliffe, 1998: 192). According to many science education authorities, the study of science may be made more interesting by applying ICT into the teaching and learning processes as a constructivist tool (Ross, Lakin & Callaghan, 2002: 132). Using ICT may boost learners' motivation and commitment to work. It can stimulate learners and positively affect their attitude towards science and science skills (Ratcliffe, 1998: 192-200). E-learning is information sharing that uses digital technology, and is used in both formal and informal education (Suktrisul, n.d.: Online). E-learning as instruction is delivered on a computer by way of CD-ROM, Internet or intranet (Clark & Mayer. 2003: 13).

E-learning also improves science teaching and learning, and provides other learning experiences, including opportunities for self-directed learning, collaboration with others, and creative use of interactive multimedia technology.

An interesting science topic that was chosen for this study is the Sandy Shores Ecosystem. Sandy shores are located in the inter-tidal zone that lies between the extremes of high and low tides. The inter-tidal zone represents the transitional area from marine to terrestrial conditions. It is a zone of abundant life and ecosystems (Nybakken, 2001: 236 – 304; (Rojchanaprai Wong, 2003: 13-31). Environmental studies, including the Sandy Shores Ecosystem, may be conducted to generate knowledge about the environment to develop a better quality life and to have a good management system of a clean environment for sustainable development. Based on this rationale, the researcher developed an e-learning module on the Sandy Shores Ecosystem for Grade-8 secondary students. The 5E instructional model was used as the central model of learning. Several

interactive learning activities and the instructional materials were delivered *via* computer either orally or through texts and pictures, such as illustrations, photos and animation. The approach will allow more relevant interactions with the local community, its wisdom and its problems. The students may develop their knowledge and scientific skills, and undergo a wider variety of learning experiences, leading to increased motivation to learn further. This e-learning module can also serve as a model in e-learning module development for science studies of many topics. Finally, the researcher believes that the use of the e-learning module will be one of the vehicles that foster the cognitive development, ICT skills, and improve attitudes towards the sandy shores environment.

Research Objective

The objective of the research was to develop an e-learning module on the sandy shores ecosystem for Grade-8 secondary students.

Hypotheses

The researcher generated six hypotheses:

1. The e-learning module efficiency is 80/80 or higher.
2. The students' academic achievement in each sample group after learning via the e-learning module is higher than before.
3. The students' ICT skills in each sample group after learning via the e-learning module is higher than that of before.
4. The students' attitude towards Sandy Shores Environment after learning by using the e-learning module is higher than before.
5. The students' academic achievement and the students' ICT skills after learning via the e-learning module are related with the students' science learning outcomes.

6. The students' academic achievement and the students' ICT skills on the three sample group after learning via the e-learning module will be different.

Scope of Research

Sample groups

The sample groups, derived by means of purposive sampling, included three classes of grade-8 secondary students at Sunthonphu Pittaya Secondary School in Klang District, Rayong Province, Thailand, studying in the second semester of the academic year 2006.

Variables

The independent variable was the e-learning module. Dependent variables were: 1) academic achievement; 2) ICT skills; and 3) attitudes towards sandy shores environment

Contents of the Research

To meet the objectives of this research, the e-learning module was developed. There were five phases of the 5E instructional model: engagement, exploration, explanation, elaboration and evaluation. The e-learning module was written on a CD-Rom. The framework of the e-learning module was divided into the following six lessons :

Module: Sandy Shores Ecosystem

Lesson 1: Living organisms and their adaptation in the sandy shores ecosystem.

Lesson 2: Components of the sandy shores ecosystem

Lesson 3: Food chains and food webs in the sandy shores ecosystem

Lesson 4: Mineral cycles and the water cycle

Lesson 5: Population

Lesson 6: Conservation in the sandy shores ecosystem

The components of the e-learning module in each lesson were divided into five

categories: learning objectives, concepts and subject contents, pre-assessment, learning activities and post-assessment.

Research Instruments

The research instruments were classified into five categories. The details of each category are as follows:

1. The e-learning module

The module was developed on with six lessons, and checked for its content validity, consistency, and language usage by five experts. The Index of Consistency (IOC) was calculated. The criterion set for the evaluation of the e-learning module efficiency was 80/80 or higher.

2. Study plans

The eight study plans for the e-learning module on sandy shores ecosystem, recorded on a CD-Rom, contained ten units requiring twenty class periods. They were checked for their content validity by five experts, and edited for the suitability of language used.

3. A student academic achievement test.

Student achievement was evaluated from the results of pre-assessment and post-assessment. The instrument used was an academic achievement test covering both formative and summative evaluations. The academic achievement test is designed to measure students' abilities in there aspects: knowledge, understandings, application, and scientific process skills. Scientific process skills related to the subject contents in this study are observation skills, classification skills, and inferring skills.

The academic achievement test was based on the contents of the sandy shores ecosystem module. The test consisted of 60 multiple-choice questions evaluating academic achievement in four areas: (1) 5 questions on knowledge; (2) 23 questions on understanding; (3) 12 questions on application; and (4) 20 questions on scientific

process skills. The testing instrument was checked for its content validity and the usage of language by five experts, difficulty index (p) and discrimination index (r). Moreover, the whole test paper was calculated for its reliability by means of Kuder Richardson formula 20 (KR-20). The reliability of the test was 0.51.

4. Evaluation form on ICT skills

The students' ICT skills were assessed before and after instruction. The instrument used was an evaluation form of ICT skills. ICT skills connected with the subject contents in this research are information searching from electronic media skills, organizing data and communication skills, and presentation skills.

The evaluation form, written on the diskette, was checked for its content validity, consistency, and language usage by five experts, and calculated for its Index of Consistency (IOC). Moreover, it was checked for its efficiency. The criterion set for the evaluation of the test efficiency was 80/80 or higher.

5. An attitude inventory form

The assessment of the students' attitudes towards the sandy shores ecosystem was measured before and after instruction. The attitude inventory form was designed for assessing students' feelings and opinions towards the sandy shores environment in two aspects: positive attitudes and negative attitudes. The form contained twenty statements of a Likert-scale type. The item statement was two-tailed with a positive side and a negative side. It was checked for its content validity, the usage of language by five experts, and for reliability. The students' attitude scores were used to estimate the Alpha Coefficient which was found to be 0.68.

Data Analysis

1. Calculating for the efficiency of the module and the evaluation form on ICT skills according to the standard criterion 80/80, (E_1/E_2). Calculating for E_1 and E_2 of the e-learning module the evaluation form on ICT skills could be done. (Saiyot & Saiyot. 1995: 220-221)

E_1 refers to efficiency of the process, calculated in percentage of the mean score from doing exercises and learning activities.

E_2 refers to efficiency of the outcomes or behavior changed in the students themselves after learning, calculated in percentage of the post test score.

2. Analyzing the data collected from the academic achievement test, the evaluation form on ICT skills, and the attitude inventory form on sandy shores environment by means of descriptive statistical devices. The data were processed by computer through SPSS for Windows Program.

3. Comparing the students' academic achievement test score, ICT skills, and attitudes towards sandy shores environment before and after learning through the module, in each sample group, by means of a dependent t-test.

4. Investigating the relationships among students' academic achievement test score, ICT skills of the three sample groups, and their science learning outcomes were divided into three levels as stated, by means of Pearson's product moment correlation coefficient. (Wongrattana. 2001: 314)

5. Comparing the students' academic achievement test score and ICT skills after using the module with the three sample groups by means of One-way analysis of variance (ANOVA).

Research Methods

The development of the e-learning module was divided into four stages:

Stage 1: Studying and Analyzing Basic Information

The researcher studied and collected information from the following resources: 1) documents on e-learning module development; and 2) opinions from science teachers.

Stage 2: Developing the E-Learning Module and Investigating Its Efficiency

This stage was to construct the e-learning module based on the results of the studies in the first stage. Four steps were carried out in this stage:

Step 1: Creating the e-learning module objectives and framework

The module framework created must be in congruence with the objectives of the e-learning module, and was divided into the six lessons. The components of the e-learning module in each lesson were then divided into five categories as follows:

1. Learning objectives: The learning objectives stated what the students will achieve after learning.

2. Concepts and subject contents: The subject contents were written in accordance with Learning Standards of Key Stage 3 secondary education Mathayomsuksa 1-3, and with the content specified in Substance 2: Life and Environment, Standard Sc 2.1 and Standard Sc. 2.2.

3. Pre-assessment: Pre-assessment was carried out to investigate the students before teaching the module in order to determine whether they have enough necessary knowledge and skills specified in the learning objectives.

4. Learning activities: The learning activities were based mainly on the 5E instructional model, which included engagement, explorations, explanation, elaboration, and evaluation.

5. Post-assessment: Post-assessment was provided after learning the

module and included four aspects evaluated in the pre-assessment.

Step 2: Checking the e-learning module framework

The e-learning module framework was checked for its content validity, consistency, and language usage by five experts. The evaluation form was then calculated for its Index of Consistency (IOC).

Step 3: Revising the e-learning module according to the experts' comments

The data gained from the evaluating the e-learning module framework by the experts was used to establish criteria for revising the e-learning module.

Step 4: Pilot testing the e-learning module and investigating its efficiency

The e-learning module was pilot tested with students who were not members of the sample groups, in order to investigate the module's efficiency. The revised module then was tested three times with forty-eight Mathayomsuksa 2 students, who were not in the sample groups. The first stage was testing for efficiency. The e-learning module was tested with three students of three different learning outcome levels: low, medium, and high, and then with another fifteen, followed by thirty students, with learning outcomes at all levels. After each testing, the e-learning module was improved and revised before being used with the sample groups.

Stage 3: Field Testing the E-Learning Module

After the e-learning module was test piloted, it was evaluated. The results obtained were used for improving the module by making it more correct and consistent for the next stage of field testing. The experimentation consisted of the following steps:

1. Setting the time period for experimentation based on the study plans of sandy shores ecosystem for three classes of

Mathayomsuksa 2 students, studying in the second semester of the academic year 2006, at Sunthonphu Pittaya Secondary School, Klang District, Rayong Province. Two periods, of fifty minutes each, was spent for teaching each unit. Ten units were used, which covered eight study plans in twenty periods. The teaching ran from November to December, 2006.

2. The experimentation process was divided into the following steps:

2.1 Purposive sampling of three classes of Mathayomsuksa 2 students at Sunthonphu Pittaya Secondary School, Klang District, Rayong Province, as the sample groups.

2.2 Three classes of sample groups were taught through the e-learning module by a teacher who attended the training. The students completed the learning activities as specified in the e-learning module. The results of the field testing experiment were collected as well.

2.3 In administering the academic achievement test, the ICT skills evaluation form, and the attitude inventory form on the sandy shores environment were administered to students in three classes of the sample groups before and after the experimentation of implementing the e-learning module.

2.4 The students' academic achievement, students' ICT skills, and attitudes towards sandy shores environment before and after learning with the module were compared.

2.5 Investigating the relationship between the students' academic achievement after learning with the module and learning outcomes of the science, which were divided into three levels: good, fair, and low. The students' learning outcomes in studying science used in the comparison were their grades from studying science while in the first semester of Mathayomsuksa 2, in the 2006

academic year. The criteria considered were as follows:

A science learning outcome with the grade higher than 2.50 was considered as good.

A science learning outcome with the grade higher than 2.50 was considered good

A science learning outcome with the grade between 2.00-2.50 was considered fair.

A science learning outcome with the grade lower than 2.00 was considered low.

2.6 Examining the relationship between students' ICT skills after using the e-learning module and their science learning outcomes, which were divided into three levels: good, fair, and low, according to the criteria in 2.5. 2.7 Comparing the students' academic achievement and their ICT skills on the three sample groups after using the module.

Stage 4 :Improving the E-Learning Module

After the e-learning module was field tested and evaluated, the results of the data analysis were used for improving the e-learning module by making it more complete and appropriate to be developed as an e-learning module prototype for the teaching of the sandy shores ecosystem for Grade-8 secondary students.

Results and Discussion

Section 1: The development of the e-learning module

The concepts and theories concerning the development of the e-learning module, and the results of the studies were applied in developing the e-learning module as follows:

1. The e-learning module framework

The e-learning module framework was checked for its content validity,

consistency, and language usage by five experts. The results show that the framework was appropriate in all areas; therefore, this e-learning module was ready for pilot testing.

2. The e-learning module

The module was a kind of instructional tool which was complete in itself and student-centered. The module's aim was to help students gain knowledge and meet the stated learning objectives. This idea is supported by Moon (2002: 151-153), who said that "modules are complete in themselves and are assessed." Similarly, Virginia (1990: Online) stated that "a learning module is a competency-based tool focused on what a learner will know or be able to do as a result of using the tool."

3. The learning activities: The e-learning module had a variety of activities in each phase of the 5E instructional model. The details of learning activities are as follows:

3.1 Engagement Phase: In this phase, students were engaged in the concepts through a short activity or relevant discussion. The researcher selected educational games, simulations and multimedia to engage students, including a sandy shore jigsaw, and a water cycle simulation. This idea was supported by Alessi & Stanley (2001: 298) who suggested that educational games are powerful educational tools and good for integrating learning across a number of subject areas, if used appropriately. Similarly, Smaldino & Russell (2005: 215) suggested that using a variety of media involves students actively and utilizes a number of their senses. Most media formats lend themselves for use in the modules.

3.2 Explorations phase: In this phase, students explored the concepts to develop a common set of experiences. The researcher provided relevant information from websites for each lesson. Students should search and investigate information from this source in the module instead of reading books

for learning in each lesson. This idea is supported by Poole (2000: 215), who stated that computers offer students an opportunity for investigation and discovery of information from sources far beyond the scale available in the normal school library. Students develop not only their subject knowledge, but also the skills needed to deal with the speed and flexibility of information retrieval available electronically.

3.3 Explanation phase: In this phase, students developed an explanation for the concepts they had been exploring. Exercises relevant to the subject contents were provided. Students completed the drills with feedback being given on screen. This idea is supported by Alessi & Stanley (2001: 209-210), who suggested that drills are useful and perhaps even essential to efficient learning.

3.4 Elaboration phase: In this phase, students extended their understanding by applying what they have learned in a new setting. The process in this phase was the same as in the former, but used different contents.

3.5 Evaluation phase: In this phase, students and teachers had an opportunity to evaluate their students' understanding. Students expressed their ideas from their investigation in the form of slides. They produced and presented PowerPoint slides. Teachers evaluated their slides, as a means of formative assessment. This idea is supported by Reynolds & Robertta (1996: 9), who maintained that production level is the top level of mutual interactivity. Production level is a two-way interaction between the learner and the program which results in a new product or information. Also, Smaldino & Russell (2005: 215) suggested that PowerPoint presentation software is user friendly. Their high quality, ease of production, and flexibility of use have made computer-produced slides popular. Students can make

slide shows with a variety of styles. Similarly, Ross (2000: 133) stated that by producing slides from computer, students can create a draft then adjust it for a final presentation, saving a lot of time. This is particularly valuable for the weaker students.

4. Implementing the e-learning module as a pilot testing experiment and investigating its efficiency

The following results are reported:

4.1 Problems found in the pilot testing experiment included a misunderstanding of language in some parts, time limitations for some activities, and technical problems with some computers.

4.2 The e-learning module efficiency was examined at this stage. The findings showed that the e-learning module efficiency was 80.50 / 84.04.

4.3 Other research instruments, used both in the pilot testing and the field testing experiment, were divided into three categories:

4.3.1 A student academic achievement test: The reliability of the test was

0.51, which is high enough to assess group scores of students' achievement.

4.3.2 An evaluation form on ICT skills: The efficiency of the evaluation form on ICT skills was greater than 80/80. This result showed that the evaluation form on ICT skills was a valid measure.

4.3.3 An attitude inventory form towards sandy shores environment: The reliability of the attitude inventory form was 0.68, showing that the attitude test was sufficiently reliable to use for classifying the student's emotional feelings towards the sandy shores ecosystem.

Section 2: The results of the hypotheses testing

The results of the hypotheses testing are, as follows:

The first hypothesis: The findings indicated that the efficiency value of the e-learning module was 80.50/84.04. (Table 1) The e-learning module had higher efficiency than the standard criterion set (80/80). Therefore, the results supported this hypothesis.

Table 1: The e-learning module efficiency in the pilot testing experiment

<i>Sample groups</i>	<i>E₁</i>	<i>E₂</i>	<i>Efficiency E₁ / E₂</i>
Classroom 1	80.56	84.78	80.56 / 84.78
Classroom 2	80.83	84.11	80.83 / 84.11
Classroom 3	80.11	83.22	80.11 / 83.22
<i>Mean</i>	<i>80.50</i>	<i>84.04</i>	<i>80.50 / 84.04</i>

The module was considered appropriate to be used with grade-8 secondary students because the development of the e-learning module was well planned at all stages: students' needs and educational

theories, a variety of learning activities, and appropriateness of the learning processes. This idea is supported by Newton & Laurence (2001: 7), who suggested that "the effective application of software in the

classroom requires a range of teachers' skills related to their understanding of the curriculum and their students' needs". Similarly, Alessi & Stanley (2001: 525) stated that "the processes of developing multimedia include document design, matching the contents with the needs and characteristics of the learners, and balancing ideas against the available budget". Consequently, the e-

learning module on the sandy shores ecosystem was an instructional tool to teach this science topic.

The second hypothesis: The findings indicated that the students' academic achievement in all sample groups after using the e-learning module was found to be significantly higher, at the .05 level, than before using the module. (Table 2)

Table 2: The comparison of students' academic achievement before and after learning by using the e-learning module.

<i>Students' academic achievement</i>	<i>n</i>	<i>Mean</i>	<i>S.D.</i>	<i>t</i>	<i>df</i>	<i>p-value</i>
<i>Class 1</i>						
Pre-test	30	30.20	4.99	-26.71	29	0.00*
Post-test	30	50.86	5.69			
<i>Class 2</i>						
Pre-test	30	30.63	4.82	-26.92	29	0.00*
Post-test	30	50.46	4.65			
<i>Class 3</i>						
Pre-test	30	30.40	5.10	-19.69	29	0.00*
Post-test	30	49.93	5.45			

*p < .05

The results supported this hypothesis. The specific results were:

1. The learning activities: The approach in the learning activities increased students' ability in different four ways, as follows:

1.1 Knowledge: Students gained the concepts and knowledge from many learning activities in the e-learning module, for example, educational games, simulations, and multimedia (Smaldino & Russell (2005: 104, 215; Alessi & Stanley, 2001: 263, 298), and searching the information from websites, as electronic media in the e-learning module (Poole. 2000: 215).

1.2 Understanding: Students expressed their understanding of the concepts and knowledge they explored and of the exercises they completed. These learning activities were useful and improved students' learning

1.3 Scientific processes skills: With the e-learning module, students learned about living organisms through pictures or other instructional media in the learning module. Students expressed their understanding from their investigation in written form *via* the PowerPoint slides. Thus they could improve their scientific processes skills, for instance, observation skills, classifying skills, and inferring skills (Reynolds & Robertta, 1996:

9; Smaldino & Russell, 2005: 215; and Ross, 2000: 133). This idea is supported by Newton & Lawrence (2001: 11), who stated that computer technology exploits new ways of working, thinking and learning. Also, Clark & Richard (2003: 13) stated that e-learning as instruction delivered by CD-ROM, Internet and intranet may enable students to build up new knowledge and skills linked to individual learning goals or improved performance.

2. Students' background: Students in the sample groups had never studied ecology or the sandy shores ecosystem. Moreover, they had never studied science through using computers. Not surprisingly, students were excited, and took an active role in studying

with the e-learning module. This finding is supported by the research of Suanpang (2006: Abstract) and Chan et al., (2002: 7), who concluded that e-learning is one type of active learning. Students enjoyed the e-learning activities, and preferred the e-learning approach to the traditional approach. Consequently, the students' academic achievement improved through the use of the e-learning module on the sandy shores ecosystem.

The third hypothesis: The findings indicated that the students' ICT skills in all sample groups after using the e-learning module were found to be significantly higher, at the .05 level, than before using the module. (Table 3)

Table 3: The comparison of students' ICT skills before and after using the e-learning module

<i>Students' ICT skills</i>	<i>n</i>	<i>Mean</i>	<i>S.D.</i>	<i>t</i>	<i>df</i>	<i>p-value</i>
<i>Class 1</i>						
Pre-test	30	13.63	0.96	-20.94	29	0.00*
Post-test	30	16.76	1.22			
<i>Class 2</i>						
Pre-test	30	14.33	0.75	-21.48	29	0.00*
Post-test	30	16.80	1.06			
<i>Class 3</i>						
Pre-test	30	14.26	0.73	-16.52	29	0.02*
Post-test	30	16.93	.86834			

* $p < .05$

The results supported this hypothesis. The approach in the learning activities increased three aspects of students' ICT skills:

1. Information searching from electronic media skill: In the Explorations phase of each lesson, students were required to search and investigate information from electronic media by clicking on a link. This process engaged and increased their skills in exploring the concepts and developing a

common set of experiences. This idea is supported by Poole (2000: 215) and by Leask & Norbert (1999: 55).

2. Organizing data and communication skills: In the Explanation phase, students developed an explanation for the concepts they had explored. Students learned and did exercises with feedback on screen. They also organized the information and practiced with the feedback appearing

on screen. Moreover, in the Elaboration phase, they extended their understanding or applied what they had learned in a new setting. In conclusion, they did the learning activities following the same process as in the previous ones, but with different content. This repetition helped increase their organizing data and communication skills. This idea is supported by Alessi & Stanley (2001: 209-210) and by Clark & Mayer (2003: 13).

3. Presentation skills: In the Evaluation phase, students expressed their ideas from their investigation in the form of slides as proof of their understanding of the concepts. They produced and presented slides using Microsoft PowerPoint. By following the same pattern of all lessons, they were trained in making presentation skills. This idea is supported by Reynolds & Robertta (1996: 9), Smaldino & Russell (2005: 215) and by Ross (2000: 133).

The fourth hypothesis: The findings of this hypothesis indicated that the students' attitudes towards the sandy shores environment in all sample groups after using the e-learning module were not higher than before learning by using the module. (Table 4) Consequently, the results did not support

this hypothesis. The results were analyzed as follows:

Students' background: Most students in three sample groups were familiar with the sandy shores environment because the school is located near the sandy shores. They had already realized the values and benefits of sandy shores very well. The study's findings revealed that students' attitudes towards the sandy shores ecosystem were satisfactory and positive. Therefore, the development of the e-learning module and other materials on environmental study were necessary to develop students' awareness and concerns of the importance of environment and the causes of environmental problems. This idea is supported by Habibi (n.d.: Online), who suggested that the major causes of environmental problems in Afghanistan were: 1) Not enough awareness of people about the importance of the environment; and 2) No media or publication about the environment. The solutions were 1) Environmental awareness development; and 2) Increased media awareness. Finally, the e-learning module is appropriate to be used in developing students' awareness and concerns in conservation of the sandy shores environment for sustainable development.

Table 4: The comparison of student's attitudes towards sandy shores environment before and after using the e-learning module

<i>Students' attitudes towards Sandy Shores Environment</i>	<i>N</i>	<i>Mean</i>	<i>S.D.</i>	<i>t</i>	<i>df</i>	<i>p-value</i>
<i>Class 1</i>						
Pre-test	30	81.96	6.33	-1.14	29	.16
Post-test	30	84.53	9.04			
<i>Class 2</i>						
Pre-test	30	82.00	6.10	-1.41	29	.15
Post-test	30	85.06	8.72			
<i>Class 3</i>						
Pre-test	30	81.80	5.80	-1.74	29	.21
Post-test	30	85.40	8.42			

The fifth and the sixth hypotheses:
The findings of both hypotheses indicated that the students' academic achievement and their ICT skills after using the e-learning module

were not related to their science learning outcomes, and were found to be no different after studying the module than before. (Table 5 and Table 6)

Table 5: The relationship between the students' academic achievement and the science learning outcomes, divided into three levels, after using the e-learning module

	<i>Details</i>	<i>Levels of science learning outcomes</i>	<i>Achievement scores after learning</i>
Levels...	Pearson Correlation	1	.69*
	Sig. (2tailed)		.00
	N	90	90
Score...	Pearson Correlation	.69*	1
	Sig. (2tailed)	.00	
	N	90	90

* p<.05

Table 6: The relationship between the students' ICT skills and science learning outcomes, divided into three levels, after using the e-learning module

	<i>Details</i>	<i>Levels of science learning outcomes</i>	<i>ICT skills scores after learning</i>
Levels...	Pearson Correlation	1	.14
	Sig. (2tailed)		.16
	N	90	90
Scores...	Pearson Correlation	.14	1
	Sig. (2tailed)	.16	
	N	90	90

*p<.05

The results did not support both hypotheses. The results were analyzed as follows:

1. Characteristics of the e-learning module: The e-learning module was written in a CD-ROM format, so students could use it individually through a computer. Some students, who finished earlier than others, could go on to the next section. While other students who took more time to complete each section could repeat it without embarrassment. During the study time, students could collaborate with peers on exploring the lessons' topics, scoring from exercise, and producing slide presentations.

Indeed, the e-learning module was appropriate for students with varied ability ranges. This idea is supported by Smaldino & Russell (2005: 35), who stated that to make efficient use of instructional media and technology, there must be a match between the students' characteristics and the content of the methods, media, and materials. Similarly, Reynolds & Robertta (1996: 42) described successful instructional packages as being: 1) appropriate for multicultural classrooms and students with a wide range of abilities; 2) have motivating topics; 3) fitting the curricula objectives; and 4) flexible by being linked to several topics, and can be

used by both beginners and advanced students, and fit several logistical settings (e.g., individual, small group, whole class).

2. Students' background: Most students in three sample groups have grown up in the sandy shores surroundings because Sunthonphu Pittaya Secondary School is located nearby sandy shores at Laem Mae Phim, Klang District, Rayong Province. From their everyday life, they learned that sandy shores are an area of academic, economic, tourism, and fishery resources, but they did not realize that the sandy shores is a good learning resource in their community. This ecosystem was the theme all students had already experienced and saw as relevant to them. This idea is supported by Parsons et al. (2001: 60-63) and by Trowbridge & Bybee (1996: 175-199, 213).

3. Students' ICT background: Students had studied using computers from grade-7 level. This experience is consistent with what has been stated in the National Curriculum in the aspect of expected learning outcomes: "Students have computer literacy and basic computer skills, for instance, word processor, slide presentation, and using the Internet." It can, therefore, be assumed that all students were familiar with using computers for learning. These computer skills benefited their learning while completing the e-learning module. This idea is supported by Parsons et al. (2001: 60-63) and by Trowbridge & Bybee (1996: 175-199, 213).

Recommendations

The following recommendations are proposed for teaching and learning science with e-learning modules:

1. Recommendations for using the results of this research study

1.1 The effective application of ICT and the e-learning module in the classroom requires a range of teaching skills related to their understanding of the

curriculum and their own students' needs. All teachers should be equipped with basic skills in ICT use (e.g., internet and PowerPoint slide presentation).

1.2 Teachers should prepare themselves by studying the 5E instructional model. They should understand their roles as mentors or facilitators and to use the study plans effectively.

1.3 The use of the study plans will help teachers know and plan how to monitor and access all students in the class, so that the students can be engaged in and follow the lessons step by step. Teachers should monitor the students' learning process to be certain that there is continuous learning throughout a school period by all students.

1.4 The e-learning module contains information from electronic media. It is easily accessible and the contents can be quickly copied to produce students' slides. Thus, these contents are not based on their own ideas. In any assessment, students can find an answer-key or feedback immediately before doing the test. Consequently, the result of assessment may not reflect real achievements. Teachers must know how to evaluate the students' work.

2. Recommendations for further study

The results of field testing the e-learning module development on the sandy shores ecosystem indicated that students had achieved more academically and in terms of their ICT skills after using the e-learning module. The recommendations for future studies are as follows:

2.1 The e-learning focusing on a student-centered approach and the 5E instructional model should be applied for developing e-learning modules at all educational levels.

2.2 The e-learning module approaches allow more relevant interactions with the local community, and addresses its

problems. This e-learning module can also serve as a model in e-learning module development for other science contents.

2.3 The study should be implemented using a larger sample and other schools in the Eastern Region of Thailand.

2.4 The study should be focused on learning about the environment and students' thinking abilities, especially problem solving skills and creative thinking.

2.5 The e-learning module should be accessed *via* the Internet.

2.6 The e-learning module should allow students to present their data and ideas using variety of ICT software in the learning activity section.

Conclusion

The e-learning module on the sandy shores ecosystem was found to be an effective instructional method and could be used as one of the vehicles for fostering the development of the cognitive abilities and ICT skills in grade-8 secondary students.

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