CHAPTER 3
Methodology

Introduction

The sections of this chapter presents the stages in the development of the constructivist thematic science program at Chiangmai zoo (CTSPZ) that influences science process skills, attitude towards science, scientific attitude, attitude towards the environment, and constructivist learning environment of middle school students. A constructivist model for curriculum development (FIGURE 5) as outlined by Driver, R. and Oldham, V. (1986) was adapted and used in the development of the program materials in this research. This research was conducted in three phases including program design, program implementation, and program evaluation.

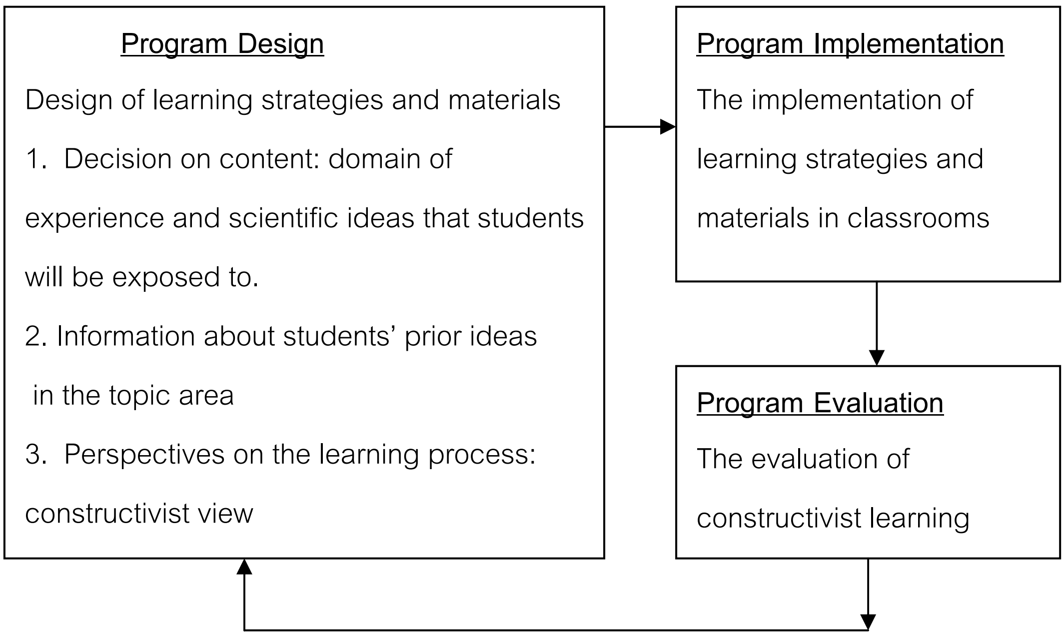

FIGURE 5 A CONSTRUCTIVIST MODEL FOR THE CTSPZ PROGRAM (adapt from constructivist model for curriculum development by Driver, R. and Oldham (1986)).

The instruments and procedures employed in this study are discussed in this chapter under the following headings:

1. Phase one: program designing
   1.1 Identifying learner needs
   1.2 Articulating curriculum intentions
   1.3 Planning instruction
   1.4 Consulting with curriculum experts
   1.5 Pilot study
   1.6 Revising the draft CTSPZ
2. Phase two: program implementation
   2.1 Research design
   2.2 The participants
   2.3 Setting
   2.4 Instrument for data collection
3. Phase three: program evaluation. (Data analysis)
   3.1 Quantitative data analysis
   3.2 Qualitative data analysis

1. Phase one: program designing

During the first phase, the constructivist thematic science program at Chiangmai zoo (CTSPZ) based on constructivist learning design (CLD) at an informal setting (Chiangmai zoo) was developed by integrating it with formal national science standards.

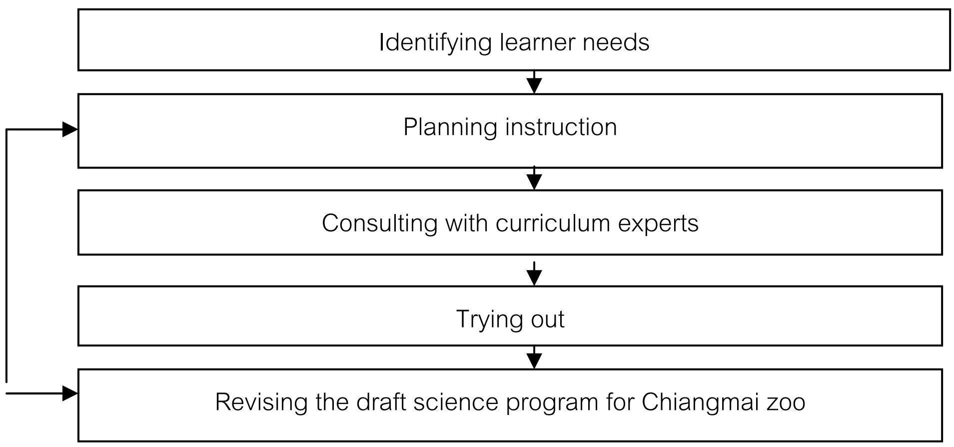

FIGURE 6 PROCESS FOR DESIGNING THE CTSPZ PROGEAM

The details for program designing are summarized as follows:

1.1 Identifying learner needs

There is general agreement among educators that curricula should be based on learner needs. In this research, needs were defined as a discrepancy between a present and a preferred state. Needs assessment is a set of procedures for gathering information about the learner's needs. These processes include consultation, collection of social indicators, and task analysis.

1 Opinion surveys

The basic reason for conducting a needs assessment prior to beginning to plan a curriculum are informational, ethical, and political. To meet these ends, two main groups of respondents were consulted.

1.1.1.1 Specialist

Telephone interviews were an effective means for reaching the two specialists:

1. Mr. Apidat Singhasanee educator at Kaowkeaw zoo.
2. Mrs. Jarunee Chaichana educator at Chiangmai zoo.

1.1.1.2 Clients

The clients of this program are students, teachers, and parents. Data information gathered from survey questionnaires conducted by a master plan of Thai zoo education, 2005 was used to ascertain their backgrounds, their interests, their aspirations and motivations, their preferences and aversions, their histories of success and failures.

1.1.2 Task analysis

Task analysis was needed to corroborate the subjective data produced by respondents in interviews, hearings, or surveys. Its function is to identify the important components of tasks that were in turn to become significant elements of the program. The directed observation of task performance was conducted by the researcher through the entire day with 10 students to monitor the nature, purpose, scope, frequency, sequence, and importance of tasks performed at Chiangmai zoo during their visit in January 2007.

1.2 Articulating program intentions

The process of program planning is a process of clarification and articulation of meaning and significance by specifying the major educational rationale, specific objectives, and science content that related them to the national science standards. Therefore this stage was about writing the program rationale, goals, and selected science content standards.

1.2.2 Program rationale

The program rationale justifies the commitment of resources to the pursuit of the program. It is essentially a brief essay that endeavors to persuade the reader to understand the significance and importance of the program. Moreover it illustrates how national science standards were used and described how classroom should be linked. It also addressed the broader learning context, such as how the teacher taught and how students were assessed.

1.2.2 Program goal

The program goals provide a sense of purpose and direction. It was stated in terms of intentions. These goals were written to communicate the overall purposes of the program to many audiences, including staff, parents, and policy makers. Goals used to guide the actions and decisions of teachers, administrators, and support staff as these personnel develop, implement, and support activities to improve the quality of science education.

1.2.3 Contents of science standards

A comprehensive set of content of science standards is the key component in the design of an effective program. A set of existing national science standards was used in this research, and then the science standards that were suitable for each unit were selected.

1.3 Planning instruction

Instruction refers to program content and teaching strategies. In this research, instruction was referred to as one part of the curriculum: the content or subject-matter and the methods or strategies. Therefore, the CTSPZ was designed as a micro curriculum. The principle focus of the CTSPZ is the development and operation of program-based activities. It was conducted through an articulation between classroom actions and includes 6 units, the design of lessons, the application of various teaching models, and the design of assessments.

1.3.1 Specifying instructional content

The goal of this step was to identify instructional content that best support the national science standards and were suitable for the Chiangmai zoo environment. This step was meant to organize and sequence the content to create coherence in the program across grade 7-9 in all units.

1.3.2 Integrating thematic units

In a field of science, at every level of education, biology, chemistry, physics, and earth science there are essential conections. These complementary subjects were intimately integrated into the CTSPZ by following a nested horizontal integration strategy. Moreover units offer educators a framework in which to impart scientific knowledge, skills, attitudes, and environmental education.

1.3.3 Specifying teaching strategies

In this step, instruction was characterized as a process in which teachers attempt to make learning sensible and students attempt to make sense of learning. Therefore, six elements of the constructivist learning design (CLD) developed by Gagnon and Collay were used as teaching strategies in this research.

1.3.4 Plan for assessment

An instructional plan also needs to include a plan for assessment. Both formative and summative assessments were use in this research.

1.3.4.1 Formative assessments provided data about how students are changing in science process skills and attitudes. Observation, records of work, and a questionnaire of self-assessment in small group discussion were used to provide feedback in an ongoing instructional situation.

1.3.4.2 Summative assessment intended to provide a final judgment on a learner as to whether there was a change on the students' science process skills, scientific attitude, attitude towards science, and attitude towards the environment. Both qualitative (interview) and a quantitative instrument, the science process assessment for middle school students, the scientific attitude inventory: a revision (SAI II), science attitude scale for middle school students, the children's attitude towards the environment scale (CATES), a constructivist learning environment survey (CLES) permission was given to use in this research and translated into Thai to use as an instruments in this step. The instruments in the Thai version was reviewed by four experts to check for content validity and tested for reliability with 40 students. Then the instruments were revised according to comments and suggestion from both experts and students.

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

The key concept for this step is to comprehend in outlook and comprehend in instrumentation. In this step, five experts about the program validity and reliability were consulted. Any reliance on a single appraisal was subjected the evaluation to validity and reliability vulnerabilities. Content and construct validities have important roles in this step because they are foundation of making good measurements on achievement. On the other hand, reliability refers to the stability of instruments over time and in alternative forms. Once the program was designed, it was evaluated by an internal evaluation, expert appraisal and confidential review.

1.5 Pilot study

1.5.1 Pilot testing

Small scale pilot testing was conducted to explore students' experiences while they attended the CTPSZ at Chiangmai zoo. It was conducted on part of the curriculum with 40 students from Chiangmai university demonstration school in January 2007.

1.5.2 Collection and evaluation of the pilot study data

The purpose of pilot study evaluation was to understand a summative phenomenon that occurs and to obtained feedback on the program experience after completion of some logical plane of instruction.

1.6 Revision of the draft science program for Chiangmai zoo

Revisions of the draft program occurred after the program had been adopted and implemented for the pilot study. The nature of this step was to provide feedback on changes that might be needed. The program revision also needed to direct some attention to the elements of the program that affect its implementation. Program revision was conducted following the guidelines below:

Program revising guide

1. Need Assessment
    - Was a need assessment conducted?
    - Are the methodology and results described?
    - Are the results used appropriately in the design of the program?
2. Rationale
    - Is the justification for the program given?
    - Are all the important arguments for the program included?
    - Does the rationale document current evidence on which the curriculum is based?
    - Are the arguments valid and rigorous?
    - Is the rationale eloquently written and convincing?
    - Are the main objections anticipated and dealt with?
    - Does the rationale deal appropriately with the social and personal significance of the program?
3. Goals
    - Are all the main intentions of the program identified?
    - Do the goals reflect student needs?
    - Do the goals go beyond the cognitive?
    - Are the goals written in a clear and consistent style?
4. Assessment
    - Are appropriate means suggested to assess attainment of each goals?
    - Are of mastery measures valid, reliable, and efficient?
    - Where appropriate, are standards of mastery clearly indicated?
5. Context
    - Is it clear how this program fits or links with a science course in school?
    - Is the relationship of the program to science standards shown?
6. Instruction
    - Does the instruction match student needs?
    - Does the instruction match the program goals?

- Is instructional content appropriate and interesting?
- Does the instruction ensure early significant success?
- Is the sequence and pacing of instruction appropriate?
- Are teaching strategies varied, interesting and challenging?
- Do strategies involve a constructivist leaning environment?

7. Pilot study
   - Is there provision for pilot and field testing?
   - Are the results of the pilot of field testing described?

2. Phase two: program implementation

2.1. Research design for the study

The design of this study was a mixed method, control group interrupted time series design in which the CTSPZ at the Chiangmai zoo served as the independent variable and the measure of students' science process skills, attitude towards science, scientific attitude, and attitude towards the environment served as dependent variables. In this design, the experimental group (A) and the control group (B) were observed over time. Both groups took a pretest and posttest. Only the experimental group received the treatment. Moreover both quantitative and qualitative methods were used. The use of survey instruments (quantitative) provided the data to reveal patterns and interview questionnaires (qualitative data) were added, supported and extended the quantitative relationships. Both quantitative and qualitative methods of the study used to explore the following questions.

Does the use of the science program, designed by the investigator and offered at the Chiangmai zoo, scientifically influence;

1. student's science process skill?
2. student's scientific attitude?
3. student's attitude towards science?
4. student's attitude towards the environment?
5. constructivist learning environment?

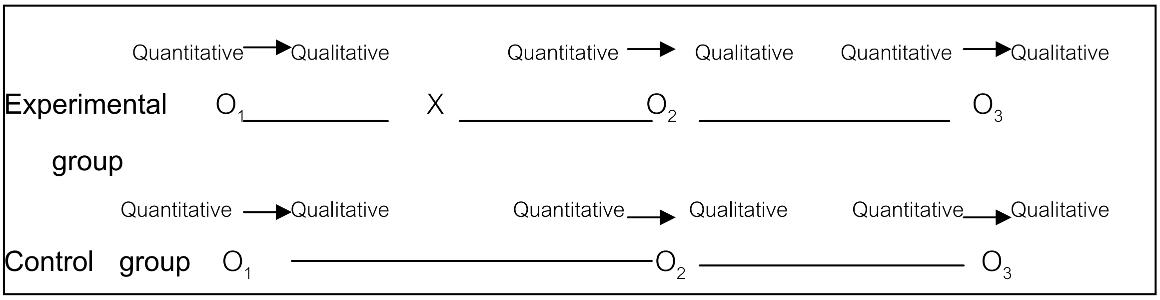

FIGURE 7 MIXED METHOD, CONTROL GROUP INTERRUPTED TIME SERIES

The symbols indicate as follows.

O_1 is observations (or pretest)

X is the treatment (The CTSPZ)

O_2 is an additional observation (or posttest) after using the CTSPZ.

O_3 is an additional observation (or posttest) after O_2 for 1 month.

An experimental group received the treatment (The CTSPZ) while they visited the zoo.

A control group was not received the treatment.

The research design (FIGURE 7) was developed using t-test to answer the following questions;

1. Whether difference in science process skills exists between pretest and posttest.
2. Whether difference in attitude towards science exists between pretest and posttest.
3. Whether difference in scientific attitudes exists between pretest and posttest.
4. Whether difference in attitude towards the environment exists between pretest and posttest.

This design includes a pretest followed by a treatment and a posttest in a single group. Students' science process skills were measured by the science process assessments for middle school students (SPAMSS) (Smith & Welliver Educational Service. 1994). Attitude towards science was measured by the science attitude scale for middle school students (Misiti.; Shrigely.;& Hanson. 1991). Scientific attitudes were measured by the scientific attitude inventory (SAI II) (Moore.; & Foy. 1995.). Students' attitude towards the environment was measured by the children’s attitude towards environment (Musser.; &Malkus. 1994). The constructivist learning environment was measured by a constructivist learning environment survey (CLES)(Taylor; Fraser; & Fisher. 1997: 293). Simultaneously, the science process skills, attitude towards science, and attitude towards the environment were explored using the interview questionnaires.

2.2 Participants

The participants were level three students who volunteered to attend the CTSPZ from Chiangmai University demonstration school and Navamindarajudis Phayap School. An activity for learner development is a teaching-learning activity required for self-development in accordance with the students’ potential. Students are encouraged to happily participate in undertaking activities in accordance with their tendency and interest.

2.3 Setting

All the units in the CTSPZ were designed for the Chiangmai zoo setting where students learned in the informal setting. The Chiangmai Zoo is located on Suthep road nearby Chiangmai University. It was established by the zoological park organization, Thailand in 1974, situated on 1327.5 acres of verdant forest land at the foothill of Doi Suthep Mountain. The zoo is surrounded by hilly terrain, home to thousands of species of wild plants and flowers adorning the natural landscape of valleys, streams and waterfalls (Chiangmai zoo. 2006: Online). Therefore, the Chiangmai zoo is highly appropriate to study science.

2.4 Instruments for data collection

2.4.1 Quantitative data collection

2.4.1.1. Science process assessment for middle school students

The Science process assessment for middle school students (SPAMSS) was used to identify the student proficiency in the use of science process skills. This instrument measured 13 science process skills: observing, classifying, inferring, predicting, measuring, communicating, using space/time relations, defining operationally, formulating hypotheses, experimenting, recognizing variables, interpreting data and formulating models. The instrument is based on a comprehensive study of process skills conducted by a science curriculum advisory committee of the Pennsylvania department of education.

The instrument is 50 multiple-choice test items, accompanied by a list of appropriate indicators of student behaviors. All behaviors would demonstrate competency in each particular process skill from the 13 process skills listed. The test items will engage students in problem solving situations which require them to apply an appropriate process skill to answer each question. This test can be administered to students in a 40-50 minute class session (Smith & Welliver Educational Service. 1994).

There are two key factors that are important for this instrument. The first factor is the reliability, that is, whether the test score is accurate, precise, consistent and reproducible. The SPAMSS has a reliability coefficient of 0.88. The second factor to consider is validity, that is, whether the test measures what you actually want to measure. Strong confirmations of this instruments validity come from the results of a project conducted by the Far West laboratory for educational research and development at Stanford University. The result was that the SPAMSS is indeed valid as a measure of an ability to use science process skills.

2.4.1.2 The scientific attitude inventory: a revision (SAI II)

The scientific attitude inventory: a revision (SAI II) was developed by Richard W. A revised version of the scientific attitude inventory: a revision (SAI II) was developed and field tested in 1983. The SAI II has 40 five-response Likert-Scale type attitude statements to assess students' scientific attitudes. The SAI II is scored by assigning point values to each of the attitude items. Point values are assigned as shown in Table 2. Scores for the various subscales can be determined by adding the scores for the respective items. Scores may be determined for the 12 subscales, a total for the positive, a score for the negative items, and a total for the entire SAI II. The range of scores for each of the Scales 1-A through 5-B is 3-15 (1-5 x 3 items). The range of scores for scales 6A and 6B is 5-25 (1-5 x 5 items). The range of scores for the entire SAI II is 40-200 (1-5 x 40 items) (Richard ; & Foy. 1997).

A split-half reliability coefficient for SAI II was computed for the entire group of 557 respondents. Application of the Spearman Brown correction of split-half to the correlation coefficient yields a reliability coefficient of 0.80. Cronbach's alpha reliability coefficient is 0.781 for this group. The results of an administration of the SAI II to 557 students indicated that the scales of the instrument can distinguish between those who have more positive attitudes toward science and those who have less positive attitudes as determined by the total score on the SAI II. The t-test comparison of the high and low scores is evident in that the various subscales contribute positively to the total score of the instrument. Coupled with judgments that the items of the instrument are related to the scientific attitudes it is supposed to assess, validity is claimed for the SAI II.

TABLE 2 POINT VALUES FOR POSITIVE ITEMS AND FOR NEGATIVE ITEMS

	Positive Items	Negative Items
Strongly agree	5	1
Mildly agree	4	2
12 neutral/undecided	3	3
Mildly disagree	2	4
Strongly disagree	1	5

2.4.1.3. Science attitude scale for middle school students

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 as follows (Misiti; & Shrigely; & Hanson. 1991).

Subcomponent 1: Investigations - eight items

Subcomponent 2: Comfort/discomfort - six items

Subcomponent 3: Learning science content - four items

Subcomponent 4: Reading and talking about science - three items

Subcomponent 5: Viewing films on TV -two items'

The SASMSS has passed several tests suggesting some degree of validity. For the internal consistency, the coefficient alphas for the 23 items on the two set of data were 0.96 and 0.92, respectively, strongly suggesting that the items are interconnected.

TABLE 3 THE RESULTS OF TESTING EACH SUBCOMPONENT AS A SINGLE

Subcomponent	Coefficient alpha	Number of items
1. Using science materials (Investigative processes)	0.81	8
2. Comfort-discomfort related to classroom science	0.68	6
3. Learning science content	0.73	4
4. Reading or talking about science	0.04	3
5. Viewing science films on TV specials	0.66	2
Total Scale	0.91	23

2.4.1.4. The children's attitude toward the environment scale (CATES)

The children's attitude 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 25 items that make up the scale were selected through item analysis from a larger pool of items. The internal consistency reliability of the scale (Cronbach's alpha) ranged from 0.70 to 0.85. Test-retest reliability was 0.68.

The CATES describes two different groups of children. When scales are administered, children are first instructed to choose which of the two groups of children described in the statements they are most like. Under each statement are two boxes (one large, one small) for marking an answer. Children check the larger box if they think they behave like the children described in the statement. They check the smaller box if they believe that they do not behave like the children described in the statement.

2.4.1.5 Constructivist learning environment survey (CLES)

The constructivist learning environment survey (CLES) was developed from the perspective of critical constructivism which recognizes that the cognitive constructive activity of the individual learner occurs within, and is constrained by, a socio-cultural context (Taylor. 1994: 30). The CLES comprised 30 items each of which was designed to obtain measures of students' perceptions of key aspects of their classroom learning environment. The version of the CLES had a 5-point Likert-type frequency response scale which comprises the categories: Almost always (5 points), often (4), sometimes (3) seldom (2), and almost never (1). Of particular interest in this study are the Cronbach alpha reliability coefficients which provide a measure of the internal consistency of each of the five CLES scales. In learning environment research, alpha coefficient values in excess of 0.70 are regarded generally as indicating satisfactory degrees of internal consistency.

2.1.4.6 The reliability for instruments in Thai version

The reliability for each instruments in Thai version are summarized as in TABLE 4.

TABLE 4 RELIABILITY FOR THE INSTRUMENTS IN THAI VERSION

Instrument	Reliability (r)
Science Process Assessment for Middle School Students	0.81
The Scientific Attitude Inventory: A revision (SAI II)	0.81
Science Attitude Scale for Middle School Students (SASMSS)	0.91
The Children's Attitude Towards the Environment Scale (CATES)	0.80
Constructivist Learning Environment (CLES)	0.83

The content validity index (CVI) for each instrument in Thai version was analyzed. Each answer from the questionnaire of three level rating scales is 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 0.25.

2.4.2 Qualitative data collection

In addition to the evaluation of the science program by using the quantitative instruments listed above, the phenomenological study was conducted to explore student's science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment. In the conduct of phenomenological study, the focus was on the essence of the students' experience when they participate in the science program (Merriam, 1998: 15). Therefore, the meaning of the student's science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment were determined using a comparative case study of their experience before and after they participated in the science program. By comparing and contrasting the results of this study, the effectiveness of the implementation of the science program were evaluated. The qualitative data were collected from both observation and interviews.

2.4.2.1 Observation

To evaluate the student's science process skills during the CTSPZ activities, the researcher gathered field notes by conducting an observation as an observer (Creswell. 1998: 121). In addition, data were collected from direct observation during the activity. The rating scale , science process skills observation instrument, records the degrees of behavior that is observed were developed to ensure that only the behaviors specified are the focus of observation.

2.4.2.2 Interview

The interview was conducted as a semi-structured interview. The interview was audio taped and transcribed to explore students' scientific attitude, attitude toward science, and attitude toward the environment. Following are interview questions for students.

Attitude toward science

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?
2. Have you ever applied knowledge about science into your life?

- If so, when?
- How?
- Where?

3. Have you ever discussed science with friends or talk to your parents about science outside the classroom? Please explain your answer.
4. Do you think that what you learn in science is part of your life outside school? Please explain your answer.

Scientific attitude

5. Do you view science information and methods as unchangeable? Please explain.
6. On scale of 1 to 10, how important is science?
7. Would you like to be a scientist after you finish school? Why or why not?

Attitude toward the environment

8. Do you leave water running while you brush your teeth? Why?
9. Please explain how you use a paper when you draw or write something. Is it important to use both sides of the paper?
10. Are people and animals equally important?

3. Phase three: program evaluation.

3.1 Quantitative data analysis

Upon completion of all instruments; science process assessment for middle school students (SAMSS), the scientific attitude inventory: a revision (SAI II), science attitude scale for middle school students(SASMSS), the children's attitude towards the environment scale (GATES), a constructivist learning environment survey (CLES), and the collected quantitative data were analyzed using the following procedure:

1. Descriptive statistic, mean, standard deviation, and variance was calculated for all instruments.
2. The t-test of significance was performed using the results data from SAMSS ,SAI II, SASMSS ,CATES, and CLES before and after using the science program.

3. 2 Qualitative data analysis

The specific approach to phenomenological analysis as advanced by Moustakas (1994) was used to analyze qualitative data. In this study, six steps from the Stevick-Colaizzi-Keen method (Creswell. 1998. 179) were used as follows.

1. Full description of students' own experiences while they are participating in the science program was explored.

2. The statements (in the observation and interview) about how students have experienced the topic were described. These significant statements were listed and each statement was treated as equal. Lists of non repetitive, non overlapping statements were developed.

3. These statements were then grouped into "meaning units". A description of the texture of the experience (what happened)including verbatim examples were written.

4. Structural description of all possible meanings, and divergent perspectives, various frames of reference about the phenomenon, and how the phenomenon was experienced, were reflected.

5. Overall description of the meaning and the essence of the experience were constructed.

6. This process was followed first for my accounts of the experience and then for that of each participant. After this, "composite" descriptions were written.