CHAPTER III

METHODOLOGY

3.1 Research Design

Research is an important tool of expanding the frontiers of knowledge, of investigation and resolving the problems that are challenging various walks of life and issues related to different disciplines and various faculties and for making life more progressive and enriched with outcome of new findings in science and humanities. Research is a process of making use of the scientific method for enhancing the horizons by broadening them to make knowledge all comprehensive. Research makes use of the logical thinking and scientific method for problem solving. The main purpose of research is to gain new knowledge, to adopt a different perspective on the existing body of knowledge to analyze event or approaches, to discover new techniques and processes, new tools, and new theories and through all these activities to expand the boundaries of knowledge and to remove the barriers of ignorance to create the environment that will be suitable to promote the advancement of human life and human outlook on life in general.

Research design includes the following procedures such as (i) the selection of topic of research and the discipline to which the topic belongs, (ii) the survey of the selected topic of research through the understanding of the problem on hand, (iii) to prepare the list and catalogue of research works and materials, (iv) the statement of problem of research and its definition, (v) the
analysis and presentation of the fundamentals of the topic of research, (vi) classification and categorization of the fundamentals of the topic of research on the basis of the research and reference materials, (vii) to ascertain the basic material and supporter evidence in accordance with the fundamentals of the research topic, (viii) to verify the validity of the material or evidence collected, (ix) to make sure of the probable solution of the problem on hand on the basis of material evidence on the research topic, (x) collection of essential material basis for research and collection of information related to the topic of research, (xi) the systematic arrangement and organization of materials collected for analysis of the research topic, (xii) analysis and interpretation of research material and supportive evidence, (xiii) the choice of quotes, references, footnotes, and to use these at appropriate points and, (xiv) preparation and the finalization of the draft of research work and the manner of presentation. These are the procedures of the research design that need to be followed by any researcher.

The methodology of research procedure consists of (i) analysis of the factors related to the topic, (ii) investigation and review of literature of the past on the topic chosen, (iii) inference for the causation on the basis of the review, (iv) positing the hypothesis, (v) collection of materials for verifying the hypothesis, (vi) finalization of the research tools, (vii) organization of the materials, surveys, experiments, theoretical discussion of the topic, (viii) the disciplined code of the use of materials, experiments, (ix) presentation in the methodological manner, use of statistical methods, (x) conclusions based on investigation, experimentation with statistical methods (xi) suggestion and plans of future directions and, (xii) the research method through objective bias and scholarly presentation and analysis. The research design of the present topic is presented in details in the next few sections of this chapter.
The researcher has selected a mixed method for this study. Firstly, the researcher was engaged in studying and analyzing basic information of the problem of study. Then, using the survey method the researcher attempted to find out and analyze the collection of data for the preparation of designing tools. The productive method was used to design tool for learning and teaching. It was used for the construction and development of instruction media on science for grade IX students only through English medium in secondary schools in Thailand. Lastly, the experimental method for testing the effectiveness of the designed tools and the design was used for two equivalent groups; one experimental group and the other control group.

**Survey method:** The survey method gathers data to involve a clearly defined problem and definite objective. The researcher used the survey method for the objective to find out and analyze the higher level concepts on Biotechnology and Biodiversity including problems and solutions in science for grade IX students in secondary school in English medium in Thailand. The survey tools were questionnaire and interview. These served as the most appropriate and useful data gathering device in a product-oriented research.

The questionnaire and interview were constructed by the researcher. These were divided into the following sections that of general information of respondents, teaching and learning in science, utilization of instructional media and using a computer program as a new technology for teaching and learning science, interview of respondent about the higher level concepts in the topics, approval of content validity from experts and research guide, comments and suggestions were collected and improvement was done. The respondents were teachers and students for grade IX students who are learning through English medium only in Thailand.
The population of respondents was of the teacher and students for grade IX students who were learning through English medium in Thailand. There are fifty-seven science teachers and two thousand five hundred students. The researcher selected all the science teachers for population, one science teacher per school. The researcher has given questionnaires to the teachers. After two months the researcher collected questionnaires. For part of interview, the researcher contact directly with the teachers for collecting data. The 345 students were selected out of 2,500. They were selected using method random sampling method as designed by Kerjcie & Morgan (1970) \(^{A-20}\) table. The researcher visited schools in area of study and near, entered the schools for discussion of science content for collection of data. The researcher distributed questionnaires and conducted interview with the sample students in a span of one week. The data obtained from the respondents was taken into consideration during the designing and developing of the SICAP.

**Experimental method:** The experimental method involves the comparison of the effects of particular treatment with that of a different treatment. Reference is usually made to an experimental group and to a control group and to test of hypothesis of the field study. Purposive sampling was used in field study. The researcher selected the students of grade IX who learned through English medium at Benchamaratrungsit II School, Chachoengsao province Thailand. The students of grades IX were chosen as the population for research. This school is near the place of the research and that there are the facilities to coordinate and contact performance of the field study. This school only teaches in English medium. The researcher has been teacher in secondary school and has sufficient experience teaching this class.

The researcher used a pre-test and a post-test for the measurement of the students’ achievement. The subject of the pre-test and post-test was their
understanding of Biotechnology and Biodiversity in science. In the beginning a pre-test was conducted to assess students’ existing prior knowledge of topics. After treatment the students were given a post-test. The two treatment conditions consisted of experiment in which an experimental group learned by self-instructional computer assisted program (SICAP) and a control group learned by traditional method. The treatment was of four weeks duration for both groups. Similar schedule was followed for both groups. This was done to avoid carry over effect of one teaching strategy into other.

3.2 The Product-Oriented Research

The product-oriented research was the type in this research, meaning the production of new knowledge and related to the production of new objective. Its main motivation and goal was of using area learning and teaching. It combined the application of theories of learning and technique design on material related to the presentation. In design, the researcher used mixed method; i.e. survey method and experiment method in field study. The survey method was used to find out and analyses the collected data for preparation of the design of product of research. It was the necessary resource for designing and giving guidance and opportunities. Creating the product for field study based on the data of the survey combined the concepts and theories of learning. After the construction of the product, it was evaluated for checking by expert’s comments. Then, for testing the effectiveness of the product by experimental method the design of two equivalent groups was used. The experimental group learned by the product research and the control group learned by tradition method. Learning theory is an attempt to describe how to people learn, thereby helping to understand the inherently complex process of learning. The theories do not give us solutions but
they do direct our attention to variables that are crucial in finding solutions. There are three main categories of philosophical framework under which learning theories fall; Behaviorism; focuses only on the objectively observable aspects of learning, Cognitive; looks beyond behavior to explain brain-based learning, and Constructivism; views learning as a process in which the learner actively constructs or builds new idea or concepts.

The team of the product-oriented research considers learning through problem a teaching method and learning process, to be the concepts of self-Instructional material. The research work was taken up with the objective to develop material technology. The technology in this field is increasingly oriented toward using computer to help solve difficult problem for the design of the product-oriented research “Self-Instructional Computer-Assisted program”. Principles of design are applied in such a way that these resemble the real teaching by focusing on the presenting of the content and arranging the activity of learning from interacting through the concept theories of learning for Self-Instructional Computer-Assisted program. The researcher has applied the learning theory to Self-instruction Computer-assisted program (SICAP) to modify by identifying learning objectives, providing learning experiences to develop knowledge, skill and attitudes, which will result in effective learning according to objectives. It also provides an accessible, interactive, and flexible way of giving multimedia presentation that utilizes textual materials, visuals, sounds and motion. Computer programs complement conventional teaching while providing a means for students to learn at their own pace
3.3 Theories of Learning

The fundamental psychological principle involved in the product-oriented research is that the researcher has to focus on the students’ need by developing them holistically. Therefore, the researcher has studied and analyzed information through the resource of concepts and theories of learning for the type of research based on learning theory.

Skinner’s theory (1968) strongly emphasized positive reinforcement throughout his writings. Early studies indicated that punishment only temporarily suppressed behaviour. Later studies did indicate that punishment can be effective. In general, a combination of strong positive reinforcement for a correct response and mild punishment for an incorrect response has been found to provide optimal support for learning. The learning strategies involved are concerned with presentation of materials and questions, hints and help messages to assist the students as needed to achieve the correct answers, followed by reinforcement of the correct response.

Gange’s learning theory (1979) view identifying learning objectives, providing learning experiences to develop knowledge, skill and attitudes, which will result in effective learning according to the educational objectives. The main concepts of Gagne’s learning theory are to encourage students to have direct experience in learning the subject matter and to be enthusiastic in furthering their studies. Based on the constructivism, the researcher has developed the production-oriented research by employing in organizing learning so that students can construct knowledge by themselves.

Bandura’s Social learning theory (1977) social learning theory has attempted to combine cognitive psychology and principles of behaviour
modification with its own special emphasis on the person in the social setting with all of the resulting ramifications. His view in regard to observational learning as, “Most human behaviour is learned observationally through modeling: from observing others, one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as guide for action.” He pointed out that observational learning is governed by four component processes: (1) attention, (2) retention process, (3) conversion of symbolic representation into appropriate actions, and (4) motivational processes.

There are many in human development, and the researcher reviewed in theories learning on which is general theoretical agreement. The major concept of skinner’s theory (1968) A-26 operates conditioning. The main idea of Gagne’s learning theory (1979) A-13 is to encourage students to have direct experience in learning the subject matters and to be enthusiastic in furthering their studies. Indeed, the main idea of Bandura’s social learning theory (1977) A-1 is to encourage students to apply work and change their learning from knowledge receivers to become knowledge seekers and users. In each case, the researcher attempted to relate these concepts to SICAP courseware design and indicate appropriate instructional strategies.

3.3.1 Principles of designing SICAP follow the concept of theories learning

Principles of designing SICAP have been applied in such a way that they resemble the real teaching strategy. Three major theories of learning are behaviorism, cognitivism, and constructivism. These theories can be described as philosophical paradigms or patterns that affect decisions about designing, as follows:
(a) **Behaviorism:** Behaviorism is an orientation in psychology that emphasizes the study of observable behaviour. It grew out of an attempt by early psychologists to make the study of behaviour more objective. The researcher has studied the concept of Skinner (1968) who strongly emphasized positive reinforcement throughout his writings. Early studies indicated that punishment only temporarily suppressed behaviour. In general, a combination of strong positive reinforcement for a correct response and mild punishment for an incorrect response has been found to provide optimal support for learning.

In respect of application in SICAP, the researcher has followed the conceptual framework of Skinner (1968) behaviorism that positive reinforcement should consistently follow each occurrence of the desired response until the selected level of mastery is reached. Although, behaviorist Skinner himself had little to say about punishment for wrong answer, most of his followers now accede that a mild punishment, a penalty such as a reduction in score, following an incorrect response can be beneficial to learning. Skinner’s illustration of how to develop a programmed learning sequence is directly applicable to the design of SICAP, which is listed as follows:

1. Obtain a clear, detailed objective specification of what it means to know the given subject matter.
2. Write a series of information, question, and answer frame that expose students to the material in graded steps of increasing difficulty and frequently retest the same facts from many different angles.
3. Require the learner to be active, i.e., require a response for each frame.
4. Provide immediate feedback for each answer.
5. Try to arrange the material and questions in such a manner that the correct response is likely to occur and be reinforced, i.e., avoids errors, so that learning is not accompanied by punishing failures.
6. Permit students to proceed at their pace.
7. Provide ample back up reinforcement (praise, merits) for diligent and effective work.

The application of these views on the importance of student control is especially helpful when considering the design and development of tutorials. In this type of learning situation, the computer plays the role of the adviser, and the learning strategies involved are concerned with presentation of materials and question, hints and help messages to assist the students as needed to achieve the correct answers, followed by reinforcement of the correct responses.

(b) Cognitivism; - Cognitivism theories are based on information-processing models. These are concerned with how individuals gain knowledge and how they use it to guide decisions and perform effective actions. These theories try to understand the mind and how it works. To achieve this, they view the computer as model of the brain and employ much of the terminology and concepts of information processing. An important concept which is contained in some cognitive theories is the executive control process. This process controls cognitive strategies relevant to learning and remembering its relation to such important activities as controlling attention, encoding of incoming information, and retrieval of stored data.

In respect of the application in SICAP, the researcher has followed the concept of Gange’s learning (1979) aspects of the cognitive theory which are stated as follows;

1. Gain attention; - SICAP should gain attention starting from presentation. It means with the presentation of the title. Therefore, the
use of different media combined will increase the interest of the learner.

2. Specify objective; - In the process of learning, objectives should be specified with the learning objective, so that the learner would know the expectation from studying. It is the process of summarizing the lesson in all the frame corners of the content. In presentation, the learning objective may show one by one on the screen, and every time the presentation should be made interesting by using of simple graphic, but do not use the animation for presentation.

3. Activate prior knowledge; - Before, starting with the new lesson, it is essential to revise the previous knowledge, so that the learner does not face any problem in learning. They are made ready to take in the new knowledge. For SICAP, it used the pre-test in checking the knowledge of the learner.

4. Present new information; - In presentation of the content on SICAP, it should start with the picture related to the content including short and easy explanation that touches as the maximum essence of the information which will create firm and strong remembrance than by just giving explanation. For the difficult concept, it should be explained in steps and continuously in the course of the content.

5. Guide learning; - In designing of SICAP, the programmer should attempt in such a way which will help the learner to understand the relation with the previous knowledge of the learner by creating meaningful learning in which the learner should analyze and interpret the new information along with base of previous knowledge together with new knowledge which is more distinctive and better understandable. Therefore, the designer may use the process of guide
discovery for the learners to find out, analyze the answer themselves which is another technique in leading the learner to learn.

6. **Elicit response;** - Leaning process will be more effective if the learner has an interaction with SICAP which will stimulate elicit response from the information. The learner should have taken into an activity related to the content and while answering the question it will increase the learner’s remembering capacity. SICAP can be designed for the learner to attach with activities such as game, which will add the interesting components for the learner.

7. **Provide feedback of the information;** - In providing feedback the interest of the learner is stimulated. It should be done as soon as the learner has found an interaction with SICAP by telling the learner whether the answer is right or wrong. The question and answer should stand on the same base which may be in the form of picture or sound.

8. **Assess performance;** - When the learner finishes studying, test must be conducted which may called as post-test, which is a measurement of study.

9. **Review and Transfer;** - Lastly, in the process learning should conclude the sum of all the content mainly the important points including different suggestions, so that the learner can review the content that had already been studied or other relevant source as a method of manipulation.

(c) **Constructivism;** - Philosophers of constructivism believed that knowledge is what human beings have created in their minds by trying to make sense or construct meaning out of events or experiences by using their former knowledge, beliefs, and expectations in interpreting meanings and understanding
all things. Consequently, knowledge is new reality but only attainable through reasonableness and best concurrent knowledge. (Trowbridge and Bybee, 1996)

In respect of the application in SICAP that the organizing of learning should be based on the constructivism approach that consists of the following major components, as listed below;

1. Associating former knowledge with new knowledge.
2. Constructing the concept of new knowledge.
3. Checking new knowledge.
4. Applying new knowledge to various situations.

It thus can be concluded that the constructivism approach is an approach to learning that emphasizes students’ building up new bodies of knowledge which associates existing new knowledge with their available former knowledge. Teachers are simple helpers who provide experience.

The Department of Curriculum and Instruction Development 2002 recommended that science learning in Thailand should be based on constructivism and that students should inquire, seek, investigate and check, and search for knowledge by various means. Students will have a relevant understanding and perception of that knowledge. Students then build up their own body of knowledge which will be processed and kept in the brain for a long time restored when they encounter immediate problems. Hence, it is obvious that students are able to build up their body of knowledge when they are required to pass through various learning processes, especially the inquiry process.

The researcher has developed the SICAP by employing constructivism in organizing learning so that students can construct knowledge by themselves. Indeed, the main ideas of the constructivism approach are to encourage students
to apply the ways scientists work and to change their orientation from being knowledge receivers to become knowledge seekers and users.

The designing and application of SICAP on teaching and learning should take into important consideration for its successful implementation the stage that are arranged as follows; -

1. **Nature of the learner;** Each learner will have different characteristic in a general way and also specific character of each learner. General character of learner includes; sex, age, thinking method, learning method, social, economical and culture. Though, these points are not related to the content of the lesson, but this information helps the teachers to take decision in choosing the level which is in a way related to the main content of the lesson as well as conversing, and teaching method.

2. **The rate of developing the lesson;** is controlling the level of learning the content, type of concept, determining the rate of developing including the following three formats of program; -

   2.1 **External-paced program.** The program should be designed to use control in determining the goal, objective, condition in learning, steps in learning and rate in development of study depends upon the program. The program is also significant in determining the success of the learner.

   2.2 **Self-paced program or leaner control.** The learner should be free and may choose the method of studying, determine the goal, objective, condition, step by themselves. The rate of development depends upon interest and capability of the learner, so that the learner is enabled to attain his own success.

   2.3 **Combination of program and learner.**

3. **Cueing.** It will help in pulling and attracting the interest of learner.
4. Format of presentation.

5. Method and activity. These are divided into arrangements of individual learning and small group.

6. Feedback. It is one of the main components of designing and developing computer program because it plays the main role in increasing the effectiveness of learning.

3.4 Population and Sampling of the Study

3.4.1 Population;

The population in this study is all science teachers and students who are engaged in grade IX students teaching and learning in English medium secondary schools in grade IX students. The totals are fifty-seven secondary schools with Government recognition in English medium in Thailand. All the fifty-seven teachers and two thousand five hundred grade IX students are teaching and learning in secondary schools in English medium in Thailand.

3.4.2 Sample; -

Sample of survey method; The sample of respondents was of the teacher and students for grade IX students who were learning through English medium in Thailand. There are fifty-seven science teachers, one science teacher per school and two thousand five hundred students. The 345 students were selected out of 2,500. They were selected using method random sampling method as designed by Kerjcie & Morgan table.
Sample of experimental method; The sample for this study was the grade IX students studying science subject at Benchamaratrungsrit II School in Thailand. The selection of the school is based on purposive sample method of field study. The finally selected total one hundred students were divided in two classes of grade IX which means that one class had fifty students (1 class: 50 students); fifty students of control group and fifty students of experimental group.

Table 3.2: Number of experimental method for sample of students in the two groups

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<thead>
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<th>No.</th>
<th>Groups</th>
<th>Number of students</th>
<th>Method</th>
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<tbody>
<tr>
<td>1</td>
<td>Control</td>
<td>50</td>
<td>Traditional method</td>
</tr>
<tr>
<td>2</td>
<td>Experimental</td>
<td>50</td>
<td>SICAP</td>
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</table>

These were chosen as the sample of interest for reasons stated below:

- The researcher has cooperation in providing facilities by both authority and teachers.
- This school imparts instructions through English medium and has maintained a well equipped support computer-lab for students.
- The nature of the research task and its application to the groups concerned.
3.5 Developing Self-Instructional Computer-Assisted program (SICAP)

Self-instructional Computer-assisted program (SICAP) begins the design of the program of learning and teaching. The design of Self-instructional Computer-assisted program (SICAP) is key element of design which includes both; Instruction design and technique design on computer program. Instructional design is the practice of effectiveness and appeal of teaching and learning due to the application of learning theory. The technique design on computer program is related to the presentation on monitor so that the color, sound, and text are required to be consistent with learning theory. The development of SICAP was divided in stages, with details as given below;

Stage 1; Studying and Analyzing documents and related studies

Self-Instructional Computer-Assisted program (SICAP) is created for grade IX students. The program is designed for students to learn understanding of Biotechnology and Biodiversity. The researcher has studied and analyzed relevant documents as follows;

- The basic Education Core Curriculum A.D 2008 related to science for grade IX students.
- Concepts and theories of learning applied in the design of materials, based on Behaviorism by Skinner (1968)\textsuperscript{A-26}, Cognitivism by Gange’s learning theory(1979) \textsuperscript{A-13}, Constructionist approach by Trowbridge and Bybee (1996)\textsuperscript{A-30}
- The teachers’ guide and study plan, the content of science textbook for grade IX students.
- The additional books of publishers both domestic and overseas, websites that are related to the studies.
Stage 2; Studying and analyzing the need of teachers and students

The study revealed useful information for creating as well as recording recommendation from the teachers and students to find out and analyze the higher level concepts of Biotechnology and Biodiversity in Science for grade IX students studying in English medium in Thailand. These factors were taken into consideration during the development and improvement of SICAP.

The researcher has constructed the questionnaire and interview for survey secondary science teachers and students who are teaching and learning in science by means of SICAP, including problems and solutions. The questionnaire and interview were divided into the following sections:

Section 1; General information of the respondents
Section 2; Investigation and analysis for teaching and learning in science
Section 3; Investigation and analysis for utilization of instructional media and using a computer program as a new technology for teaching and learning in science
Section 4; Interview the respondents about the higher level concepts of Biotechnology and Biodiversity topics which the respondents need for teaching and learning in science

The students are three hundred and forty five respondents out of two thousand and five hundred students who are learning in English medium in Thailand. The teachers are fifty two respondents from fifty seven teachers who are teaching science in English medium in Thailand.
Stage 3; Developing of Self-Instructional Computer-Assisted program (SICAP)

This stage was to construct SICAP based on the result of the studies in the first and second stage. Two steps were carried out in Step1; Creating the Self-Instructional Computer-Assisted program (SICAP), and Step2; Evaluation and Revising SICAP according to the experts’ comments.
Figure 3.1 Developing a Self-Instructional Computer-Assisted program (SICAP)

1. Selection of Problem
2. Finalization of the higher level concept from Biotechnology and Biodiversity topics in Science
3. Content analysis as per objectives
4. Discussion the content with the guide and experts
5. Script writing and Design storyboard for SICAP
6. Creating the program with Authoring System Window version 7.0
7. Checking and Revising by the experts’ comment of educational technology
8. Pilot study
9. Suggestions
10. Experimentation

1. The content of subject by typing in words document and save (.doc) file.
2. A picture and animation from internet.
   - www.google.com/imghp/th/
   - www.wikipedia.org/
   - www.science-animation.org/
   Using Snag IT and save (.BMP) file.
3. Sound effect and music; using sound recorder and save in (.WAV) file.
**Step1: Creating the self-instructional computer-assisted program (SICAP)**

The researcher has created the content on topics by designing teaching strategy using the theory of learning based on the requirement of teachers and students. Apart from that the researcher may use making program in the form of Authoring system featuring the use according to the maximum required point, most important, the easiness of program in forming complicated work and mostly popularly used. The program SICAP has prepared by programmer. SICAP as follows;

1. Collection of the content related to Biotechnology and Biodiversity based on requirement of teachers and students together for using for grade IX students. More details are added from the textbooks of publishers domestic and overseas.

2. Script writing was divided the content in group from easy to difficult model, pictures, animation and sound corresponding to the content such as descriptive sound, music before starting the lesson etc.

3. Storyboard explaining the relationship and link from one content to another covering the entire unit. Using a media that is corresponding to the content and explanation of details used in storyboard. The combining into the media of teaching such as message, graphic or picture presentation, animation for matching the content of subject, different practical work which is descriptive for checking related knowledge frame and type of media. The forty-one frames are illustrated in the storyboard. The frame of the program is characterized by the major components of the program. Steps in creating a storyboard;-
3.1 Prepare a picture and animation from internet source;
- www.google.com/imghp/th/
- www.wikipedia.org/
- www.science-animation.org/

Using SnagIT program capture picture and save in (.BMP) file. In creating a picture edited and improved it to modify for making it interesting and understanding of students in the framework.

3.2 Prepare sound effect or music that startles the senses with auditory or visual stimuli corresponding to the content using sound recorder and save in (.WAV) file.

3.3 Prepare the content of subject by typing in word document file.

3.4 The structural pattern of the program the following details will be required.

- The first slide presents the title of the self-instructional computer-assisted program (SICAP) on Biotechnology and Biodiversity, that is, self-instructional computer-assisted program (SICAP) on Biotechnology and Biodiversity.
- The second slide has the formal function through which the use of the different buttons for different functions is presented, and
- The third slide is intended for the learner to enter his/her name and the formal feature “Welcome” to the program
- The fourth slide has introducing test and explaining that which consisted of thirty multiple choices with four alternatives in which the
test acts to rotate to be capable of preventing the student to remember the test, when students answer the question whether correctly or incorrectly it will give different sound feedback and record students performance after the test. **If the students do not perform well in the pre-test, so the students will not pass into the units of study and the post-test after it.** This is an important point of pre-test.

- The fifth slide has information the objective of learning
- The next few slides carry out the formal functions mainly about the use of the program.
- Pretest is provided as a multiple choice test that students have to do before learning. The result by recording the mark the teachers to follow after.
- The first topic which is that of Biotechnology. There are seven which offer the contents of the topics. And next, the fifteen slides are the sub-test of topic.
- The second topic is on Biodiversity. There are eight slides of contents. And, the fifteen slides are sub-test of topic.
- Post-test is provided a multiple choice test that students have to do after learning when students finish performing all of them the program will give immediate result by recording the mark the teachers to follow after.
- Activities are practices as exercises. It provides four activities which student can do as Biotechnology and Biodiversity and different kinds of activities are included; true or false, drag and drop, and match the word helping the students to practice and revise the lesson.
- **Active 1 and Active 2 (True or false)**; the students should read the sentence. If the sentence correct click once in block, so that the sentence wrong will double click in block.
  - Active 1; Biotechnology
  - Active 2; Biodiversity

- **Active 3 (Drag and drop)**; the students must move the sentence and drop in empty block.

- **Active 4 (Match the word)**; the students read the sentence. And then, the students select the word and put in empty block of the sentence.
  - The last slide is exit of program learning will be easy, if the students wants to come out from the program learning will be button such as Yes or No, when coming out of the program will shut down immediately.

This is how the program is designed and constructed for carrying out the self-instructional computer-assisted program (SICAP).
Figure 3.2 The program SICAP on Biotechnology & Biodiversity

Start

Using the control bottom of SICAP

Type your name and Press Enter to continue

Introduction of SICAP

Objective of Lessons

Menu

Objectives  Pre-test  Learn  Active  Post-test  Exit

Biotechnology  Content  Exercise

Biodiversity  Content  Exercise

Active 1

True or False

Active 2

True or False

Active 3

Drag and Drop

Active 4

Match the word

Yes

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<td>4</td>
<td>Deoxyribonucleic acid (DNA)</td>
<td>9</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>5</td>
<td>Benefic of Biotechnology</td>
<td>10</td>
<td>√</td>
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<tr>
<td></td>
<td></td>
<td>11</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>14</td>
<td>√</td>
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<td>6</td>
<td>Public opinion on Biotechnology</td>
<td>15</td>
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</table>
Table 3.4: Detail of Unit II Biodiversity

<table>
<thead>
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<th>No.</th>
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<th>Picture</th>
<th>sound</th>
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<tr>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Definition</td>
<td>1</td>
<td>√</td>
<td></td>
<td></td>
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<td></td>
<td>2</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Classification of Organisms</td>
<td>3</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>√</td>
<td>Diagram</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vertebrates &amp; Invertebrates</td>
<td>5</td>
<td>√</td>
<td>Diagram</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Vertebrates; Fish, Reptiles, Mammals, Amphibians, Birds</td>
<td>7</td>
<td>√</td>
<td>Diagram</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Classification of plants</td>
<td>8</td>
<td>√</td>
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<td></td>
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<tr>
<td>6</td>
<td>Flowering of plants</td>
<td>9</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Monocotyledons</td>
<td>10</td>
<td>√</td>
<td>√</td>
<td></td>
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<tr>
<td>8</td>
<td>Dicotyledons</td>
<td>11</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Non-flowering plants</td>
<td>12</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Maintaining Biodiversity</td>
<td></td>
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</tr>
</tbody>
</table>
Step 2: Evaluation and Revising SICAP according to the experts’ comments

The Self-Instructional Computer-Assisted program (SICAP) was checked for its content validity, by the experts for each area; the content and technology. Both fields should correspond and covering the entire requirement for measuring.

1. Result of Evaluation Checklist by Experts.

The five-point scale of 5 means Excellent, 4 means Good, 3 means Average, 2 means Fair, 1 means should be modified for evaluation. Evaluation form (Online: [www.moe.go.th.stm/cai06.htm](http://www.moe.go.th.stm/cai06.htm))
Table 3.5: Result of Expert’s evaluation Checklist on Content

<table>
<thead>
<tr>
<th>No.</th>
<th>Topic</th>
<th>Experts’ scores</th>
<th>total</th>
<th>$\bar{X}$</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Expert. 1</td>
<td>Expert. 2</td>
<td>Expert. 3</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Content is relevant in accordance with behavioral outcome</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>2.</td>
<td>Content validity</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>3.</td>
<td>Validity in content coherence according to step by step structural arrangement</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>4.</td>
<td>Content relevance in each step</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>5.</td>
<td>Clear explanation for content</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>6.</td>
<td>Clarity in content summary</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
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<tr>
<td></td>
<td><strong>Total Scores</strong></td>
<td>25</td>
<td>26</td>
<td>25</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td><strong>Mean Scores</strong></td>
<td>4.17</td>
<td>4.33</td>
<td>4.17</td>
<td>12.67</td>
</tr>
</tbody>
</table>

### Image and Language

|     | Validation in image use                                             | 5         | 5         | 4         | 14      | 4.67    |
| 7.  | Validation in Language use                                          | 5         | 4         | 4         | 13      | 4.33    |
| 8.  | Relevance between image and narration                               | 5         | 4         | 5         | 14      | 4.67    |
|     | **Total Scores**                                                     | 15        | 13        | 13        | 41      | 13.67   |
|     | **Mean Scores**                                                      | 5.00      | 4.33      | 4.33      | 13.67   | **4.57** | Good    |
Table 3.6: Result of Expert’s evaluation Checklist on Technology

<table>
<thead>
<tr>
<th>No.</th>
<th>Topic</th>
<th>Experts’ scores</th>
<th>total</th>
<th>( \bar{X} )</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Expert. 1</td>
<td>Expert. 2</td>
<td>Expert. 3</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>An appropriate format to gain attention</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Specify objective statement is very interesting</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3.</td>
<td>Information and guideline in using lesson</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Simplicity and interesting aspect in using lesson</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
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<td>Total Scores</td>
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<td>17</td>
<td>18</td>
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<td></td>
<td>Mean Scores</td>
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<td>4.50</td>
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<tr>
<td>5.</td>
<td>Content validity / principle</td>
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<td>4</td>
<td>5</td>
<td>13</td>
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<tr>
<td>6.</td>
<td>Relevance to objective of lesson</td>
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<td>4</td>
<td>4</td>
<td>12</td>
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<td></td>
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<tr>
<td>7.</td>
<td>Relevance to curriculum / overall relevance</td>
<td>3</td>
<td>3</td>
<td>4</td>
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<tr>
<td>8.</td>
<td>The length of content and lesson is suitable for the level</td>
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<td>4</td>
<td>5</td>
<td>13</td>
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<td></td>
<td></td>
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<td>15</td>
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<td>( \bar{X} )</td>
<td>meaning</td>
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<td>9</td>
<td>An appropriate use of using image / sound / graphic</td>
<td>5 5 5 15</td>
<td>5.00</td>
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<td></td>
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<td>10</td>
<td>Font side and format of letter / alphabet</td>
<td>5 4 5 14</td>
<td>4.67</td>
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<td>11</td>
<td>An appropriateness of using color in designing screen</td>
<td>5 5 5 15</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Quality of image / graphic / sound and animation in lesson</td>
<td>5 5 5 15</td>
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<td>13</td>
<td>The total of screen design</td>
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<td>Techniques in presentation showing the continuity of content</td>
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<td>4.67</td>
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<tr>
<td>15</td>
<td>Providing an opportunity to the leaner in direction control and slow/ fast learning</td>
<td>5 5 4 14</td>
<td>4.67</td>
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<td>16</td>
<td>An assistance or suggestion when learner needs</td>
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<td>An explanation or concept summary is done in appropriate time</td>
<td>4 4 5 13</td>
<td>4.33</td>
<td></td>
<td></td>
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<tr>
<td>18</td>
<td>Language use is short, concise and suitable for the level of learner</td>
<td>4 4 4 12</td>
<td>4.00</td>
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<td></td>
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<td>19</td>
<td>Providing suitable sample in appropriate time</td>
<td>4 4 4 12</td>
<td>4.00</td>
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<td>20</td>
<td>The quantity of data for presentation is each screen</td>
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<td>4.33</td>
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<tr>
<td>No.</td>
<td>Topic</td>
<td>Experts’ scores</td>
<td>( \bar{X} )</td>
<td>Meaning</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>total</td>
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<td>21.</td>
<td>The presentation is accorded with the learning process of Syllabus</td>
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<td>56</td>
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<td><strong>Time</strong></td>
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<td>Appropriateness of time with content</td>
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<td>Appropriateness of time with narration</td>
<td>4</td>
<td>4</td>
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<td>Appropriateness of time in presenting all lessons</td>
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<td>4.67</td>
<td>4.00</td>
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</tr>
<tr>
<td><strong>Interaction and Feedback</strong></td>
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<td>25.</td>
<td>Giving an opportunity to learner to participate in lesson</td>
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<td>5</td>
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<td>15</td>
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<tr>
<td>26.</td>
<td>Variety and appropriateness of format of interaction</td>
<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>27.</td>
<td>An appropriateness and right according to principle of feedback</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
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<tr>
<td>28.</td>
<td>Concise and clarity of question and instruction or suggestion in answering questions</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>No.</td>
<td>Topic</td>
<td>Experts’ scores</td>
<td>( \bar{X} )</td>
<td>meaning</td>
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<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>total</td>
</tr>
<tr>
<td>29.</td>
<td>Questions are accorded with objective</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22</td>
<td>21</td>
<td>22</td>
<td>65</td>
</tr>
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<td></td>
<td>Mean Scores</td>
<td>4.40</td>
<td>4.20</td>
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<td>Others</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>Easy to install program or operate</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>31.</td>
<td>Give an opportunity to learner to have options easy for use</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>32.</td>
<td>An appropriateness of program with other current</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Mean Scores</td>
<td>4.33</td>
<td>4.67</td>
<td>4.33</td>
<td>13.33</td>
</tr>
</tbody>
</table>

2. Evaluation SICAP by the experts’ comment in field of the content on Biotechnology and Biodiversity found that quality as good as explained below:

- **In the field of content:** It is evaluated if it is thorough and covering the objective, if it explains the content clearly, correctly and also if the test paper is corresponding to the objective. Distribution of content is appropriate; presentation is in procedure which is modernized and interesting. Practical content is appropriate but also some contents are too difficult and not appropriate for the level of education.
- **In the line of picture;** it is noticed if the use of screen picture is using screen picture consisting of appropriate size, corresponding to the content and the use of correct language and symbol, containing clear sentence and sound stimulation the interest of students.

- **In application;** it may promote the motivation in studying and possible in teaching instead of teachers.

- **Suggestion;** If given for improving SICAP found out that glossary or the definition pertinent to the subject matter should be explained behind each unit, some content should be adjust for correctness and clarity creating the interest in student and motivation in learning. The researcher has adjusted according to the suggestion given by the expert for increasing the effectiveness of SICAP

3. Evaluation SICAP by the experts’ comment in field of the technology found that quality is as well as explained below:-

- **In the field of picture and animation:** It is evaluated if it does help for understanding the content, picture use consist of appropriate size, message is clear and corresponding to the content.

- **In the field of Sound;** It is evaluate if it clear and distinct, related, stimulation the interest.

- **In the field of designing;** It is evaluated if continuous, the length of different unit presented is appropriate, learner can control the level of study in good form, designing of the screen is appropriate, size, alphabet color and background use in content is appropriate and clear. The designing of program is easy and appropriate for the interaction with students.
- **In arranging the content:** It is evaluated if contents are clear and distinct explanatory content of the lesson, continuous presentation giving the opportunity for the learner to control by themselves of the process question and answer. In using program it is convenient, estimation if the result is appropriate which is different and sufficient, most importantly do the learners get an immediate feedback of their result.

- **Suggestion:** as given by the experts in this field that SICAP needs improvement that is in the explanation which is small and not distinctly clear. The researcher has improved according to the suggestion given by the experts.
3.6 A pilot study

The researcher has carried out the pilot study of the Self-Instructional Computer-Assisted program (SICAP) on Biotechnology and Biodiversity for checking the feasibility and to improve the tools of research before the main research. The Self-Instructional Computer-Assisted program (SICAP) on Biotechnology and Biodiversity was test piloted with students who are not selected as the same experimental group and control group. These were three steps to try out. The researcher has applied concepts to improve the SICAP (Espich & William. 1967: 75-79). For testing, the program learning before using in SICAP that has been created so that it matches with the specific requirement, recording on CD-ROM for testing with the a pilot students.

3.6.1 Objectives of pilot study:

1. To find out the useful of SICAP on Biotechnology and Biodiversity for individual, small group, and field group
2. To find out its effectiveness of SICAP on Biotechnology and Biodiversity for grade IX students.
3.6.2 Procedure of pilot study:

1. The Individual Trial

In individual trial testing; the format of testing individually for finding the drawback of different line of SICAP; clarity of presentation, clarity of picture for feedback, the students provide faulty and opinion of the lesson by interviewing with the students. The trial was carried out with only one student. The student was assigned to do a pre-test. And then the student was learned science on Biotechnology and Biodiversity via self-instructional computer assisted program (SICAP). While the student was studying through the self-instructional computer assisted program (SICAP) on Biotechnology and Biodiversity, the student was asked to do the exercises. After that, the student was asked to take a post-test. The scores student obtained from a pre-test and a post-test were calculated to find out the effectiveness of respectively. Then the researcher improved the self-instructional computer assisted program (SICAP) following the students ‘comments.
2. **A small group Trial**

The three students were participated in this step. They were asked to do pre-test before learning science on Biotechnology and Biodiversity via self-instructional computer assisted program (SICAP). While the students were studying through self-instructional computer assisted program (SICAP), they did the exercises from the lesson. Then they were asked to do a post-test and give some opinions. In the step of a small group try out, the effectiveness of the process were calculated from a pre-test and a post-test. Then the researcher improved the self-instructional computer assisted program (SICAP) following the students ‘comments.
Figure 3.4: Steps of trying out (SICAP) on a small group Trial

3. The Field Trial

The ten students were participated in this step. They were asked to do pre-test. Then they learnt via the self-instructional computer assisted program (SICAP). They did the exercises and the post-test. The pre-test and the post-test scores from the field study try out were determined to find out the effectiveness of the self-instructional computer assisted program (SICAP)
**Figure 3.5:** Steps of trying out (SICAP) on Field group

1. **Create SICAP on Biotechnology and Biodiversity**
2. **Examined**
3. **Field group**
4. **Evaluate the effectiveness of the SICAP on Biotechnology and Biodiversity**
5. **Students’ comment on SICAP**
3.7 Result of a pilot study

The researcher tried out the SICAP for checking the feasibility or to improve the tool of research before the main research. There were three trial steps to evaluate SICAP such as individual trial, a small trial, and field group trial.

Table 3.7: The three trials of the pilot study

<table>
<thead>
<tr>
<th>Trial steps</th>
<th>Pre-test (%)</th>
<th>Post-test (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual trial (1)</td>
<td>42.23</td>
<td>56.67</td>
</tr>
<tr>
<td>A small group trial (3)</td>
<td>41.30</td>
<td>70.74</td>
</tr>
<tr>
<td>Field group trial (10)</td>
<td>42.23</td>
<td>82.90</td>
</tr>
</tbody>
</table>

Figure 3.6: Result of the effectiveness of SICAP of pre-test and post-test
3.7.1 The result of SICAP tried out

1. Individual trial; The self-instructional computer-assisted program (SICAP) had the effectiveness on the 56.67% of post-test.

Student’s comment; -

- Changing of topic each unit too difficult because the closing of current topic before opening the program for studying the new content. The researcher should relate content of different unit together, so that the students may open the content without closing the program.

2. A small group trial; The self-instructional computer-assisted program (SICAP) had the effectiveness on the 70.74% of post-test that higher than scores of individual trial.

Student’s comment; -

- The content that are difficult and more than specification of learning and utilize time in understanding. Therefore, the researcher should modify the lesson and also the test again before testing in next step.

3. Field group trial; The self-instructional computer-assisted program (SICAP) had the effectiveness on the 82.90% of post-test in final test of trial steps after individual trial and a small group trial.

Student’s comment;-

- Sometime, the scores obtained from doing the test may be incorrect. The researcher has modified by giving add the command to deleted scores to be zero before doing the test the next time
3.7.2 Feedback of the Pilot-study

The feedback from the try-out groups indicated overall satisfaction on the design and instructional material included in the SICAP specially designed on Biotechnology and Biodiversity. The researcher has modified SICAP according to the suggestions given by the experts and research guide. There are some suggestions an animation in particular of specimens presented. This feedback is a general comment on the improvement of the material presented. This feedback will be taken into account in designing the program two subjects and the summative test is that the items need to be expanded. This will help the learners to gain confidence in understanding the concepts and making it more clear and exact through more of exercises added to the present design.

The feedback which is specifically obtained is in the form of comments by the pilot study of the individual trial, a small group trial and field group trial. The first comment is that the change from one unit to the preceding or the succeeding unit is rather difficult. The principle of continuity of material in a sequence is disturbed because a new unit cannot be opened before the current unit is closed. This is a valid comment. The self-instructional computer assisted program (SICAP) enables the learner to learn at his own pace and in his own convenient method. The progression forward and the movement backward are essential in such a program. This mobility is blocked by the device of looking the next unit before the current unit is closed. The simultaneous placing of one unit with the other is bound to enhance the understanding of the concepts. This will enable the learner to grasp the topic in its entirety and also in its compartmentalization. The researcher has duly made the correction in the program. This comment necessarily emphasized the significance of the feedback of the field-trial. This comment was duly looked into and implemented and this gave the uniform
pattern of sequential continuity to the content material of the program for learners.

The second comment is from the second small group of three students. The comment is on the content that is difficult. It is more than the specified time and unit for understanding the concept. This point was even in the general comment already discussed. Breaking up of informative units into smaller bits and giving more time for adjustment and understanding of the content is the point raised by the comment. The researcher has carried out certain adjustments in the present program. The program when revised will incorporate the improvements suggested by the groups of students who took the field-trials. The improvements carried out on the basis of the comments are sequential continuity through adjusting the program, removing the discrepancy of incorrect scored and the content unit and time adjustment. The feedback of the pilot study has incorporated some changes and has given directions for the future and further improvement in self-instructional computer assisted program (SICAP)

The third group comment is in the feedback is equally significant. It is a technical hitch. The scores obtained from the test indicated incorrect responses. The researcher duly corrected the technical error in the program. The add command was inserted in the program. The deleted scored were to be shown and the change to zero. This removed the discrepancy of incorrect scores shown. It is a minor hitch, but the comment from the group of individuals is valuable to make the program fool-proof. This brings out the fact that the real test of pudding lies in tasting it and so the real test of instructional design lies in its actual execution of the groups chosen for the field trials. In using program it is convenient, estimation if the result is appropriate which different, most importantly do the learners get an immediate feedback of their result.
3.8 Tools of study

3.8.1 Questionnaire and interview;

Questionnaire and interview in the study were the tools which were used to find out and analyze the higher level concepts of science for grade IX students. These were constructed by the researcher, scrutinized, and criticized by experts and research guide, suggestions were collected and due improvement was carried out. The questionnaire and interview objectives are to find out and analyze the higher level concepts from Biotechnology and Biodiversity topics from science for grade IX. These were divided into the following sections:

Section 1; General information of the respondents
Section 2; Investigation and analysis for teaching and learning in science
Section 3; Investigation and analysis for utilization of instructional media and using a computer program as a new technology for teaching and learning in science
Section4; Interview about the higher level concepts on Biotechnology and Biodiversity topics that the respondents need for teaching and learning in science

Preparation; - The questionnaire and interview were constructed and developed step by step as follows:

1. The researcher has studied how to construct the questionnaire and interview in the field study
2. The researcher has collected and arranged the issues with regard to the higher level concepts on the topic chosen.
3. The researcher has constructed four sections based on the compilation of the higher level concepts on the topic chosen.
4. The questions and interview were examined by experts and research guide with validity suggestions, the comments and suggestions have been collected and due improvement have been carried out.

**Evaluation:-**

1. Checking the content validity by the experts; the student respondents are 345 out of 2,500 students who learned through English medium in Thailand. The teacher respondents are 52 from 57 teachers who taught science in English medium in Thailand

### 3.8.2 Pre-test and Post-test

Pre-test and post-test is the achievement test. The achievement tests attempt to measure what students has learned till then and what is that his or her present level of a performance. The achievement tests scores are used in placing, advancing, or retaining students at particular grade levels. In research, the achievement tests scores are used frequently in evaluation of the influences of courses of study, teaching methods and other factors considered to be significant in educational practice. Pre-test and post-test have been constructed and administered on two equivalent groups by the researcher. Each test consisted of same thirty multiple choice questions. The main objective of pre-test was to examine the achievement level of the students in science content before the experiment. The same test was administered on two groups as a post-test. The main objective of the post-test was to examine the achievement level of the student in science content after the experiment.
Preparation; - The researcher has constructed the achievement test by the application of the following steps;

1. The researcher has studied and analyzed the objectives of science learning and the content of science from the science curriculum, measurement document and textbook of science on Biotechnology and Biodiversity for grade IX students.

2. The researcher has constructed the test about Biotechnology and Biodiversity that consisted of thirty multiple choices with four alternatives. It was of thirty marks and of one hour’s duration test.

3. The items of the test have been checked for content validity by the experts and research guide and accordingly the content have been improved and corrected.

Evaluation;-

1. Checking the content validity by the experts.

3.8.3 Self-instructional computer assisted program (SICAP)

Self-Instructional computer assisted program (SICAP) on Biotechnology and Biodiversity in Science has been designed and constructed by the research following the steps detailed below:

Preparation;-

1. The researcher has studied content and objectives the higher level concepts on Biotechnology and Biodiversity in science for grade IX students.
2. The researcher has designed storyboard of the self-instructional computer assisted program (SICAP).
3. The researcher has designed and created the self-instructional computer assisted program (SICAP) by using internet, multimedia and animation.
4. The researcher has evaluated the effectiveness of the self-instructional computer assisted program (SICAP).
5. The self-instructional computer-assisted program (SICAP) has been tested as pilot study with grade IX students at Benchamaratrungsarit II School who were not selected in the same sample groups for the efficiency.

Evaluation:-

1. Checking the content validity by the experts in the field of science teaching and learning, and the experts from the field in educational technology.
2. Testing pilot three times with students of same standard but who were not to be included in the finally selected sample groups for the effectiveness
3.9 Procedure of study

Figure 3.7: the procedure of main study

Finalization of the problem of study

Finalization of objectives

Review of the related literature regarding

To find out the higher level concepts on Biotechnology and Biodiversity in Science for grade IX students

To analyze the higher level concepts on Biotechnology and Biodiversity in Science for grade IX students

Developing a Self-Instructional Computer-Assisted program (SICAP)
Science test for sample selection based on previous knowledge
1 control gr. 50 sts and 1 experimental gr. 50 sts.: sample 100 students

Pre-test

Control group (50sts.)  Experimental group (50sts.)

Implementation of the Self-Instructional Computer-Assisted program

Post-test administration for 2 groups
1 control gr. 50 sts and 1 experimental gr. 50 sts.

Data collection

Statistical analysis and interpretation of data

Conclusions and Suggestion
3.9.1 The procedure of the main study;

The procedure of study is a step by step presentation of procedure of carrying out the research activities related to the topic of research. The procedure chat out the fourteen steps of the present research topic in carrying out the procedures, processes, methods, activities, experiments and investigatory analysis. The first step is the finalization of the problem of study. The research regarded the problem of present that;(1) the students of grade IX cannot understand when the teacher explained on content; (2) Time no enough for the teachers to explain on the content;(3) Nowadays almost teachers have over load work for teaching on Science subject;(4) The teachers need a new technology media as assisted instruction. The second step is the procedure in the research method is the finalization of objectives. The researcher begins with defined learning objectives. It concludes with a plan to reach those objectives. This plan specifies the instructional events and materials that will provide the condition for leaning. Instruction is planned by curriculum, teachers, instructional designers, and students. The third step is the review of literature of the past which is presented in the relevant sections of the second chapter of the present study. The resources of the review of literature were the Basic Education Core Curriculum B.E 2551 (A.D 2008), Educational research, Results of studying from theses and dissertations, and theories learning emphasized on theory of behaviorism, cognitive and constructivism from texts, and handouts presented in educational conference. The fourth step is to find out the higher level concepts of Biotechnology and Biodiversity in science for grade IX students. The researcher used the survey method attempted to find out the collection of data. In the case of the present research this step is carried out and the same is presented in brief for preparation next step. The fifth step is to analyze the higher level concepts on Biotechnology and Biodiversity in science for grade IX students. This analysis is
duty carried out by the present researcher and the analysis is the basis of the experiment that has been used for testing and verifying the hypothesis of the present topic of research. The program is present which shows how the studied analysis of the contents of Biotechnology and Biodiversity topic is attempted by the researcher. The **sixth step** is developed a self-instructional computer-assisted program (SICAP). This step is evidently completed in the preparation and finalization of the program. The **seventh step** is science test for sample selection based on previous knowledge for one control group of fifty students and one experimental group of fifty students making the sample of one hundred students. This is implicit in the finalization of selection of groups for field work. The **eighth step** is pre-test which further leads. The **ninth and tenth** steps of test of the self-instructional computer assisted program (SICAP) for the experimental group of fifty students and the target control group of fifty students more. The experiment is carried out through pre-test and instructional sessions. The new teaching technique and new teaching materials are introduced and put for application in actual classroom situation. The **eleventh step** is administration. The **twelfth step** is post-test administration for two groups of one control group of fifty students and one experimental group of fifty students. After the implementation of the post-test, the experiment is over. The post operative work begins which is of the next few steps. The **thirteenth step** is data collection. The **fourteenth step** is statistical analysis and interpretation which is carried out in the final portion of the present research work. The **fifteenth step** is of conclusion and suggestions which is duly carried in the last chapter. All the steps have thus been carried out as demanded by the discipline of the methodology of educational research.
Figure 3.8: Research design step of Experimental method

Selection two equivalent groups (Sample 100 students)

Control group
(50 students)

Experimental group
(50 students)

Pre-test

Traditional Method Treatment

Experimental (SICAP) Treatment

Post-test

Data Collection

Statistical Evaluation & Interpretation

Conclusions
3.9.2 **Explanation;** Research design step of Experimental method

The flowchart of research design step of experimental; equivalent-group, shows that the flowchart has five steps.

**The first step** is selection of two equivalent groups (sample one hundred students). The sample of one hundred students was chosen through these two groups of fifty students each with the experimental group of fifty students and the control group of fifty students. **The second step** is the pre-test administration for two groups of one control group of fifty students and one experimental group. **The third step** of the research experiment. After pre-test both the groups were given training through their corresponding methods. The control group was given traditional method treatment and the experimental group was given experimental SICAP treatment for a period of four weeks. After, the sessions were carried out in the traditional and in the self-instructional method. **The fourth step** of post-test was conducted and then, it was followed by the next step. **The fifth step** is collected data. **The sixth step** was statistical evaluation and interpretation. The learning outcome and the pre-test, exercise and post-test scores were evaluated, interpreted and statistical methods were used for further analysis. **The last step** is conclusions.
### 3.10 Time table

**Table 3.8:** Time table of four weeks experiment per day three hours for every group

<table>
<thead>
<tr>
<th>Week</th>
<th>Content</th>
<th>Activities</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| 1<sup>st</sup> | 1. Pre-test  
2. Learning objectives | Pre-test | 1. Results from doing a pre-test.  
2. Results from doing a pretest on SICAP |
| 2<sup>nd</sup> | 1.Genetic engineering  
2.A genetically Modified Organisms (GMOs)  
3. Cloning  
4. Deoxyribonucleic acid (DNA) | L & D | |
| 3<sup>rd</sup> | 1. Benefits of Biotechnology  
2. Public opinion on Biotechnology  
3.Definition of Biodiversity | L & D | Checking the exercise on Biotechnology |
| 4<sup>th</sup> | 1. Classification of Animals  
2. Classification of plants  
3.Post-test | L & D  
Post-test | Checking the exercise on Biodiversity  
Results from doing a post-test |

**Note:**

1. L & D means learning and doing in the SICAP for experimental group, and learning and doing in the worksheet for control group.
2. Teaching Materials; A multiple choice pre-test and post-test with 30 questions, the textbook about Biotechnology and Biodiversity.

3.11 Statistical analysis

The statistical devices employed for data analysis were:

- mean ($\bar{X}$)
- standard deviation (SD)
- t-test