CHAPTER 4
Results

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

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

1. Phase one: program designing

1.1 Identification of learner needs

1.1.1 Specialist

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

1.1.2 Clients

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

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

Needs educational materials 30.71%.

Task analysis

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

TABLE 5 TASK ANALYSIS: ZOO VISIT

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

Summary

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

1.2 Articulating program intentions

1.2.1 Program rationale

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

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

1. Describe the setting (e.g. student background and needs, resources, timetable);

2. Describe the intended teaching program (e.g. scope, themes, methods) and explain how it is designed to meet the needs of the particular student group;

3. Explain how the assessment outline is designed to provide an opportunity for the student group to succeed.

1.2.2 Program goals

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

1. To promote the CTSPZ as a model system linked with informal and formal science education based on the national science standards for level 3 students.

2. To enhance students' science process skills, scientific attitude, attitude towards science, attitude towards the environment, and the constructivist learning environment.

3. The CTSPZ was developed as a prototype for science teachers to adapt and use in the setting of each school.

1.2.3 Contents of science standard

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

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

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

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

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

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

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

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

1.3 Planning instruction

1.3.1 Specifying instructional content

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

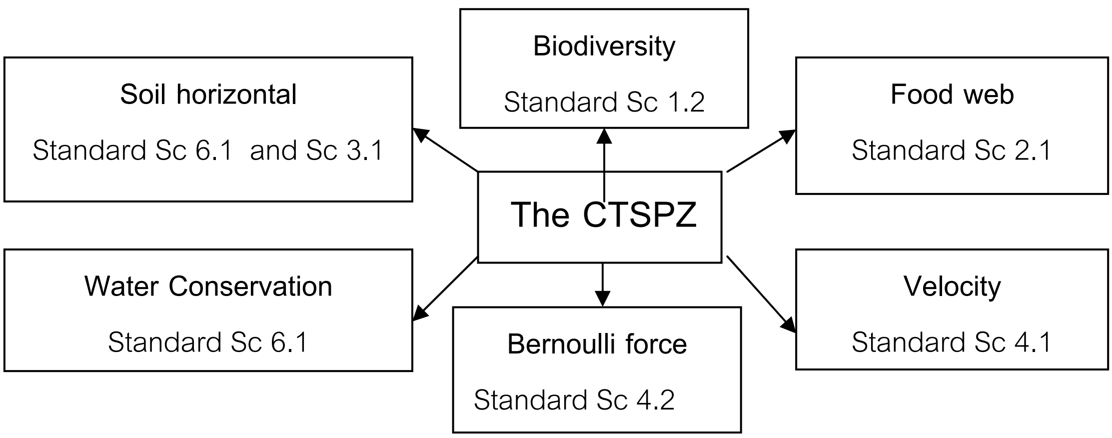

FIGURE 8 INSTRUCTIONAL CONTENTS FOR THE CTSPZ

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

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

TABLE 6 A CATEGORIZATION OF SCIENCE PROCESS SKILLS IN THE CTSPZ

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

1.3.2 Integrating thematic units

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

1.3.3 Specifying teaching strategies

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

1. The situation frames the agenda for student engagement by delineating the goals, task, and forms the learning episode.

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

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

4. Question aim to instigate, inspire, and integrate students thinking and the sharing of information. Questions are prompts or responses that stimulate, extend, or synthesize student thinking and communication during a learning episode.

5. An exhibit asks students to present publicly what they have learned; this social setting provides a time and place for students to respond to queries raised by the teacher, by peers, or by visitors about the artifacts of learning.

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

1.3.4 Planning for assessment

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

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

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

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

5 means the most suitable

4 means very suitable

3 means suitable

2 means not very suitable

1 means the least suitable

Results of the suitability were categorized into 5 levels

4.51 – 5.00 means the most suitable

3.51 – 4.50 means very suitable

2.51 – 3.50 means suitable

1.51 – 2.50 means not very suitable

1.00 – 1.50 means the least suitable

TABLE 7 LEVEL OF SUITABILITY OF THE DRAFT PROGRAM

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

TABLE 7 (continued)

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

TABLE 7 (continued)

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

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

Consistent is weight as +1

Unsure is weight as 0

Inconsistent is weight as - 1

The formula used to calculate the CVI is

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

Where CVI means The content validity index

ΣR means Summation of expert' opinion marks

N means A number of expert

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

TABLE 8 CONSISTENCY OF THE DRAFT PROGRAM

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

TABLE 8 (continued)

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

Suggestions from the experts

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

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

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

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

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

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

1.4 Pilot study

1.5.1 Pilot study

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

1.5.2 Collection and evaluation of the pilot study data

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

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

1. Time management

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

2. Informal environment

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

3. Instructional materials

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

1.6 Revision the draft science program for Chiangmai zoo

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

1.6.1 The organization in each unit

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

1.6.2 Instructional material

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

1.6.3 Time management

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

1.6.4 Evaluation

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

2. Phase two: program implementation

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

TABLE 9 CLASSIFICATIONS OF SUBJECTS BASED ON TWO SCHOOLS

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

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

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

3. Phase three: program evaluation

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

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

The results of the program implementation are presented below.

3.1 Quantitative data analysis

3.1.1 Science process skills

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

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

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

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

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

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

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

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

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

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

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

* $p < 0.05$

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

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

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

TABLE 12 (continued)

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

TABLE 12 (continued)

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

* $p < 0.05$

** $p < 0.01$

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

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

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

TABLE 13 (continued)

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

TABLE 13 (continued)

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

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

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

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

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

3.1.2 Scientific attitude

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

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

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

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

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

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

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

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

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

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

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

* $p < 0.05$

** $p < 0.01$

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

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

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

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

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

3.1.3 Attitude toward science

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

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

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

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

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

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

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

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

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

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

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

** $p < 0.01$

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

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

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

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

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

** $p < 0.01$

3.1.4 Attitude toward the environment.

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

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

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

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

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

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

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

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

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

0.01 level in both schools.

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

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

** $p < 0.01$

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

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

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

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

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

* $p < 0.05$

2.1.5 Constructivist learning environment

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

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

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

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

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

* $p < 0.05$

** $p < 0.01$

3.2 Qualitative data analysis

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

3.2.1 Students' behaviors observation

3.2.1.1 Science process skills

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

Findings

Basic skills

Observing

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

Classifying

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

Measuring

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

Prediction

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

Communicating

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

Inferring

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

Integrated skills

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

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

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

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

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

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

3.2.2 Semi-instructional interview

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

3.2.2.1 Scientific attitude

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

Results

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

There were only two students who wanted to be scientists.

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

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

3.2.2.2 Attitude toward science

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

Results

Question 1: How do you feel about science?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.2.2.3 Attitude toward the environment

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question 3: Are animals and people equally important?

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

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

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

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

However, one student changed her answer on the posttest.

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

3.2.2.4 Constructivist learning environment

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

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

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

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