CHAPTER III

METHODOLOGY

Introduction

From the limitation of research study in teaching and learning genetics of disadvantaged students in Thailand welfare schools, the research aims to survey teaching and learning genetics in disadvantaged high schools in Thailand from biology teachers and students who have learned genetics in high schools; to survey genetics concepts of disadvantaged high school students who have learned basic genetics and will next learn molecular genetics; to study the results of teaching and learning molecular genetics in genetic concepts and communication skills of disadvantaged students after implementing molecular genetic instructional units which are based on social constructivism in disadvantaged high school classrooms.

This chapter will review the research methodology, including the investigation of the existing situation of teaching and learning genetics of disadvantaged high school students in welfare schools of Thailand, and the implementation of genetic instructional units.

To concern ethics in this research, the researcher did not refer to the names of students, teachers, and welfare schools which joined in the research. For coding in this research, the name of each school is represented by an English alphabet, such as ‘A’ and ‘B’. For student’s code, ‘AM01’ refers to the first student who is male in school A, and ‘AF14’ refers to the fourteenth student who is female in school A. The ordering number of each student depends on their ordering in the regular name list in their schools.

Interpretive Paradigm

The interpretive paradigm is a way of trying to understand real situations which happen to real people in the real world (Cohen and Manion, 1995: 36-38; Neuman, 2003: 76) and does not accept any techniques which prepare people before they meet the real situations (Husen, 1988: 7). Thus, an interpretive paradigm is a way of trying to understand and interpret how people create and maintain their social worlds (Neuman, 2003: 76). Interpretive research starts from a small point and moves to a broader frame. It explains specific events in-depth, details meaning and the researcher thus tries to understand the events or situations from the participants' point-of-view.

Interpretative study is concerned with specific issues or problems, which the researcher is interested in. It is a process to help people to understand the world which is changing everyday (Banister et al., 1994: 2-3). From Neuman (2003: 76), for researchers who used interpretive paradigms, the goal of social research is to extend an understanding of social life and to find out the way which people construct meaning in ordinary settings. Interpretivism is relates to the differences between people and the objects of the natural sciences and requires the scientists to take hold of the subjective meaning of social action (Bryman, 2001: 13). It emphasizes the subjective more than the objective. The subjective is "based on your own ideas or opinions rather than facts" (Wehmeier, 2000: 1296). The objective is "not influenced by personal feelings or opinions…or… considering only facts" (Wehmeier, 2000: 873).

The appropriate research paradigm in this research is an interpretive paradigm, since the purpose of this research is to understand the situations in an everyday genetics classroom at high school level, such as teaching and learning. The results of the research will have different contexts, and situations can be different. The researcher has chosen a methodology which relates to the context and the situation in the schools.

Trustworthiness

Qualitative researchers focus on ways to confine a view inside each situation and thus to provide a detailed method to understand events. They are more interested in authenticity than validity. Validity was defined as truthful by Neuman. On the other hand, "*Authenticity* means giving a fair, honest, and balanced account of social life from the viewpoint of someone who lives with it everyday (Neuman, 2003: 185)".

Lincoln and Guba (1985: 304-316) argued that the major components of trustworthiness are internal validity and external validity.

1. Internal Validity-Credibility

Lincoln and Guba (1985: 304-316) replaced internal validity with "credibility", which can defined as the scope to which variations in an outcome (dependent) variable can be ascribed to controlled variation in and independent variable. Similarly, Cook and Campbell (1979: 37) define internal validity as "the approximate validity with which we infer that a relationship between two variables is causal or that the absence of a relationship implies the absence of a cause".

Lincoln and Guba (1985: 304-316 cited Campbell and Stanley, 1963) named the threats to internal validity, which are history, maturation, testing, instrumentation, statistical regression, differential selection, and experimental interaction. History is referred to the specific external events which occur between the first and second measurement. Maturation is referred to the process which is operating within the respondents as a meaning of the passage of time. Testing refers to the effects of taking a test of the scores of a second testing. Instrumentation refers to changes in a measurement instrument or changes in the observers or scores used. Statistical regression refers to tendencies when comparison groups have been selected on the basis of initial extreme scores or positions. Differential selection refers to the effects of comparing fundamentally non-comparable groups. Experimental

interaction refers to an effect which may be mistaken for the effect of the experimental variable.

Lincoln and Guba (1985: 304-316 cited Denzin, 1978) suggest four different modes of triangulation: the use of multiple and different sources, methods, investigators, and theories which can make more enhancing credibility in research findings and interpretation.

2. External Validity-Transferability

Lincoln and Guba (1985: 304-316) replaced external validity with "transferability", which Cook and Campbell (1979: 37) defined as "the approximate validity with which we infer that the presumed causal relationship can be generalized to and across alternate measures of the cause and effect and across different types of persons, settings, and times".

Lincoln and Guba (1985: 304-316) referred to the treats to external validity, which were presented by Lecompte and Goetz (1982), which are selection effects, setting effects, history effects, and construct effects. Selection effects refer to the fact that constructs being tested are specific to a single group. Setting effects refer to the fact that the results may be a function of the context. History effects refer to facts that may militate against comparisons from historical experiences. Finally, construct effects refer to the fact that the constructs studied may be irregular to the studied group.

3. Reliability-Dependability

In qualitative research reliability can be regarded as "a fit between what researchers record as data and what is being researched" (Cohen et al., 2000: 119). They defined reliability as essentially a synonym for consistency and replicability over time, over instruments and over groups of respondents. In detail, it is defined as stability, equivalence, and internal consistency. It is concerned with precision and

accuracy and with the question of whether the results of a study are repeatable (Cohen and Morrison, 2000: 117; Bryman, 2001: 29).

Lincoln and Guba (1985: 304-316) replaced reliability, which is usually tested by replication, by “dependability”. To concentrate on the measurement or assessment process are the ways to check the reliability of dependability. To scrutinize the process of the inquiry and the product of inquiry are the methods to increase dependability. The products of inquiry, which are the data, findings, interpretations, and recommendations can be supported by data and can be internally coherent. Then it establishes the *confirmability* of the inquiry.

4. Objectivity-Confirmability

Lincoln and Guba (1985: 299-300) replaced objectivity by “confirmability”. The normal criterion for objectivity is intersubjective agreement. To be objective means that multiple observers can agree on a phenomenon judgment. The ways of treating for objectivity are not: using imperfect methodologies that make it possible for inquirer values to represent the real data; engaging in inquiry with an explicitly ideological purpose; and relying completely on data which is provided by a single observer. Lincoln and Guba (1985: 299-300 cited Halpern, 1983) proposed six trials methods to enhance confirmability. Using electronically recorded materials (VDO), written field note, unobtrusive measures, and survey results are the ways to collect raw data, to reduce data, and to analyze data which have concerned confirmability.

Case Study

A ‘case study’ is a general term to investigate an individual, group, or phenomenon (Sturman, 1997: 61). Techniques used in the investigation may include both qualitative and quantitative approaches. In a case study, triangulation can be a useful technique (Cohen, et al., 2000: 115). To explain what and why things happen,

to understand a case, requires a thick description and an in-dept investigation (Lincoln and Guba, 1985; Stake, 1995: 102; Sturman, 1997: 61).

Lincoln and Guba (1985) suggested that a case study report should consist of an explanation of the problem, purpose, nature of study, context, methodology, instruments engaged, trustworthiness, and significance of the case and outcomes.

Case study researchers should be concerned with patterning explanations with a rich description of the case, since they can help reader to understand the case and can be used to generalize other cases or other settings.

The advantage of a single case study is that it can be used for generalizations. The case study methodology can be applied to a number of settings or cases in a multi-site case study (Sturman, 1997: 62). Another advantage of a case study is in helping researchers connect the actions of individual people to large-scale social structures and processes (Neuman, 2003: 33 cited Vaughan, 1993).

For data collection, Lincoln and Guba (1985) proposed a number of ways to collect data, such as interviewing and observation. They argued that the purposes of interviewing are: for obtaining information of persons; reconstructions of such information experienced in the past; explain the present, and predict the future by using tape recorders and handwritten notes, etc. In their view, the purpose of observation is to present information in-depth by using videotape recorders, field notes with context maps such as the classroom and the students' movements within it.

For this research data analysis was separated into two main categories. The first one was data from Likert scales, which were coded and analyzed in percentage and described. The second one was data from open-ended questions, which were categorized, grouped and analyzed by interpretation.

Triangulation of sources or methods or investigation is a research technique for data collection and data analysis which is used to decrease the possibilities of error

in qualitative methodologies. A variety of research techniques were used for data collection, unstructured interviewing, participant observation, questionnaires, and the analysis of documentary material (Parry, 1992: 77). This is a way to increase trustworthiness in the research which may include credibility, transferability, dependability, and confirmability (Braud, 1998: 214).

The two following paragraphs are an overview of the research methodology, which was composed of two phases. The first phase was the investigation of the existing situation of teaching and learning genetics of disadvantaged high school students in welfare schools in Thailand. The second phase was the implementation and evaluation of genetic instructional units.

The first phase was done in September to December, 2004. The objectives of the first phase were to study the current situation of teaching and learning genetics to disadvantaged high school science students in welfare schools, and to investigate the prior knowledge of the students in genetics. The information from this phase would be used to develop the genetic instructional units (GIU) for disadvantaged high school science students in the welfare schools of Thailand.

Research Methodology

The methodology of this research is interpretive research, which the researcher describes the results of the study. The study has two phases as follows:

1. Phase I: The existing situations of teaching and learning genetics and the prior knowledge of disadvantaged high school students in the welfare schools of Thailand. This phase of the research is composed of two research questions, which are ‘What are the current situations of teaching and learning genetics to disadvantaged high school science students in welfare schools in Thailand? (in the first semester of the 2004 academic year)?’, and ‘What are the basic genetics concepts held by high

school science students in welfare schools in Thailand? (in the second semester of the 2004 academic year)?'.

2. Phase II: Developing of Genetic instructional units (GIU) and studying teaching and learning genetics using GIU that helps disadvantaged high school science students in welfare schools of Thailand to understand genetic concepts and develop their communication skills. This phase was done January to February, 2005. This phase of the research is composed of two research questions, which are 'How to develop Genetic instructional units (GIU) that helps disadvantaged high school science students in welfare schools of Thailand to understand genetic concepts and develop their communication skills?', and 'What are the impacts of the genetic instructional units (GIU), based on a social constructivist approach, on teaching and learning of disadvantaged high school science students in welfare schools of Thailand?'.

Subjects

1. Phase I: The subjects in investigation the current situations of teaching and learning genetics to disadvantaged high school science students in welfare schools in Thailand were 18 biology teachers and 129 science students from 17 welfare schools which have high school level genetics classes in Thailand.

The subjects for studying basic genetic concepts of disadvantaged students were 157 disadvantaged high school science students who were studying genetics in the 2004 second semester (they had finished basic genetics and will starting on molecular genetics) in 16 welfare schools of Thailand.

2. Phase II: The subjects of students in *Case I* were twenty-three Grade 10 science students in a classroom of a welfare school in Bangkok (School A), Thailand and, in the subjects in *Case II* were eight Grade 12 science students in a classroom of a welfare school in Nonthaburi province (School B), Thailand

Instruments

1. Phase I: *Teachers' Questionnaire Form* and *Students' Questionnaire Form* were used to survey the existing of teaching and learning genetics for disadvantaged students in Thailand. *Basic Genetic Concepts Survey* was used to survey basic genetic concepts of disadvantaged high school students.

2. Phase II: The instruments for collecting students' genetic concepts were *Advanced Genetic Concepts Survey* with unstructured interview of students' responses, *videotape recording*, and *students' journals*. The instruments for collecting students' communication skills were *videotape recording, cassette tape recording, students' journals, observation forms,* and *teacher's journals.*

Instrumentation of *Teachers' Questionnaire Form* and *Students' Questionnaire Form*:

The sequencing of teaching and learning genetics surveys development were:

1. The researcher studied the science curriculum, 'Handbook for Learning Management in the Section of Science' (IPST, 2002), Science 045 (biology handbooks of teachers and students according to the second science curriculum structure in Thailand), Science 048 (biology handbooks of teachers and students according to science structure 3rd in Thailand), basic education curriculum (Ministry of Education, 2001) and related documents for setting teaching and learning frameworks.

2. The teaching and learning frameworks were composed of genetic concept topics, teaching and learning strategies, instructional materials, assessment and evaluation, problems and problem-solving in teaching and learning genetics, which were related to the reviewed documents.

3. The researcher proposed the questionnaires to research committees, which included a genetics expert and two science educators in a university, for content

validation. Then, the researcher edited the surveys after the committees gave feedback.

4. The researcher proposed the questionnaires to three genetic experts in university, for validated content and language. Then, the researcher edited the surveys after receiving feedback.

5. The teachers' questionnaire was trial out with three biology teachers. The students' questionnaire was trial out with five disadvantaged high school students in welfare schools in order to check language used and the time needed for completion.

6. The researcher edited the questionnaires with the committees.

7. The researcher implemented the teachers' questionnaire with biology teachers in welfare schools, and the students' questionnaire with disadvantaged science high school students in welfare schools of Thailand.

The instruments comprised of a Teachers' Questionnaire Formbout teaching and learning genetics for teachers and a Teachers' Questionnaire Formbout teaching and learning genetics for students. The Teachers' Questionnaire Formbout teaching and learning genetics for teachers (Teachers' Questionnaire Form) was composed of 17 questions. The questionnaire consisted of open-ended questions and closed-ended questions using the Likert scale. The questionnaire had two parts. Part A was concerned with the background information of teachers including age, gender, teaching experience, experience in professional development, and their duties in school. Part B consisted of questions asking about the difficulties of genetics topics, including problems and problem-solving in genetics; teaching strategies with instructional materials, assessment and evaluation that teachers had used successively; and suggestions for teaching genetics in high school classrooms of welfare schools in Thailand; and the training topics they would need.

The Teachers' Questionnaire Formbout teaching and learning genetics for students (Students' Questionnaire Form) was composed of 10 questions. The questionnaire consisted of open-ended questions and closed-ended questions using the Likert scale. The questionnaire had 2 parts. Part A was concerned with the background of students including the students' gender, age, grade, and favourite subjects. Part B consisted of questions asking about genetics learning experiences, including the difficulties of genetics' topics; problems and problem-solving in learning genetics; teaching and learning genetics; and suggestions for teaching and learning genetics; and using genetics knowledge in their daily lives.

Instrumentation of *Basic Genetic Concepts Survey*:

1. The researcher studied 'Basic Education Curriculum' (Ministry of Education, 2001), 'Handbook for Learning Management in the Section of Science' (IPST, 2002), Science 045 (biology handbooks of teachers and students according to the second structure of science curriculum in Thailand), Science 048 (biology handbooks of teachers and students according to the third structure of science curriculum in Thailand) for setting genetic concepts in the basic survey.

2. The researcher made a list of genetic concepts at high school level (the fourth level) according to science contents and science content standards.

3. The researcher searched a literature review of alternative conceptions in each genetic concept.

4. The researcher developed question items a 'basic genetic concepts survey' which was related to science content standards and qualities of science students in the handbook of IPST and related to genetic concepts in the former and current curriculum, and literature review. The survey consisted of two-tier multiple choice diagnostic questions and open-ended questions. The 'basic genetic concepts survey' had a total of 15 questions. It was composed of seven concepts; which were

inheritance traits, gene, chromosome, dominant and recessive alleles, genetic diseases, sex chromosome, and genetic engineering.

5. The researcher proposed the surveys to research committees, which included a genetics expert and two university science educators, for content validation. Then, the researcher corrected the surveys after the committees gave feedback.

6. The researcher proposed the surveys to five experts, including two science curriculum developers of IPST and three university-level genetic experts, for content validation. Then, the researcher edited the surveys after receiving feedback.

7. Each survey was trial out with five disadvantaged high school students in welfare school in order to check the language used and time needed for completion.

8. The researcher corrected the survey with the help of the committees.

9. The researcher implemented the survey with disadvantaged high school science students in welfare schools of Thailand.

The instrument was a 'basic genetic concepts survey', which was composed of two-tier multiple choice, 2 diagnostic instrument items and 13 open-ended items, consisting of basic genetic concepts. The basic genetic concepts survey were designed to explore students' basic genetic concepts including inheritance traits, gene, chromosome, dominant and recessive alleles, genetic diseases, sex chromosome, and genetic engineering.

Instrumentation of *Advanced Genetic Concepts Survey*:

1. The researcher studied the 'Basic Education Curriculum' (Ministry of Education, 2001), 'Handbook for Learning Management in the Section of Science' (IPST, 2002), Science 045 (biology handbooks of teachers and students according to

the second structure of the science curriculum in Thailand), Science 048 (biology handbooks of teachers and students according to the third structure of the science curriculum in Thailand) for setting genetic concepts in the advanced survey.

2. The researcher made a list of genetic concepts at high school level (the fourth level) according to science contents and science content standards.

3. The researcher conducted a literature review of alternative conceptions in each genetic concept.

4. The researcher developed an ‘advanced genetic concepts survey’ which was related to science content standards and the quality of science students in the handbook of IPST and related to genetic concepts in the former and current curriculum. The survey consisted of two-tier multiple choice diagnostic questions and open-ended questions. The ‘advanced genetic concept survey’ had 12 questions. It was composed of 11 concepts; which were DNA function, DNA position, nucleotide, chemical components of DNA, DNA structure, DNA replication, DNA transcription, DNA translation, genome, mutation, and genetic engineering.

5. The researcher proposed the surveys to research committees, who are a genetics expert and two university science educators, for content validation. The researcher then edited the surveys after the committees gave feedback.

6. The researcher proposed the surveys to 5 experts, who were 2 science curriculum developers of IPST and 3 university genetic experts, for content validation. The researcher then edited the surveys after they gave feedback.

7. Each survey was trial out with 5 disadvantaged high school students in welfare schools for checking language used and time consumed.

8. The researcher corrected the surveys with committees.

9. The researcher implemented the survey of disadvantaged high school science students of Thai welfare schools.

The advanced genetics survey includes gene and chromosome, chemical structure of DNA, properties of DNA, nature of DNA RNA and protein synthesis, causes and effects of mutation, along with genetic engineering and applications.

Instrumentation of *Observation Form*:

The observation form or observer's recorded paper was adapted from research committees' document. The recording items were teaching followed social constructivist approach, sequencing of GIU, problems and solving problems in GIU classroom, and suggestion.

Instrumentation of *Genetic Instructional Units (GIU)*:

The development of the GIU was based on guiding principles: teaching and learning genetics in Thai welfare schools; basic genetic concepts of disadvantage students in Thai welfare schools; social constructivist approach; promoting student communication skills. The detail of the instrumentation is in Chapter 5.

The genetics instructional units (GIU) included genetics materials [DNA investigation, DNA chemical structure and structure, properties (replication, transcription, and translation)]; genome; mutation; genetic engineering and applications, and molecular genetics science fair; teaching manuals; and students' workbooks.

Data Collection

1. Phase I: The first semester of the 2004 academic year after students had finished genetics basic part at high school level and teachers had some teaching experience in genetics at high school level

1.1 The sequencing of collecting data of teaching and learning genetics was showed as follows:

1.1.1 The researcher asked for the letters for doing research from the Faculty of Education, Kasetsart University. The letters were sent to school participants for cooperation from principles of the schools to distribute the questionnaires to their teachers and students in welfare schools.

1.1.2 The Teachers' Questionnaire Form and Students' Questionnaire Form were sent to 32 biology teachers and 320 high school science students in 32 welfare schools where genetics was taught for science students at high school level from 42 welfare schools in Thailand. (Each school received 1 Teachers' Questionnaire Form and 10 Students' Questionnaire Form)

1.1.3 Telephone calls were used to clarify the responses and to ask for questionnaires from schools which did not send any questionnaires back. Some schools taught genetics at the end of the semester. The students did not pay attention to answering the Students' Questionnaire Form because they were studying for their examinations. In some schools, the number of students was less than ten. Moreover, some schools could not finish their lessons on time. Then, teachers postponed calling students to answer the questionnaire until examination time and some students did not answer the questionnaire.

1.1.4 Responses of Teachers' Questionnaire Form were 18 from 32, which included telephone calls. The response-rate of Teachers' Questionnaire Form was 56.25 percent. For Students' Questionnaire Form, there were 129 responses from 320, a 40.31 percent.

1.2 The basic genetic concepts survey was sent to disadvantaged high school students after finished Mendelian genetics and will start Molecular genetics. The sequencing of collecting data of students' basic genetic concepts at the second semester of the 2004 academic year was showed as follows:

1.2.1 Three hundred and thirty one surveys were sent by mail to 32 out of 42 welfare schools where genetics were taught for science students at high school level in Thailand. Each school received 10 surveys, except for school A and school B which received 23 forms and 8 forms respectively. School A and B the same number of survey forms as science students in their high school program.

1.2.2 Telephone calls were made to the schools which did not send any Students' Questionnaire Form back. Some schools did not have a science program at high school level in the second semester. Some schools taught genetics in the first semester, so there were no subjects to answer the survey form.

1.2.3 The Response of the survey was 157 from 331, or 47.43 percent.

2. Phase II: The second semester of the 2004 academic year after students had finished learning genetics by GIU at high school level and teachers taught genetics using GIU at high school level.

The results of teaching and learning genetics after implementing GIU were collected in the second semester of the 2004 academic year. Videotape recordings, cassette tape recordings, student journals, observation forms, teacher's journals, and advanced genetic concepts survey were used for investigating students' genetic concepts. Videotape recordings, cassette tape recordings, students' journals, teachers' journals, and observation forms were used for students' communication skills.

For the data collection and data analysis, two case studies were conducted to implement and evaluate the molecular genetic instructional units in two welfare schools. After school A changed their teachers' duties, the biology teacher, who had accepted the use of 'Molecular Genetics Instructional Units' in her class could not teach the units. After conferring with 2 Thai advisors and discussing the situations of welfare education schools in Thailand, the researcher taught using the units by herself in school A where she had worked as a science teacher. According to the distance for

collecting data and tracking data, school B was contacted to use the units. The data collection in Case I and II were as follows:

2.1 In case I the researcher as a teacher in school A (in Bangkok), 'Kate', used the instructional units in a Grade 10 science high school classroom. Kate adapted each unit, such as contents and teaching-learning methods, with a teacher who had 6 years teaching experience in high school, along with another expert who taught biology. In case II, before implementing the GIU in School B, 'Marty', a biology teacher in School B, had gathered information on her students' prior knowledge from the basic genetic concepts survey and information on the existing situation of genetic teaching and learning for disadvantaged students in welfare schools of Thailand from the first phase. The instructional units were implemented with 8 Grade 12 science students in a classroom of School B in Nontaburi Province;

2.2 Data in school A were collected by using basic genetics concepts survey and interviews with each student to clarify his/her answers in each concept. The researcher then used the instructional units in school A. In each unit, data was collected by using videotape recordings, cassette tape recordings, students' journals, observer's recorded papers, and teacher's journals. Kate recorded in her journal and interviewed students. The teacher as an expert observed and recorded the classroom in each class when Kate taught in the class. Advanced genetic concepts survey and interviews with each student about his/her answers were used in school. In school B, the research as an observer collected data in the observer's recorded papers;

2.3 Triangulation was used between the advanced genetics survey and student journals for recording the genetic concepts of the high school science students. Triangulation were used among videotape recordings, students' journals, observer's recorded papers, and recorded papers after teaching in each class for recording communication skills in classroom discussion, group discussion, reporting of constructed knowledge to the class, DNA model invention, and presentations in a mini molecular genetics fair. The example topics of student journals included 'what did I learn today?' and 'what do I feel today?';

Data Analysis

1. Phase I: The data analysis of this part of the research was separated into two types. The first one was data from the Likert scales, which were analyzed into percentages and described. The second one was data from open-ended questions, which were read, categorized, and interpreted.

All questions with Likert scale in both teachers' and students' questionnaires were analyzed in percentage and described. Open-ended questions were categorized, grouped, and interpreted.

The researcher studied the congruence of teachers and students' opinions in the difficulties of genetics' topics; problems and problem-solving in genetics; and the congruence of teaching and learning genetics between questionnaires A and B from each of the twelve schools that sent back both of Teachers' Questionnaire Form and B from 17 possible schools. (1 school did not send back Teachers' Questionnaire Form, and four schools did not respond to Students' Questionnaire Form).

For the data analyses of results from basic genetic concepts survey, the researcher read all of the students' responses in each item. Some of educators separated students' conceptions into four, five or six groups. Marek et al. (1990), Haidar and Abraham (1991), and Brickhouse et al. (2000) categorized students into four groups, which were scientific conception, partial understanding, alternative conception, and no response or no understanding or no conception. Westbrook and Marek (1992), Muthukrishna et al. (1993), Lumpe and Starver (1995), Atwood and Atwood (1996), and Haidar (1997) categorized students into five groups, which were scientific conception, scientific partial understanding, scientific and alternative conception, alternative conception, and no conception. Renner et al. (1990), Westbrook and Marek (1991), Abraham et al. (1992), and Lawson et al. (1993) categorized students into six groups, which were scientific conception, partial understanding, scientific and alternative conception, alternative conception, no conception, and no response. Students who were categorized into 'scientific

conception' were referred to as those that understood a concept in the same manner as a scientist. Students who were categorized into 'partial understanding' were those that understood some parts of the scientists' concept. Students who were categorized into 'scientific and alternative conception', were those that understood some parts of the scientists' concept with some misunderstanding about that concept. Students, who were categorized into 'alternative conception', were students who had alternative conceptions in that concept. Students who were categorized into 'no conception' were those did not have any theory or understanding about that concept. Finally, students who were categorized into 'no response' were students who did not answer the question which asked for an investigation of their concept(s).

The researcher classified the students' responses into four groups which were 'scientific understanding', 'partial understanding', 'alternative conceptions', and 'no response or no understanding or no conception' (Marek et al., 1990; Haidar and Abraham, 1991; and Brickhouse et al., 2000). The criterion for categorizing students in each group was as same as in the basic genetic concepts survey categorization. The researcher checked the reliability of the students' conceptions responses with an expert who was a content specialist in a university.

The criteria of the progression of students' communication skills were abilities to participate with their peers and with their teachers, answer questions, write journal entries, present their knowledge or models, and discuss issues with their peers and teachers among learning with GIU. The researcher read, coded, categorized and interpreted student journals, observer's recorded papers, and teacher's journals for data of genetic concepts, and communication skills. Videotape recording and cassette tape recording were transcribed verbatim, coded, and interpreted for data of communication skills. The researcher used data triangulation for analytical information.

2. Phase II: For data of students' genetic conceptions, researcher read, coded, categorized and interpreted student journals. Videotape recording and cassette tape recording were transcribed verbatim and described students' communication skills.

Student journals, observation forms, and teacher's journals were analyzed by read, coded, and interpreted for data of communication skills through answering questions, writing journal entries, presenting their knowledge or models, and discussing issues with their peers and teacher in learning molecular genetics instruction units in the classroom.

For the data analyses of results from advanced genetic concepts survey, students' responses which were categorized into 'scientific understanding' referred to those who understood the concept as same as a scientist. The responses which were categorized into 'partial understanding' referred to those who understood some parts of scientists' concept without any alternative conception. The responses which were categorized into 'alternative conceptions' referred to those who had concept (s) differ from scientific concepts. The responses which were categorized into 'no response or no understanding or no conception' referred to those that did not have any theories or understanding about that concept or did not answer the question which asked for investigating their concept or did not respond at all. The categories of the responses were checked by an expert who was a content specialist.

Summary

The researcher adopted an interpretive methodology for the study given the aim was to investigate the current situation for teaching and learning of genetics by disadvantaged students and develop and implement as teaching unit to enhance student learning. Interpretive paradigm is appropriate when the intention is to track and to understand the real impact of using a GIU. The data collection methods were teacher and student questionnaires on the existing situation for teaching and learning and student basic genetic concepts. The results of the surveys informed the development of instructional units for disadvantaged student learning in genetics. The method used to study the teaching and learning of genetics in two welfare schools was that of case study. In the case studies, data was collected using a concept survey, unstructured student interviews, videotape recording of lessons, and student journals. The use of more data collection methods served to increase the trustworthiness of the

research. The results of phase 1 surveys are shown next in Chapter 4. The results of the phase II classroom implementations are documented in Chapter 6 as case studies.