CHAPTER V

DEVELOPMENT OF GENETIC INSTRUCTIONAL UNITS (GIU)

Introduction

This chapter is development of genetic instructional units (GIU), which is composed of the principles of GIU design, sequencing of GIU development, and genetic topics of the genetic instructional units. This was the second phase of the research study, which was done from January to February, 2005. The objective of the second phase was studying the implications of using the GIU to teaching and learning genetics: including changes and developments in students' genetic conceptions and communication skills.

Development of Genetic Instructional Units

The development of GIU was employed to answer the research questions in the second phase which were: '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?'.

The purposes of this phase are to develop genetic instructional units for disadvantaged high school science students in the welfare schools of Thailand; to explore advanced genetic concepts and the communication skills of disadvantaged high school science students; and to study the implications of using GIU with disadvantaged high school science students in the welfare schools of Thailand.

The GIU were developed to be an alternative choice for teaching genetics with disadvantaged students. The GIU were also developed to relate with the National Education Act (1999, 2nd edition 2002), the Basic Education Curriculum (Ministry of Education, 2001), and the Handbook for Learning Management in the Section of Science for high school students in Thailand; with a focus on the parts of equalities of

a science learner, the science contents, and the science content standards (IPST, 2002:5-9). The main concerns were students constructing their own knowledge, and students learning participation by communicating with peers in groups and in the classroom. This part was presented in three sections; which were principles of GIU design, sequencing of GIU development, and genetic topics of GIU.

1. Principles of GIU Design

Before designing the GIU; the researcher explored the existing situation of genetic teaching and learning for disadvantaged students in Thai welfare schools, along with the students' prior knowledge of genetic concepts which they brought into a genetic classroom. These were the important things to consider before developing genetic instructional units which were suitable for disadvantaged students in each school.

1.1 GIU are Related to Genetic Teaching and Learning in Thai Welfare Schools.

The purposes of the surveys were finding teachers' and students' perceptions about genetic teaching and learning in disadvantaged Thai high schools in respect to 1) difficult genetic concepts for understanding in teaching and learning 2) teaching and learning strategies 3) instructional materials 4) assessment and, 5) problems and solving problems, including teachers' and students' suggestions for genetic teaching and learning. The researcher used the results from the surveyed of biology teachers' and science students' perceptions of genetic teaching and learning to develop the GIU. The results showed that 9 out of 16 concepts, which were 'Dominant and Recessive', 'Homozygous and Heterozygous', 'Genotype and phenotype', 'Chromosome', 'Relationship between Gene and Chromosome', 'Chemical Structure of DNA', 'DNA Properties and DNA Synthesis', 'DNA and RNA in Protein Synthesis', and 'Genetic Codes', were in the same level of difficulty in both teachers' and students' perceptions. For teaching and learning strategies, most of genetics' teaching and learning strategies were teacher explanations, students had

chances to discuss and present in their classrooms. The results showed some teachers identified doing activities in group as a part of successful teaching and learning genetics. Some teachers identified using practical model as instructional materials in teaching DNA structure. The results showed the students need a variety of assessment with dynamic assessment.

The researcher realized that checking students' prior knowledge before teaching each concept is importance. In teaching and learning genetics each concept, teacher should motivate students into the lesson by using a variety of situations; using a variety of teaching strategies to let student thinking and constructing their own knowledge through communication among social interactions. For instructional materials, teacher should use practical instructional materials that students can touch and do activities with more capable peers or teacher. For assessment, teacher should use a variety of dynamic assessment. In this way, teacher can help students when they had alternative conceptions before moving to next concept.

1.2 GIU are Based on Basic Genetic Concepts of Disadvantaged Students in Thai Welfare Schools

The results from the basic genetic concepts survey contained significant information for developing the GIU. The results indicated that the majority of students had: 'Alternative Conceptions' in gene, chromosome, dominant and recessive alleles, and genetic diseases concepts; 'Partial Understanding' in inheritance traits and sex chromosome concepts; and 'No Conception' in genetic engineering concepts. It showed the significance of adjusting students' knowledge before teaching new concepts. The alternative conceptions which student held can be affected to students' understanding next concepts, such as gene and chromosome concepts affected to DNA concept.

1.3 GIU are Based on a Social Constructivist Approach

The GIU developed were based on a social constructivist approach, which was aimed at students constructing their own knowledge by participating with the teacher and other students as more capable experts. The sequence of each unit contained an invitation or motivation, surveying students' prior knowledge, revising students' basic knowledge, activities, sharing ideas with peers, and whole class discussions; which were related to a social constructivist approach, along with the feedback from teachers and students in genetic teaching and learning from the survey (Driver and Oldham, 1986; Perkins, 1999; Cosgrove and Osborne, 2001: 108-110; Gray, 2005). Activities in each unit promoted students' thinking to find suitable explanations for each concept. Each step of the activities and dynamic assessment as scaffoldings to help students develop their Zone of Proximal Development, which is the distance between the actual development level and the level of potential development when they work with a more expert other (Kozulin et al., 2003: 7-8; Gindis, 2003: 207-217). The activities were variable, flexible and with an emphasis on practical activities, which was suitable for disadvantaged students in both average and inclusive classrooms (Palincsar and Klenk, 1992). Worksheets, students' journals and a variety of dynamic assessments were a part of the formative assessment or dynamic assessment of students while they were on the learning path with their peers. The social interactions between students and their teachers were effective ways to assess and develop students' learning. Social issues were raised in the orientation and activities' parts of the GIU.

1.4 GIU are Based on Promoting Student Communication Skills

An important part of the qualities of science students before finishing basic education is that students should have the ability to communicate their scientific knowledge to other people in their society, particularly in the area of making decisions about social issues. The GIU placed an emphasis on students' communication skills, which were the abilities of students to participate with peers and with their teacher, answer questions, write journal entries, present their

knowledge or models, and discuss issues with their classmates and teachers for learning molecular genetics instruction units in the classroom. The activities in each unit had to encourage and give opportunities for students to communicate among others. Language as a tool in communication that students used in their social interaction is a part of scaffolding that teacher set through classroom activities (Osborne, 1996: 60-68). The instructional materials were made to be uncomplicated for students, such as containing clear pictures or concrete instruments that students could touch and do activities with, so they can explain clearly by themselves.

2. Sequencing of GIU Development

2.1 The researcher studied the 'Basic Education Curriculum' (Ministry of Education, 2001), and the 'Handbook for Learning Management in the Section of Science' (IPST, 2002) for setting learning framework genetic contents, along with teaching and learning strategies. According to the curriculum reform in Thailand, the former versions of students' and teachers' handbooks of IPST [Science 045 (biology handbooks of teachers and students according to the second structure of the science curriculum in Thailand) and Science 048 (biology handbooks of teachers and students according to the third structure of the science curriculum in Thailand)] were studied as well.

2.2 The researcher used information from the related researches of education in Thailand and other countries, social constructivist teaching and learning, disadvantaged students, genetics education, genetics alternative conceptions, and communication and classroom interactions; along with the first phase of this research, such as the difficulties of students in learning genetic concepts, teaching and learning in welfare schools, and the basic genetic concepts of disadvantaged students in welfare schools in order to develop the GIU framework. The researcher surveyed the genetic teaching and learning of disadvantaged students in welfare schools, where genetics was taught at high school level. The results of the surveys contributed to the development of teaching and learning strategies, instructional materials, and assessment and evaluation; which was suitable for disadvantaged students in schools

A and B. The researcher surveyed the basic genetic concepts of disadvantaged students in welfare schools, which taught genetics at high school level. The respondents answered the survey after they had studied basic genetic concepts. The results contributed to the development of some activities to adjust students' knowledge before studying to new concepts.

2.3 The researcher developed a GIU framework based on social constructivist approach; which was composed of learning outcomes, genetic concepts, activities, instructional materials, along with the assessment and evaluation of each unit. The framework was related to science content standards, the qualities of science students in the handbook of IPST and the genetic concepts in the former and current basic educational curriculum.

2.4 The researcher proposed the GIU framework to research committees for checking content validity and edited it after the committees gave feedback.

2.5 The researcher developed each unit of the GIU in the Thai language, which were composed of 12 units (18 periods) with instructional materials. (Each period was 50 minutes)

2.6 The researcher proposed the GIU to research committees, who were a genetics expert and two university science educators, for content validity, main ideas, learning activities, and language. The researcher then edited the GIU after the committees gave feedback. The GIU were validated in terms of content, appropriateness of the questions, language used, learning activities, and quality of influence in each unit. The whole units were validated by science teachers, who had experience in teaching science for disadvantaged students in welfare schools.

3. Genetic Topics of the Genetic Instructional Units

The twelve genetic topics of the Genetic Instructional Units consisted of; DNA definition and significance, DNA discovery, DNA chemical components and

structure, Invention of DNA model, Presentation of DNA model, Genome, DNA properties (Part 1: DNA replication), DNA properties (Part 2: DNA Transcription), DNA properties (Part 3: Translation), Mutation, Genetic engineering, and Mini Molecular Genetics Fair. An overview of the Genetic Instructional Units is shown in Table 5.1 below. The overview of activities in each GIU is shown in Appendix C.

Table 5.1 Table of the Genetic Instructional Units

Units	Concepts	Activities
DNA definition and significance	-The nucleus is the center of the controlling system of a cell, which is important in the processing of cell division and reproduction, because the cell has chromosomes which have genetic materials (DNA) inside them. -DNA is genetic material which living organisms can inherit from generation to generation. -Chromosomes are composed of genetic material and protein histone. Each living organism can exchange pieces of chromosome during cell division for reproduction. Therefore, living organisms in the next generation have some parts like mother and some parts like the father.	-Teacher used 'Tsunami' and 'Human finger in fermented meat', which helped to set questions and to raise students' thinking. -Link to students' prior knowledge of chromosomes, DNA, and cell division by using worksheets. -Using daily live issues for problem solving in group -Whole class discussion
DNA discovery	Scientific discovery to confirm that 'DNA is genetic material', including the fact that DNA can be transferred from one living organism to another or can help living organisms transfer their traits from one generation to the next , along with the fact that non living organisms which do not have DNA cannot increase their numbers.	-Using DNA bands for finding millionaire's son links to how scientists' discover DNA and scientists' Nobel Prize experiment -Link to students' prior knowledge of grouping living organisms in each group of the animal kingdom -Using scientific experiments raises group discussion of the discovering of DNA; that is scientific experiments confirm that

Table 5.1 (Continued)

Units	Concepts	Activities
		DNA is genetic material and scientific knowledge can change when we have superior explanations or evidence.
DNA chemical components and structure	-DNA or deoxyribonucleic acid is composed of nucleotides which are two strands in helix (double helix), which are presented as a twisted ladder representing the sugar-phosphate backbones of the two strands and whose rungs represent base pairs between Adenine (A) and Thymine (T), and Guanine (G) and Cytosine (C). -Each polynucleotide is composed of nucleotides, which link by the bonding of deoxyribose sugar and phosphate groups. -The nucleotide is composed of a nitrogenous base, deoxyribose sugar and the phosphate group.	-Refers to DNA discovery and links to studies about the chemical components of DNA. -Do work sheet for finding students' prior knowledge of chemical components of DNA. -Do 'Looking for chemical components of DNA' activity sheet by using plastic models to find components of nucleotide in small and whole class activities -Whole class discussion of the variety of bases in DNA, chemical components of DNA, and DNA structure
Invention of DNA model	-DNA model invention can be used to explain DNA components and structure. Moreover, it can promote group work, in which each number has a responsibility.	-Use a DNA plastic model which students invented in Unit 3, and a DNA paper model for similarity to start the lesson. -Ask questions for revising students' knowledge of chemical components and the structure of DNA -Whole class of students set the criteria for marking their DNA model and invent their own DNA models in each small group -Whole class discussion

Table 5.1 (Continued)

Units	Concepts	Activities
Presentation of DNA model	Scientific discovery has to have reliable reasons, along with imagination. People who have scientific knowledge should have the ability to communicate with other people for understanding theories or principles, which may lead to the discovering of other phenomena. Therefore, after understanding the components and structure of DNA, students should have the ability to communicate their scientific knowledge to others.	-Classroom was decorated by DNA paper models to motivate students into the lesson. -Each group of students presents their DNA models in front of the class and handed in the conclusion of members' responsibilities and budgets to the teacher and also gave points to their favorite presentation(s). -Whole class discuss the chemical components and structure of DNA by considering students' own DNA models
Genome	-Genome is the base ordering of entire DNA in each living organism. -When people can transcribe the entire DNA code from a living organism, they can understand the living mechanism of that living organism, which can lead to medical developing, sanitary, agriculture, and food technology *per se*.	-Revise prior knowledge of bases ordering in students' DNA model. -Use songs from the 'Genomic Music' album for explanation that the music comes from the base ordering of some parts of a *Labrador retriever's* DNA, which is coded with music notes -Group discussion of the different kinds of living organisms will have different tempos, and the meaning and the significance of genomes. -Whole class discussion of the meaning and significance of genomes
DNA properties (Part 1: DNA replication)	-DNA can synthesize itself (DNA replication), which is semi-discontinuous. The new strand has the same structure and series of nucleotide as the template strand.	-Check students' prior knowledge of DNA by putting texts about chemical components of DNA into a DNA structure chart.

Table 5.1 (Continued)

Units	Concepts	Activities
		-Use DNA plastic models with activity sheets for doing a model of DNA replication in each small group. -Whole class discussion of the ordering of DNA replication
DNA properties (Part 2: DNA Transcription)	-DNA acts as a template for the production of RNA. -Transcription is the production of an RNA strand from a DNA template. The RNA strand moves from the 5'-end to the 3'-end. RNA has three types; mRNA, tRNA, and rRNA. -Each group of the three bases in mRNA is called a codon. An anticodon is a three-base sequence in tRNA. Each anticodon matches with a specific codon.	-Checks students' prior knowledge of DNA and RNA -Using the same DNA plastic model which students studied about DNA replication in Unit 7 and 'DNA transcription' worksheet for whole class discussion of DNA transcription
DNA properties (Part 3: Translation)	-Protein synthesis, translation, is the manufacture of a protein with the sequence of amino acids specified by a mRNA molecule. -AUG is the start codon of protein synthesis. -The process of protein synthesis or translation is: tRNA, which has anticodon UAC which carries methionine, moves to match with mRNA, which has codon AUG; 2nd tRNA which has another amino acid, matches with the next codon on the mRNA in ribosome, producing a peptide bond between two amino acids; 1st tRNA separates from mRNA and ribosome, ribosome moves through mRNA from 5'end to 3' end, new tRNA with new amino acid	-Teacher asks questions of codon and anticodon -Students watch videotape of 'Translation and protein synthesis' and write answers on a 'Translation and protein synthesis' worksheet in small group -Using 'V.M. Ingram's experiment' and 'Haemoglobins of people with and without sickle cell anemia' transparencies and 'Proteins with genetic traits' worksheet for whole class discussion.

Table 5.1 (Continued)

Units	Concepts	Activities
	matches with mRNA and produces the peptide bond again and again, until the codon is either UAA or UAG or UGA which are the stop codons of translation.	
Mutation	-Mutations may include base deletion, base insertion, base change, or base inversion, etc. which can be caused by radiation, chemical agents, food or temperature, which are mutagens (mutation-causing agents). -Mutation can be both advantages and disadvantages.	-Teacher asks questions about DNA, bases, and amino acids -Students read and see VCD daily live issues about mutation, such as 'A monkey face child' -Whole class discussion about the causes of mutation; how to protect yourself from mutation; and the effects of the mis-ordering of bases
Genetic engineering	Genetic engineering is the technique for manipulating DNA molecules *in vitro* by cutting target DNA by using restriction enzymes. Then, ligate with vector by DNA ligase, and introduce the recombinant DNA into a host cell for amplification. The recombinant DNA, when transformed into cell, has to replicate itself.	-Whole class talk about Geneic Modified Organisms (GMOs), based on reports from a variety of media -Two groups read 'Plant GMOs' story and two other groups read the 'Genetic engineering' story. Afterwards they can explain their understanding to each other. Each group pair answers 'GMOs and genetic engineering' worksheet -Do activity sheet by using actor cards and situation cards for playing their roles to make decisions about genetic engineering situations in daily life -Whole class discussion of genetic engineering and social values

Table 5.1 (Continued)

Units	Concepts	Activities
Mini Molecular Genetics Fair	Students use their knowledge to construct their artifact(s) with presentations to let other people understand the concept which they want to present in groups.	-Confirm classroom diagram, which shows the position of each group on the board and the set times for preparing places and presentation -Each group of students present their own topics and answer questions from audiences -Whole class discussion on 'Concept map of molecular genetics'

Summary

The design of the GIU was based on the existing situation of teaching and learning genetics in welfare schools, the basic genetic concepts of disadvantaged students in some Thai welfare schools, a social constructivist approach, and an aim to promote student communication skills. The sequencing of GIU development for genetics concepts was from easy to difficult concepts. The genetic topics of the GIU were comprised genetics materials, DNA investigation, DNA chemical components and structure, DNA properties (replication, transcription, and translation), genome, mutation, genetic engineering and applications, and molecular genetics science fair; teaching manuals; and students' workbooks. The GIU was composed of 12 units (18 periods). Each period was 50 minutes. Each unit included an introduction to the lesson using social issues from students' daily lives and that linked students' prior knowledge to new concepts. The GIU was validated in terms of content validity, main ideas, learning activities, and language by the researcher's research committee which included a genetics expert and two university science educators. The GIU was also validated by science teachers who had experience in teaching science for disadvantaged students in welfare schools. The units included a variety of classroom activities with an emphasis on language as a tool for social interaction among peers

and between students and teacher, as per se a social constructivist view of learning. In the conclusion part of each unit, an opportunity is provided for students to conclude genetic concepts in their journals or through discussion and presentation. Group work with groups of mixed genders and abilities was a part of the unit as was the use of concrete instructional materials. The results of the implementation of the GIU are presented in Chapter 6.