CHAPTER VI

RESULTS OF GIU IMPLEMENTATIONS AND DISCUSSION

Introduction

This chapter presents the results and impacts of the implementation of the genetic instructional units (GIU) on the teaching and learning of genetic concepts and the communication skills of disadvantaged high school students in two Thai welfare schools. The units were based on a social constructivist approach.

After checking a sample of Thai disadvantaged students' prior knowledge and alternative conceptions in genetics; and exploring genetics teaching and learning for disadvantaged students, the researcher developed 12 genetics instructional units based on the investigated data and research literature. This was done according to research question 4 and sub-research question 4.1 which were as follows:

> Research Question 4: What are the impacts of the genetics instructional units (GIU) based on a social constructivist approach, on teaching and learning of disadvantaged high school science students in welfare schools of Thailand?
>
> Research Question 4.1: And what are the advanced genetics concepts and communication skills of disadvantaged high school science students in Thai welfare schools after using the genetic instructional units?

Genetic Instructional Units (GIU) Overview

Each unit was based on the principles of GIU design, which were:

1. The GIU were related to the existing situations of teaching and learning genetics in Thai welfare schools;

2. The GIU were based on basic genetic concepts of disadvantaged students in Thai welfare schools;

3. The GIU were based on social constructivist approach;

4. The GIU were based on promoting student communication skills.

The GIU consisted of 12 units, which are shown in Table 6.1 below. These units were planned cooperatively by the researcher and the school teachers.

Table 6.1 Overview of the Genetic Instructional Units

Units	Concepts	Number of Period(s)
1	DNA definition and significance	1
2	DNA discovery	1
3	DNA chemical components and structure	2
4	Invention of DNA models	1
5	Presentation of DNA models	2
6	Genome	1
7	DNA properties (Part 1: DNA replication)	2
8	DNA properties (Part 2: DNA Transcription)	1
9	DNA properties (Part 3: Translation)	2
10	Mutation	1
11	Genetic engineering	2
12	Mini Molecular Genetics Fair	2
	Total	18

Each unit consisted of learning outcome(s), genetic concept(s), teaching and learning processes, instructional materials, and assessment and evaluation procedures.

The Genetic Instructional Units were implemented with disadvantaged students in two separate welfare schools.

Case I of the Implementation of GIU

This section presents the context of school A, including the teacher and students, and the teaching results; learning results; problems of the implementation; along with conclusions.

The Context of Case I

The instructional units were used by the researcher, who was on leave from school A to complete this research. The researcher had graduated from the faculty of Science (B.Sc.) with a diploma in Professional Science Teaching. She had 2 years previous experience of teaching biology in a provincial middle school near Bangkok with financially poor students and on year teaching in school A.

School A was a welfare school in Bangkok, the capital city of Thailand. The school's visions included developing inclusion and promoting knowledge, career professions and ethics. Most students in the school were disadvantaged in some way. Some had intellectual disabilities, were autistic, had learning disabilities, or were hearing impaired. The school was large and included students from kindergarten to high school level with mixed genders. The ratio of students to teachers was 19.4: 1. The ratio of average students to students with disabilities was 7.4: 1.

The high school level (Grade 10-12) had 9 classrooms from out of a total of 75 classrooms in the school. The Science program had only one classroom in each high school level. Non-average students, who attended the science program classroom, should have an I.Q. of 70-90 or should have a hearing ability of 27-85 decibels. Grade 1 and Grade 7 students were checked before attending the program for I.Q. and Grade 7 and Grade 10 were checked for hearing ability. The 2004 academic year was the first to have intellectual disability students in science class at high school level. Students in the school usually left before graduating. Some of the reasons for this were the limited of study time and or the lack of attention to examinations.

In the first semester of the 2004 academic year, Grade 10 students in the science program had a Grade point average in biology of 1.4. The Grade 10 science program classroom of 23 students, who participated in this research, included 14 males and 9 females. The categorization of students is shown in Table 6.2 below.

Table 6.2 Background Information of Students in School A

Code	Disability	Father and mother separated	Financially Poor[c]	Orphan	Did not live with father or mother
AM01[a]	Hearing Impaired				
AM02		/			
AM03		/	/		
AM04			Not stable		
AM05			/	/	
AM06					/
AM07		/	/		/
AM08			/		/
AM09			/		
AM10		/			
AM11	Autism	/			
AM12			/		/
AM13			/		/
AF14[b]		/			
AF15					/
AF16	Intellectual disability				
AF17		/	/		
AF18	Intellectual disability		/		
AF19		/	/		/
AF20			/		/
AF21			/		/
AF22			/		
AM23[d]					

Note: a. AM01 means the first male student in the name list of school A.

b. AF14 means the fourteenth female student in the name list of school A.

c. Financially Poor means parent(s) had a monthly salary of less than 10,000 baht (about 250 USD.), except for AF20 and AF21 whose financial status was calculated from a family monthly payment (Their parents was the same nun in a Catholic church, who had no responsibility for their payments.)

d. AM23 had behavioral problems in previous schools.

From the Table 6.2, most students were poor, living with people who were not their families, or had broken homes. The class was an inclusive classroom; including 2 intellectually disabled children, an autistic child, a hearing impaired child, and 19

disadvantaged students. Twelve of them (more than half) had more than one underprivileged aspect to their background.

The Implementation of Genetic Instructional Units (GIU) in Each Unit of Case I

Before implementing the GIU, the teacher as a researcher surveyed students' basic knowledge, and in each unit of the GIU students were checked for their prior knowledge. A biology teacher observed the class and gave feedback concerning classroom practices to the researcher.

1. Unit 1

The units were based on social constructivism and used social issues to raise students' interest. Students' prior knowledge of DNA, chromosome, and cell division were limited. The limitation of cell division concepts might have been as a result of the ordering of biology topics in the school. The students had not learnt about the process of cell division. The teacher introduced the students into the unit by using a variety of real social situations; such as 'Tsunami', 'Human finger in fermented meat', and 'Miss Jingjai and Mr.Sandee'. The Teacher checked the students' prior knowledge and raised students' thinking by asking questions. The students had chances to discuss in their small groups and with the whole class, to ask questions, and to answer questions. Students used their communication skills by having discussions with their peers and the teacher, along with writing journals to the teacher.

However, the teacher could not finish this unit in 50 minutes (one period). She used one additional period for this unit. Some students were not familiar with talking or discussing with their peers in class. The first unit challenged them to change their roles both in the classroom and in their journals. Most of them wrote journals to conclude their knowledge after learning without suggestions or opinions. Even though most journals showed more understanding of the benefits of DNA, some student sent blank journals back to the teacher. The teacher encouraged students' to

speak out by replying to their journals. When the teacher asked the students for the cause of the blank journals, they said that they did not have any idea how to write a journal in a short time frame. The teacher thus learned to spend some more time on the students' writing. However, AM11, an autistic child who had a speaking problem in his profile, dared to be a volunteer in reading a social situation about DNA to the whole class. It showed that when the teacher gives an opportunity for him to show his abilities, he could learn. The observer agreed on a variety of teaching strategies which could promote students' learning. However, she suggested that the teacher should be stricter in controlling the classroom.

2. Unit 2

The teachers introduced the students into the unit by referring to the Unit 1 activity, where students had to find a millionaire's son by using DNA bands. The teacher stimulated the students' curiosity by showing scientists' Nobel Prize experiments and other experiments (see detail in Table 5.1 and Unit 2 of Appendix C). The teacher explored the students' prior knowledge about the kingdom of living organisms and cell types by asking questions about the categorization of living things before moving onto bacteria and experiments. Some gaps in the students' prior knowledge were met by the use of a transparency and a worksheet on the different cell types. The students had a chance to discuss in small groups to find answers to the displayed questions, and also to discuss the questions and answers with the whole class. Students were encouraged to tell their ideas to their groups' and to the whole class. However, some students preferred to share their ideas in their own group alone. Discussion with peers and the teacher, and writing a journal to the teacher were used to develop students' communication skills.

Student feedback after studying the scientists' experiment showed some interesting points. The unit raised students' understanding of the nature of science, particularly their understanding that science knowledge can change when more correct and trustworthy information becomes available. Moreover, students thought that the scientific experiment was not difficult, but interesting. They thought that a

good scientist is not only a person who has strong knowledge, but should also one who has good observation skills and is open-minded.

The researcher collected some students' alternative conceptions through Focus stage (see detail in Appendix C) using 'Griffith's experiment of *Pneumococcus sp.* type R and S' and 'Avery, McCloid, and McCarty's experiment with protease, RNase, and DNase' transparencies, such as Prokaryotes have cell walls; Prokaryotes have nuclear membranes; Eukaryotes do not have nuclear membranes, and bacteria which have capsules can not be a pathogen of human disease.

The teacher had to challenge students' knowledge by using inquiry technique in order to raise students' thinking and allow them to find the scientific knowledge by themselves in both experimental transparencies (see detail in Unit 2 of Appendix C). An interesting point was that some students switched their answers between prokaryotes and eukaryote many times during the classroom discussions. They accepted that the similarity of specific terms made them confused at times.

3. Unit 3

The students came late to class for unit 3. For this reason, and because she was concerned about the time consumed doing activities, the teacher felt rushed and almost immediately gave the plastic DNA models to begin the 'Looking for chemical components of DNA' activity sheet. The teacher checked students' prior knowledge of the chemical components of DNA before moving to the activity. The students were interested in the pieces of the DNA model and enthusiastic about the activity. The model pieces gave students a chance to investigate the chemical components of a nucleotide by themselves and to investigate the chemical components of polynucleotides and DNA in small groups and whole class activities respectively. The students used their communication skills in discussions with peers in their groups and in discussion with the teacher along with the whole class, in drawing nucleotide pictures, and writing journals for the teacher.

Unit consisted of hands-on activities, with students paying attention to the activities and to their artifacts. They learned to compare their products with their peers. They also learned to co-operate individual products in order to produce a classroom artifact. This was the first step for the students' invention. They learned to work with peers by sharing the same goals. Hands-on activities with interesting learning materials raised the students' participation and learning. The teacher spent one period less than planned on this unit. The observer commented that the activities were interesting for disadvantaged students and that the students seemed to like the activities. However, she wondered how long the knowledge retention for these students would last.

4. Unit 4

The teacher introduced students into this unit by referring to the use of DNA bands in finding the millionaire's son, along with the DNA plastic models from their activities in Unit 3. The teacher allowed the students to compare DNA plastic models and DNA paper models. The teacher checked the students' prior knowledge about the chemical components of DNA. Students had chances to discuss in their small groups in order to create their own DNA models. They asked questions and brainstormed in their small groups about the possibility and budget to invent the DNA models. The students set the class marking criterion and planned their models by themselves. Discussion with peers and the teacher, drawing their DNA models, and writing journals for the teacher were interesting ways to develop their communication skills.

This unit encouraged students who had less confidence through the sharing of their opinions in small groups and through asking questions to the teacher when she walked into each group and listened to the students' ideas. She learned that when she changed her role as a teacher the students changed their roles as well. In other former units, she walked into students group, but only as a role model and some students answered her questions or asked questions to her. In this unit, she was a listener who shared ideas when students explained and discussed their ideas. The activity or

learning processes which encouraged students to present their ideas were strategies for promoting the students' thinking. The teacher's role thus affected the students' role.

5. Unit 5

The teachers started this unit by having the students decorate their DNA paper models, while the teacher went around the class and gave a toffee to each student. She thought that giving stimulus (toffee) to the students should motivate their learning as in Unit 4. However, this time was a small amount of mistakes made. The teacher told the students that the decorating and giving of toffees was a part of that day's activity. However, some students who came into the classroom late ate their toffees before the teacher explained why they had been given them. When she told that the toffees were the way each student gave points to the best presenting group, those who had eaten their toffee were looked down upon by their peers. Each group of students presented their DNA model in front of the class. Other students along with the teacher asked questions and the whole class discussed the models. The students developed their communication skills by asking and answering questions during their presentation periods with their DNA models, together with writing journals for the teacher.

The teacher had to emphasize the importance of honesty to the students, because some of them used their own toffee to add to their group's points. The teacher and the observer agreed to change the stimulus from toffees to other materials which were cheap and could not be eaten. The observer told the teacher that eating in the classroom was a common problem in school A.

During the presentations, the researcher found some alternative conceptions of students which were: Genes are in the base of DNA (AF21); DNA is a component of genes (AF19, AM02, AM11, AM12, and AF22) and DNA is a turned left helix (AF19). Another alternative conceptions were that base codes are A (Adenine), T (Thymine), G (Guanine), and C (Cytosine), which can separate to 64

bases or 20 bases (AF19); Same species received DNA from the same sources, such as half from male and half from female. Then, the same species will have same DNA (AF22). Yet another alternative conception was that bases in humans have almost the same ratio. Suppose that a base has an atom and atomic mass number, the bases thus cannot mix because they have difference rations and are not stable. When the bases are mixed, they will become stable and can stay together (AF22). The teacher corrected students' alternative conceptions by asking questions to prompt students to think and thereby correcting their alternative conceptions by themselves.

6. Unit 6

This unit was composed of introducing, checking students' prior knowledge, inquiry, small group discussion, investigation, and a whole class discussion. The teacher introduced students into the unit by turning on music which was decoded from bases on DNA of living organisms. Students' communication skills were developed by having discussions with their peers and the teacher, together with writing journals for the teacher.

The teacher learned that changing teaching strategies could raise students' learning. Intellectual disability students, a hearing impaired student and students who were not role models paid attention to the music and moved their bodies by following the tempo. One group revealed the problem of having an autism student paired with average students. Most students in the class noticed the situation and looked to the group many times. The teacher had to decrease the stress in the classroom, because everybody in the class worried about the violent emotional behavior of the autism student. He had hit his advisor in the previous semester, when she said something he did not like. The teacher pretended that nothing had happened in the class and tried to keep talking to him about the unit. Then, he neglected his conflict with another student and paid attention to the lesson instead. From that situation in the classroom, the teacher felt quite confident that to teach in an inclusive classroom one needed knowledge about each student along with knowledge about teaching courses for special education.

7. Unit 7

Teachers checked students' prior knowledge of DNA by putting texts about chemical components of DNA into DNA structure charts and linking these to a 'Photo hunt' game for finding the different points in the chart, which is popular amongst teenagers. The teacher gave pieces of plastic DNA model to students. Students had chances to investigate how to replicate DNA by themselves in small groups. They were proud to show their DNA replication models. They taught other groups when their group had finished. Students developed their communications skills by talking with peers in their groups and with the teacher in whole class discussions, together with writing journals for the teacher.

Students in this unit showed they liked to learn with hands-on activities. Some students paid attention to helping their groups when they had seen that other groups had finished. Students who were role models did not deny sharing their ideas by explaining and discussing to others in their groups. They said many times that it seemed like they were playing a game. However, the teacher spent one more period than originally scheduled on this unit. One of the causes of this was teaching the students' correct behavior, such as the polite way to sit and the forbidding of using mobile phones in class.

From the whole class discussion, the researcher found some alternative conceptions of students on of which were that when DNA is replicated, the chromosomes and DNA of the father and mother decreases. Another alternative conception was that when DNA is replicated, both polynucleotides (which are composed of DNA templates), can replicate at the same time. A new DNA was synthesized from 5'end to 3'end, while another one was synthesized from 3'end to 5'end. The teacher adjusted the students' alternative conceptions by asking questions to challenge students to re-think their ideas.

8. Unit 8

The introduction stage of this unit, which involved the teacher asking questions, did not raise the students' curiosity. However, checking students' prior knowledge by matching DNA or RNA in boxes was interesting for the students and could be linked to a whole class discussion. Students at times needed some explanation from the teacher when they read the papers and wrote answers on their DNA transcription worksheets. For the conclusion, some students lead the discussion while the teacher played the role of a supporter. Students used their communication skills by speaking with peers in their group and with the teacher in whole class discussions, together with writing journals for the teacher.

The teacher realized the different learning styles of each student, such when they were listening or presenting. However, students need to learn in a variety teaching methods. They like to change their roles sometimes. Teaching and learning activities should promote students' abilities.

Even though some experts were concerned that the worksheet might be difficult for disadvantaged students at high school level, most students showed their learning ability of answering the questions by sharing their ideas in their groups. However, the teacher spent one more period than scheduled on this unit. Teaching had to stop sometimes, due to students' behavior.

The alternative conceptions which were found in this unit during the whole class discussion were that DNA was not a protein and it may have RNA contaminate with in DNA. That was the way DNA synthesizes protein. Another idea was that RNA was synthesized and sent to the nucleus. The teacher helped students understand scientific concepts by asking questions to let the students think and change their alternative conceptions by themselves, such as 'Can RNA contaminate with in DNA?', 'How can RNA contaminate with in DNA happen?', 'Why do you think like that?'. The examples of whole class discussed that RNA could not contaminate with

in DNA because did not have Uracil in DNA and RNA has to have DNA as a template.

9. Unit 9

Students paid attention to a videotape that the teacher prepared for teaching in this unit. After checking students' prior knowledge by asking the differences between codons and anticodons, other stages of social constructivist perspective followed; which were inquiry, small group discussion, investigation, and a whole class discussion. Teachers asked questions by turning on the videotape of 'Translation and protein synthesis'. Students had to write answers on their 'Translation and protein synthesis' worksheets at the same time. Along the way of turning on the videotape, students had a whole class discussion. Students' communication skills were developed in the learning activities by speaking with others in their groups and with the teacher in the whole class discussion, together with writing journals for the teacher after the class.

The teacher spent two more periods than scheduled on this unit. Some students could understand the concepts after watching the video the first time. However, some of them showed lacked knowledge of DNA transcription. In the second viewing of the videotape, students who had understood after the first viewing started talking and thus disturbed the rest of the class. The observer commented that she had also had this problem in other subjects when using videotapes. However, most students asked to revise their understanding by seeing the videotape a third time after a class discussion. To solve this problem the teacher might have to reserve more time between each viewing of the videotape to allow for student discussion.

The researcher found some alternative conceptions when asking questions to the students which were;

a. RNA can be found in small living organisms, such as grass.

b. Anticodon is three bases on mRNA (AM07).

The teacher adjusted students' alternative conceptions through classroom discussion and allowing them to correct their alternative conceptions by themselves.

10. Unit 10

This unit was based on social constructivism, because it consisted of introducing, checking students' prior knowledge, inquiry, small group discussion, investigation, and a whole class discussion. The teacher used social contexts, such as the 'Strange Tree', 'A monkey faced child', and 'Grilled pork' stories and linking them to the 'Genetic codes table' and mutation. Students developed their communication skills by discussing with peers and the teacher, together with writing journals for the teacher.

The students were interested in the discussions when the unit was linked to social contexts which were real situations in students' daily lives. However, before using the video CD 'The monkey faced child', the teacher had to emphasize about students' wording. Students had to realize that nobody wanted to have an abnormal body. Moreover, they had to realize that they were in an inclusive classroom.

The researcher found students' alternative conceptions when linking concepts in Unit 10 to this unit. The alternative conceptions from Unit 10 were;

a. Protein is synthesized in mRNA.

b. Protein is synthesized in RNA.

The alternative conceptions of this unit were;

a. Amino acids are proteins.

b. The monkey faced child in Thailand was a conseuqnce of genetic transferring.

11. Unit 11

This unit consisted of an introduction, checking students' prior knowledge, inquiry, small group discussion, investigation, and a whole class discussion. The teacher used social issues, planting Genetically Modified Organisms' raising students' idea of planting GMOs plants in their society. Students shared their ideas through their roles by using their knowledge. They developed their communication skills by having discussions with their peers and the teacher, together with writing journals for the teacher. Students learned how to use their values to make decisions on social issues. For example, they learning that having an open-ended mind and co-operating could help society more than being selfish and argumentative.

Students enjoyed playing their roles and learned how to use their knowledge to make decisions and to live with others. The activity did not take too long, but the benefits were obvious as the students adapted their knowledge for use in their everyday lives.

12. Unit 12

For this unit, students had chances to present their knowledge in topics of their choice. The teacher's role was to attend each group and ask questions. Students paid good attention to their presentations. Each group had a presentation board with a variety of games for attendees. They spent approximately two weeks planning for a mini molecular genetic fair in which to make their presentations. They chose 'DNA', 'DNA Translation', 'Genome', and 'Genetic Engineering' for their presentations. The teacher went to their classroom to observe the progression of students' tasks and their preparation three times per week. Students asked questions, discussed and solved their problems with the teacher.

However, the researcher found some alternative conceptions in students' presentations which were;

a. Chemical agents from genetic engineering were left in the modified living organisms and were poisoned by other living organisms, which ate them (Group 2).

b. GMOs is a technique for doing genetic engineering (Group 2).

c. Genetic engineering is a subject of genetic transfer technology (Group 2).

d. Each person has the same genome (Group 1).

e. When DNA replicate, both polynucleotides (which are composed of DNA templates), can replicate at the same time.

f. Each living organism has a different sized and shaped genome (AM12 and AM05).

g. Each living organism has a different size, shape, trait, length, and sequence of genome (AF21).

h. Each living organism has a different shape of bases, but they are the same kind of bases (AM12).

i. All humans have the same sequence of bases (AM12).

j. The size and shape of bases have an effect on the size and shape of living organisms (AM12, AM05).

Examples of the Teaching and Learning During the Implementation of the GIU in Case I

Unit 3 is an example of social constructivist teaching and learning, which teacher promoted student learning linking student prior knowledge and new genetic concept, using meaningful interesting activities, and grouping techniques to promote students' communication skills.

In the case I, Unit 3 provides a representative example of the teaching and learning genetics for disadvantaged students that occurred through a unit that incorporated the social constructivist ideas of linking to student prior knowledge and promoting student understanding through activities and student talk. The teacher began the unit by referring back to concepts from the previous unit and informing students what they would be learning in the current lesson. To link previous concept to next concepts is important for teaching disadvantaged students.

Teacher: From DNA discovery last unit you learnt how to discover DNA. Today you will learn more about DNA. Along the way I will give each of you a pack of plastic models and you will do worksheet no. 4 'Chemical components of DNA'.

Worksheet no.4 was designed to find out students' prior knowledge of the chemical components of DNA. A sample question was, 'What are the components of DNA?'. While the students were doing the worksheet the teacher walked around the room giving a pack of models to each student and checking students' answer. Once most of the students had completed the worksheet the teacher reviewed the answers with the whole class. The worksheet had the scientific name in the left column and a space for students' answers on the right. Students had to tick in the items that they thought they were components of DNA. To use dynamic assessment and checking students' prior knowledge were importance for teaching the students.

Teacher:	We will answer together. The first item, sugar, is it DNA component?
Students:	Yes, it is.
Teacher:	The second one, base, is it DNA component?
Students:	Yes, it is…teacher, phosphate group as well.
Teacher:	Only three of them? What's about acid?
Students:	No, it is not DNA component.
Teacher:	How could you know?
Students:	We read the extra sheets on the back of our book…You told us to read when we have time. Did you remember?
Teacher:	Did you?...That's good. How could they composed into DNA?
Students:	I think they need something to link each other.
Students:	Yes, I agree…but I don't know what it is.
Teacher:	You will know after you join in the next activity.

The performance of students that reading further the lesson was surprised both teacher and observer. The observer who taught this class in the last semester told that normally the students might not read books even for examination. The observer asked the researcher for the sources of the extra reading at the back of the students' handbook. The beneficial of the extra readings, the students told the researcher that all of the extra readings were not too long and easy to understand. In case that they could not understand, they feel free to ask the researcher or post in to classroom discussion.

Once the students had answered all the questions on the worksheet no. 4, the teacher introduced the next activity which was to use the models to explore the components of nucleotides. Activity sheet no. 2 'Looking for the chemical components of DNA' in the student practical book detailed what the students were to do. The students read the activity sheet and then the teacher asked the students to combine all six pieces of the model (1 base, 1 sugar, 1 phosphate and 3 chemical bonds). All of the students were able to do this. Some of them showed their products to the class (see the picture in Appendix F). The teacher then moved on to teach the

name of the product and each of its components. This information was included on Activity sheet no. 2 where it was stated that the product was called a nucleotide and there was a key for the names of each of the component pieces. However, because she knew that some students had reading difficulties the teacher checked student understanding of the components names using the 'Components of nucleotide' transparency. The transparency had pictures of each of the plastic model components in the left column and a space for the scientific name on the right. The teacher asked the students to match the symbol of the chemical component with each piece of model and to give its scientific name. Students pointed to each plastic piece and told the teacher which were its scientific symbol and its scientific name.

When she was sure that all of the students knew the component names, the teacher asked them to draw or explain the product. As the students drew a picture of the model in their hands, the teacher walked around the class checking that the students could identify each piece of the model. She reminded the class as a whole that they needed to identify each piece of the model.

Teacher:	Identify each piece of the model in your picture as well. Students…see the activity sheet with me. In the sheet, it shows that the thing in your hands is called a nucleotide, so what do you think that what are the components of a nucleotide?
Students:	Sugar.
Teacher:	What else?
Students:	Phosphate group.
Teacher:	And?
Students:	Base.

The teacher noticed that a few students did not answer in the whole class and she suggested that students who were unsure 'go back to see your drawing' because the drawings showed both the links among each component of nucleotide and the names of each piece. The teacher spoke softly to a hearing impaired student who had just smiled and said nothing during the class to make sure that he could follow what

was required. She said, ‘Could you follow? If you hear did not clear, you can tell me, ok?’. AM01 nodded and smiled.

The next task was for the students to combine their model with that of their friends using the white or bonding pieces. When the students had done this they told the teacher that the product was called a polynucleotide and some of them taught this word to other students who did not know it.

AM08:	Why did you call it a polynucleotide?
AM12:	Because, it has more than one nucleotide.
AM08:	Yes, I knew that it had more than one nucleotide…but, why did you call it a polynucleotide? How did you know that?
AM12:	…
AM02:	From chemistry.
Teacher:	What do you mean?
AM02:	In chemistry, if you have more than one…it was called poly…
AM05:	We could call it ‘bi’ or ‘di’ in chemistry, if we had only two.
AM03:	Yes, but we had more than three nucleotides linked together in this activity.
AM08:	Oh, I see…Umm, I should not skip chemistry class.

The students then separated out their models. The teacher asked them to find out which bases could match with each other. Once all the students had found their matching base they read and answered the questions on the activity sheet. The teacher checked that the students realized which bases fitted together, asking:

Teacher:	What are your results? Can your nucleotide match with anyone?
Students:	Green has to match with yellow.
Teacher:	What are they?
Students:	Thymine and Adanine.
Teacher:	What’s about Guanine?

Students: It matched with Cytosine.
Teacher: Then, what do you have to do next?
Students: Combine our model with other couples in the white side.
Teacher: Combine it all.

The next step was for the whole class to combine their models as one piece to show how the polynucleotides combine to form the DNA structure. From the activity sheet, students had to twist their model in the clock wise direction. From the sheet, students knew that their model was called 'DNA'. After students twisted their model, one student compared it with a staircase that had been in a fire. Each step of the activities moved from easy to difficult concepts as scaffolding for helping disadvantaged students learn complicated concepts. Moreover, using plastic models as practical instructional materials was another scaffolding to help students learning genetic (Palincsar, 1998; Kiraly, 2000; Bauer et al., 2001).

The conclude of the lesson, the teacher asked questions to probe and clarify student thinking and understanding, such as, 'How many types of bases do we have?'; 'Which ones can combine together?', 'When you have places to step on, what's about the place for hanging?'. Students followed the questions and compared their model and teacher's model. The whole class discussion summed up the lesson ideas as the ordering of bases in DNA varies; each DNA molecule is composed of 2 polynucleotides; each polynucleotide is composed of nucleotides and each nucleotide is composed of a base, a sugar, and a phosphate group.

In this unit, the teacher used a sequence of activities to build student understanding through physical models and discussion. Students worked in pairs, in groups of 5-6 and in the whole class to compose a nucleotide and then polynucleotides and finally a DNA structure. The teacher catered for the disadvantaged students through her use of hands-on activities, physical models and the coupling of reading and drawing with talk. Dynamic assessment and evaluation were used during the answering of the activity sheet and in each step of composing the model. The plastic models in the unit were easy to use and understand which

suited with principles for using instructional materials with disadvantaged students. The seating position of the hearing impaired student was such that he could see the teacher's mouth.

Unit 1 is an example of exploring students' prior knowledge and correcting alternative conceptions of the students. For example, an alternative conception of inheritance traits was that inheritance traits can be transferred from relatives or from older brother or elder sister. When the teacher taught about where DNA comes from, she started with the topic of the transferability of inheritance traits and let students discuss in their small groups and then as a whole class. The teacher also had worksheets about the transferability of DNA from parents to their offspring. The teacher also introduced students to the activity sheet 'Who is the millionaire's son?'. The former alternative conception which she found became the problem issue for discussion, which was, 'Do you think DNA can be transferred from your uncle or your older brother to you?' and 'Why do you think like that?'.

The examples of the inquiries into genome units were shown in the focus stage of Genome Unit (Unit 6), the teacher turned on two songs after explaining that each note melody came from each base in living things.

Teacher:	If the music had notes which were derived from base ordering in a dog and a shrimp, do you think that both of the songs would be similar or different?
Students:	Different.
Teacher:	Why did you think like that?
Students:	They are different animals.
Students:	They have different DNA.
Teacher:	How about music derived from different plants? Would the songs be similar or different to each other?
Students:	Different.
Students:	May I listen to the music?

The teacher turned on song derived from rice and played it for about two minutes.

Students: Wow! It was lovely.

Teacher: Suppose that I play all the entire of the songs together. Did you think that the songs derived from the base orderings of dogs, shrimps, and rice were the same length?

Students: No, they did not have the same length…the tempo of each song was different as well.

Teacher: Why do you think like that?

Student: They have different bases.

Teacher: What do you mean?

Student: They each have a different base ordering.

When students could answer by constructing their own knowledge with the teacher acting as a facilitator, they were proud of themselves and felt free to communicate with others. For example, 'Genomes' was a topic students chose to present in the mini molecular genetic fair in the last unit. One of the presenters on that day was an intellectually disabled child. When the teacher asked questions, her answers were scientific concepts and she answered with confidence.

An example of investigation as an effective teaching strategy was shown in Unit 3 as well. Each student did the activity of composing their own nucleotide by using pieces of plastic models. Then, they had to find out their couples from selected from base in their nucleotides. After that they had to cooperate with other students in the class to build a DNA strand. They enjoyed themselves and felt free to do the activity. Some students, who never talked to each other before in the class, helped each other to compose the nucleotide. They learned that if someone did not finish his or her part, the activity of the whole class would be slowed. The small group discussion was an interesting strategy to use in an inclusive classroom. Disadvantaged students, who were not role model students, paid attention to discussions within their small groups.

According to Gray (2005), which reported that social constructivist teaching could promote a democratic environment in the classroom in which everybody in the classroom has chance to present his/her ideas in small groups or the whole class, which is related to the 1997 Constitution of Thailand that the significance of equity of the people is importance. Unit 4 is an example of the promotion of democracy in GIU classroom.

The following interactions, taken from Unit 4, illustrate the promotion of democracy in the classroom. In this unit students in groups had to create a DNA model. Everybody in the group had a responsibility in this, so they had to choose person who matched with the position. When they were worked together the students proposed a name that suited the position to be taken by a group member through the agreement of the group and the candidate. The following sequence shows how AM12 became chairman of the group.

AF21:	Who should be the chairman of our group?
AM07:	You.
AF18:	Yes, I agree.
AF21:	Really? I don't think so.
AM07:	Why? I think you are a good at student. This position will suit you.
AF21:	Umm, how can I say?...Teacher.
Teacher:	Any problems?
AF21:	I want to say something, but I don't know that I should say it or not.
Teacher:	What is it about?
AF21:	About the position in our group.
Teacher:	Do you want to say to me or want to say to your group in front of me?
AF21:	Umm…I'm not sure.
Teacher:	May I ask you some questions?
AF21:	Yes.

Teacher:	How do you feel to join in this group?
AF21:	I like this group…I mean I feel comfortable to be a member in this group.
Teacher:	So…
AF21:	Yes, I want to say to members, but want to have you here.
Teacher:	Ok. I'm here.
AM07:	What do you want to say, just say it?
AM05:	Yes, you can say anything. If I agree, I will tell you…anyway if I disagree, I will also tell you…just say it.

After AF21 asked everybody that would not angry with her idea, she told that she wanted to have a good work, but did not want to order anybody and also did not want to work alone. Finally, they had a conclusion that they would help each other to do the model, so anyone can be the chairman. After that they decided that the one who suited with chairman position should be the one who could communicate with everybody in the group (included AM01, a hearing impaired child), and did not have responsibility in other subjects. The way that everybody in the group had chances to speak out their ideas, respected others' reasons, and voted the position by respecting group agreement were the ways of democracy classroom.

The Unit 4 and 5 can be examples of teaching disadvantaged students by using small mixed ability cooperative groupings with mixed gender and abilities. The benefits of setting group like that, promoted students performance in their group discussion and presentations (communication skills) which linked to their daily lives.

Groups of students in Unit 4 were small mixed ability cooperative groupings. Each group had 5-6 students of mixed gender and abilities. To create a DNA model in this unit, they had to connect the concept of DNA components in the former unit to the new model they had to develop by themselves with low cost materials. In unit 5, students had to present their DNA model to the class. Each group created their own ways of presentation. A variety of students' abilities in each group affected to a variety of the DNA model and presentation. Each member could show his/her ability

in group work. Some groups of students started their presentation in Unit 5 by referring to the benefits of DNA in social contexts before starting their presentation of DNA model.

AF22: … DNA is important, because we can use it to check for relationships in a family, and to identify a body or germs…

AF19: …DNA is in the nucleus, the nucleus has chromosome, a chromosome has genetics inheritance controlling…DNA or genetic material can use for detecting thief and finding relative…

Setting the students in small groups with mixed gender and abilities appeared to promote the students' communication skills, not only in the presentation but also in reading, speaking, and discussion. For example, in Unit 11, students had to learn by role play as though they were people in the community where genetic engineering was an issue (see details in Unit 11 of Appendix C). They had to present their ideas about the issue using through role play cards and value cards. From this activities, the ability of students in discussion as a communication skill were developed which were presented in Appendix G.

From the above examples, the researcher concluded the Implementation of the GIU in Case I as teaching and learning results as follows.

1. Teaching Results

In this study, to teach genetics with disadvantaged students in inclusive classroom should composed of linking social situations or the former lessons to motivate students into the lesson; checking students' prior knowledge before teaching new concept; using practical instructional materials; teaching each step from easy to complicated one; using a variety of activities, such as inquiry, small group discussions, investigations, and whole class discussion; using a variety of assessment periodically; using grouping techniques with mixed gender and mixed abilities.

2. Learning Results

From the former examples, The GIU could promote students learning genetics in the classroom. This section shows students' prior knowledge before participating with the GIU, the implementation of GIU, along with students' advanced genetic concepts.

2.1 Students' Prior Knowledge

The prior knowledge of disadvantaged students in seven genetic concepts in school A is shown in Table 6.3 below.

Table 6.3 Students' Prior Knowledge in Seven Genetic Concepts

Concepts	Group of Concepts	Number of Students
1. Inheritance Traits	Scientific conception (S)	1
	Partial understanding (P)	**15**
	Alternative conception (A)	7
	No conception (N)	-
2. Gene	S	-
	P	-
	A	**23**
	N	-
3. Chromosome	S	-
	P	2
	A	**19**
	N	2
4. Dominant and Recessive Alleles	S	3
	P	3
	A	**12**
	N	5
5. Genetic Diseases	S	1
	P	9
	A	**12**
	N	1
6. Sex Chromosomes	S	-
	P	**12**
	A	4
	N	7
7. Genetic Engineering	S	-
	P	2
	A	**20**
	N	1

From Table 6.3, most students did not have scientific conceptions in any of the 7 concepts. Most of them had 'alternative conceptions' in gene, chromosome, dominant and recessive alleles, genetic diseases, and genetic engineering concepts; and 'partial understanding' in inheritance traits and sex chromosome concepts.

2.2 The Implementation of the GIU

The GIU promoted students genetic concepts and communication skills of the students. For the communication skills, the students could understand the words of their peers more than the teacher's words. It showed in their sentences in videotape, such as "Oh, I see…umm…it was easier wording" or "I understand your meaning teacher, my friend explained to me". For this study, the researcher used social constructivist learning in the genetic classroom as active learners, such as setting questions, investigation, invention, along with discussion by speaking, writing, and presenting.

Students who attended the GIU classes had the ability to set questions in the class. These were the examples of students' questions in Unit 1 (DNA definition and significance):

a. What is DNA?
b. Where is DNA?
c. What is the function of DNA?
d. What is the full name of DNA?
e. What is the importance of DNA to our body?
f. Do DNA exist only in living organisms?
g. Why do we have to study DNA?

Moreover, the students could set criteria for marking their artifacts, such as in the 'creating a DNA model' activity in Unit 4 (Invention of a DNA model).

To assess students' work on inventing DNA models and giving presentations, the teacher along with the students argued that the criteria should be as follows: DNA model was composed correctly: 3 marks; low cost materials used: 3 marks; creativity: 3 marks; beauty: 2 marks; presentation was composed of the right concepts: 3 marks; responsibility: 3 marks; clear voice: 3 marks. Moreover, the GIU also promoted students' ability in DNA inventions.

The GIU promoted students' investigation in every unit. They investigated information for increasing their knowledge by answering teachers' questions, and answering by reading extra materials.

Students felt free to discuss both in small groups and as a whole class. They showed their agreements or disagreements when the class had discussions. It seemed that starting with small groups was a way to support their ideas before showing them to the whole class.

The GIU encouraged students to be participants in the classroom and also promoted students' communication skills, which applied to both disadvantaged students and special needs students. They had more chances to read (both in class and in extra reading documents), to write (in students' journals, on the board, in worksheets), to discuss (with peers and the teacher) and to present their ideas to their groups and the whole class. For example, the autism child volunteered to read the DNA investigating story to the whole class.

The students showed positive feelings in the units, which were shown in their journals as follows:

"I felt enjoyable, enthusiastic to find answer by myself" (AF22 in Unit 2)

"I enjoy, felt free, and did not felt any stress. Everybody had chances to show their opinions" (AM23 in Unit 2)

"I enjoy in the lesson and had got knowledge much" (AM03 in Unit 4)

"Even thought I felt bored that sometimes someone talked too much in the class, I like and love this subject more." (AF21 in Unit 4)

2.3 Students' Advanced Genetic Concepts

Another purpose of this study was to explore the genetic concepts of disadvantaged Thai high school students in the 2004 academic year after using the GIU. The instrument used was an advanced genetics concept survey, which consisted of two-tier multiple choice diagnostic questions and open-ended questions. Some students were interviewed to clarify their ambiguous responses. Data were analyzed by grouping the responses and calculating the percentages. Therefore the third sub-research question was:

What are the advanced genetics concepts of disadvantaged high school science students in Thai welfare schools after using the genetic instructional units?

The results showed 11 advanced genetic 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. The results showed alternative conceptions in 9 concepts surveyed. The number and percentages of students categorized by each genetic concept are shown in Table 6.4 below.

Table 6.4 Number of Students Categorized by Advanced Genetic Concepts

Concepts	Group of Concepts	Number of Students (n=23)
1. DNA function	Scientific conception (S)	**13**
	Partial understanding (P)	9
	Alternative conception (A)	1
	No conception (N)	-

Table 6.4 (Continued)

Concepts	Group of Concepts	Number of Students (n=23)
2. DNA position	S	4
	P	7
	A	-
	N	**12**
3. Nucleotide	S	2
	P	**10**
	A	9
	N	2
4. Chemical components of DNA	S	**13**
	P	7
	A	2
	N	1
5. DNA structure	S	5
	P	**13**
	A	4
	N	1
6. DNA replication	S	1
	P	**15**
	A	5
	N	2
7. DNA transcription	S	2
	P	7
	A	**11**
	N	3
8. DNA translation	S	1
	P	**12**
	A	7
	N	3
9. Genome	S	**9**
	P	7
	A	5
	N	2
10. Mutation	S	8
	P	**11**
	A	-
	N	4
11. Genetic engineering	S	-
	P	**16**
	A	6
	N	1

From table 6.4 above, the mode of students' conception groups was quite similar. DNA position and mutation were the concepts in which students did not have alternative conceptions. About one third of the students had alternative conceptions in nucleotide, DNA transcription, and DNA translation. The results of students' understanding in each concept were as follows:

A. DNA function

The scientific conception of DNA function was that ‘DNA is genetic material which contributes to helping living organisms inherit traits from generation to generation. The next generation will inherit some parts from father and some parts from the mother’. From Table 6.4 above, most students had scientific conceptions in DNA function. The results came from two questions (Q1 and Q2).

Question 1: In the case of the ‘Tsunami’ situations in the southern part of Thailand, many people passed away. It took time to pick up the bodies. Most of the bodies had decomposed and could not be identified from their faces. What is the thing which helped the scientists to identify the bodies? And why do you think like that?

Question 2: An elected official who looks after the general welfare of the people in a district wanted to find his son, who was taken away when he was young. From the DNA finger prints of the official, his wife, and four men, who claimed to be his son, who is the official’s son? And why do you think like that?

Both questions were open-ended. The alternative conception of students was that the ‘Son has DNA more than the father’.

Only one student in school A did not understand how DNA is transferred from father to son. The result was not related to former alternative conceptions which were found by Marbach-Ad and Stavy (2000), which included that DNA in the daughter’s cells are identical to the DNA that was in the mother’s cells because the DNA duplicates and then divides. However, Buntting et al. (2003) presented information that university students had alternative conceptions in DNA function.

B. DNA position

The scientific conception of DNA position is that ‘DNA is composed of genes and it is on chromosomes’. From Table 6.4 above, most students had no conception in DNA position. The results came from question 4 (Q4).

Question 4: What is the relationship among chromosomes, cells, genes, nucleus, and DNA?

Even though Lewis et al. (2000a) found that students’ were confused about the position of genes-DNA-chromosomes-cells, no answer showed alternative conception of students in this concept.

C. Nucleotide

The scientific conception of nucleotide is that ‘nucleotide is composed of base, sugar, and phosphate group’. From Table 6.4 above, most students had a partial understanding of nucleotide. The results came from question 3 (Q3.1).

Question 3.1: Is DNA in the eight corners round in the picture? If you think that it is not DNA, please identify what is it? And why do you think like that?

Even though alternative conceptions of nucleotide were limited, the results showed alternative conceptions of students in school A which were:

a. The things which are composed of base, sugar, and phosphate groups are chromosomes, genes or DNA.

b. Nucleotide is also called DNA.

D. The chemical components of DNA

The scientific conceptions of the chemical components of DNA is that ‘DNA is composed of two strands of polynucleotides’, ‘Each polynucleotide is composed of nucleotides’, and ‘Both polynucleotides are connected by hydrogen bond between bases by Adenine matches with Thymine and Guanine matches with Cytosine’. From Table 6.4 above, most students in school A had scientific conceptions in this area. The results came from question 3.2 (Q3.2).

Question 3.2: Is DNA in the circle of the picture? If you think that it is not DNA, please identify what is it? And why do you think like that?

Even though alternative conceptions of the chemical components of DNA were limited, the results showed alternative conceptions which were that: ‘DNA is a genome’ (from a student in school A); and that ‘DNA was not composed of two strands of polynucleotides’ (from a student in school A).

E. DNA structure

The scientific conception of DNA structure is that ‘DNA is composed of polynucleotides which are two strands in helix (double helix), which are presented as a twisted ladder turning to the right’. From Table 6.4 above, most students had a partial understanding of DNA structure. The results came from question 5 (Q5).

Question 5: From these four pictures, which one(s) is/are DNA? Why do you think like that?

Even though alternative conceptions of DNA structure were limited, the results showed difficulties of student in school A in identifying DNA by looking at the structures in the pictures (is this wording okay?). Most students, who

could not answer with a scientific concept, could identify only DNA as a kind of strand which is composed of bases.

F. DNA replication

The scientific conception of DNA replication is that 'DNA replication is DNA synthesizing. The new strand has the same structure and series of nucleotides as the template strand'. From Table 6.4 above, most students had a partial understanding of DNA replication. The results came from question 6 (Q6).

Question 6: From these four pictures, which one(s) is/are DNA replication? Why do you think like that?

The results showed that some students in school A did not have the ability to correctly identify a DNA replication model from the four pictures.

Even though there were limited findings of the alternative conceptions of DNA replication, Kindfield (1994) found alternative concepts of the timing of replication and Wood (1996) found conceptions that DNA was not capable of replication.

G. DNA transcription

The scientific conception of DNA transcription is that 'Transcription is the production of an RNA strand from a DNA template. The RNA strand moves from the 5'-end to the 3'-end'. From Table 6.4 above, most students had a partial understanding of DNA transcription. The results came from question 7 (Q7).

Question 7: From these four pictures, which one(s) is/are DNA transcription or RNA synthesis? Why do you think like that?

The results showed that some students in school A did not have the ability to identify DNA transcription models from other pictures. The results showed alternative conceptions which were that:

a. Students chose DNA translation instead of DNA transcription.

b. DNA transcription starts from decoding the AUG until finding a stopper or stop code.

c. DNA transcription has an RNA match with a DNA template.

d. DNA transcription has bases matched with mRNA.

The alternative conceptions were related to Marbach-Ad and Stavy (2000), who found that students lacked of understanding of the transcription process.

H. DNA translation

The scientific conception of DNA translation is that 'Protein synthesis, translation, is the manufacture of a protein with the sequence of amino acids specified by an mRNA molecule. 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; 2^{nd} tRNA which has another amino acid, matches with the next codon on the mRNA in ribosome, producing a peptide bond between two amino acids; 1^{st} tRNA separates from mRNA and ribosome, ribosome moves through mRNA from 5'end to 3' end, new tRNA with new amino acid matches with mRNA and produces the peptide bond again and again, until codon is UAA or UAG or UGA. UAA, UAG, and UGA are the stop codons of translation'.

From Table 6.4 above, most students had a partial understanding of DNA translation. The results came from question 8 (Q8).

Question 8: From these four pictures, which one(s) is/are DNA translation? Why do you think like that?

The results showed that some students did not have ability to identify DNA translation models from the four pictures and the alternative conceptions included that 'DNA translation is DNA transcription'. The alternative conceptions were related to Marbach-Ad and Stavy (2000), who found that students lacked understanding of the translation process.

I. Genome

The scientific conception of genome is that 'Genome is the entire gene of each living organism'. From Table 6.4 above, most students had scientific conceptions of genome. The results came from question 9 (Q9).

Question 9: In the present time, there are a number of projects conducted in order to find the genomes of living organisms. What is genome? Why do scientists in many countries need to know about the genomes of living organisms?

Even though, it had limitation of papers presented genome alternative conceptions, the results showed alternative conceptions of students in school A which were:

a. Genome is inherited.

b. Genome is a kind of genetic code.

c. Genome is a decoration of plant genetics by using a number of decorating methods.

d. Genome is decoded genetics.

e. Genome is a genetic extension.

J. Mutation

The scientific conception of mutation is that ‘Mutations may include base deletion, base insertion, base change, or base inversion, etc. which can be caused by radiation, chemical agents or temperature’. From Table 6.4 above, most students had a partial understanding of mutation, and nobody had alternative conceptions. The results came from question 10 (Q10).

Question 10: Morakot liked the sweet, big watermelons in her grand mother’s garden. She asked her grandmother for some watermelon seeds and grew them in her garden. However, her watermelons were small and were not sweet. Her mother told that her that the watermelons were mutated. If Morakot’s mother is right, what were the causes of the mutation?

Albaladejo and Lucas (1988), Bahar et al. (1999), and the MDA (2001) presented mutation alternative conceptions of people. Albaladejo and Lucas found that mutation consists of a change, such as a metamorphic change or a developmental change. Bahar et al. found that mutations happen in response to problems faced by organisms. MDA (2001) presented that gene defects are always caused by environmental factors of mutation.

K. Genetic engineering

The scientific conception of genetic engineering is that ‘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 host cell for amplification. The recombinant DNA, which transformed into cells, has to replicate itself. Genetic engineering can be applied to producing hormones, vaccines, parts of DNA, modify microorganisms or plants or animals’.

From Table 6.4 above, most students had a partial understanding of genetic engineering. The results came from questions 11 and 12 (Q11 and Q12).

Question 11: If we referred to ‘a rat that passed the genetic engineering process’ what are the scientific processes that it passed? Please explain.

Question 12: What are the examples of genetic engineering application? (Give at least two examples)

The genetic engineering alternative conceptions of students in school A were:

a. Genetic engineering is as same as drug testing.

b. Genetic engineering is the locating of DNA.

c. An advantage of genetic engineering is the recycling of unused things.

The results showed different genetic engineering alternative conceptions from Hill and O’Sullivan (1998), who found misunderstandings about how gene therapy can cause cystic fibrosis.

The 4 groups of students: intellectual disability, autistic, hearing impaired, and others (financially poor, broken homes, didn’t live with their father or mother) needed recognition from the teachers. Intellectual disability students paid attention to the lesson, when they felt familiar with the teacher. The students would talk and discuss when they felt comfortable with the people in their groups. Some alternative conceptions which they brought into the classroom made the researcher wondered, such as “I had some inheritance traits from my brother because I have many traits looks like him”.

An autistic student needed to be taught with a clear voice and be given clear information in everything teacher wanted him to do. The teacher asked the previous teacher and other students about the undesirable performance for the autistic. He had a limitation in controlling his emotions and behavior. He felt uncomfortable when other students talked about him behind his back or smiled to others when he explained his ideas. Teachers of such a student need to talk to other students about their behavior in the classroom. Moreover, teachers should explain to other students that it is not nice behavior for living in the society, not because of spoiling the autistic child. In this classroom, the teacher did not explain this, but she asked some questions and let students think about the answers, such as "what do you feel when you try to explain your idea to me, but your colleagues talked to others or smiled at you as if you are a joker?". Some teachers came to observe the GIU class, especially the one who had conflict with the autistic student before. They observed how to control students in a class which had an autistic student.

Meanwhile, the hearing impaired student had short term interest. He had hearing equipment to help him hear well. However, he preferred to take it off. He explained that it made him feel different from other students. Moreover, when he communicated to his group, who were hearing impaired students from other classes, they used hand language. He needed to join in group that had at least one person who he could communicate with. He did not disturb classroom activities, but sometimes he did not participate in the whole class discussion. The teacher had a limitation in using hand language to communicate with him. The teacher communicated to him by speaking, and he replied back by writing. This is a key problem for inclusive classrooms which have a mixed variety of disadvantaged students. Even though Niyomthum (1996) argued that one should not have a variety of disadvantaged students in the same classroom, this welfare school put them into the same classroom. The limitation of teachers who had graduated in special education could not distribute in each classroom. The hearing impaired student answered only a few questions in the advanced genetic concepts survey. He explained that he answered in the survey more than other subjects in this semester. He had a serious headache when he had

examination, and the researcher asked him to do the survey at the same time of his final examination.

Other disadvantaged students who were financially poor, had broken homes, and did not live with their father or mother also needed understanding from the teacher. Most of them had limitation attention spans. They needed a variety of learning activities. For example, they paid attention to activities in Unit 3, but did not fully participate in Unit 9. However, there was no different in the results of their advanced concepts from Unit 3 and 9. They could show their ideas in presentations and inventions, especially when they were in groups with other students they felt comfortable working with.

3. Problems and Solving Problems of the Implementation

The implementation of the GIU in school A had problems which were solved as follows:

A. Teaching and Learning Process

The teacher as a researcher did not stop teaching after finishing one concept. The teacher moved on to the next concept. The students seemed tired and did not participate in the lesson. The teacher realized that after finishing each concept, she should stop for a while and let students take a break before going on to the next concept.

Teaching in welfare schools was time consuming. Students needed more time for studying each concept.

B. Place

The classroom which was used for implementing the GIU was a long distance from the students' main classroom, but had the necessary equipment for use

in the units. It was on the 6th floor of the other building of the students' classroom. The students were not allowed to use the elevator. Thus, they took 5 to 10 minutes for walking to the GIU's classroom.

The teacher who controls the GIU classroom did not allow moving tables and chairs in the first two periods. The researcher had to have first talk and explain about the importance of sitting and working in groups. Then, he allowed for moving the tables and chairs, but the researcher and students had the responsibility to move them back after every period. The understanding of seating places, instructional materials, and cooperation in the setting and learning environment were important factors in the implementation.

C. Instruments

The old overhead projector in the science classroom was out of order. The researcher had to ask for another projector, but the class had to be moved to the room where the projector was available. However, the new overhead projector in the new room could not be used sometimes.

The lesson that the researcher learnt from teaching the GIU by herself in school A was the importance of developing the GIU before asking other teachers to use them. She learned about the advantages and limitations of the GIU from implementing the units by herself. The GIU could promote students' learning in a number of ways. To implement the GIU each time, the teacher should adapt some parts or activities to suit the students' backgrounds, along with the genetic prior knowledge and genetic alternative conceptions which students brought into the classroom.

Case II of the Implementation of the GIU

The Context of Case II

School B was a welfare school in Nonthaburi province near the main river, which had a different purpose from school A. The school wanted to educate children whose their parents worked on boats on the river. Normally, these children did not have any chance to study, because they regularly changed their living places along the river depending on their parents' work. When children of people who worked on the boats decreased, school B allowed other disadvantaged students to attend the school, such as hill tribes, orphans, poor students, and prostitute at-risk students. The school has 1st Grade to 12th Grade with mixed gender students. The ratio of students to teachers in the school was 740: 52 or 14.2 students per teacher. The school did not separate students of the science program and the art program into different classrooms, as there was only one classroom for each high school level. Students who wanted to learn in the science program had to go to another classroom. Then, only in science subjects those students in the same class had to separate: one group learns physics, chemistry, and biology; another group learns physical and biological science.

There were 8 students, 3 males and 5 females, who participated in the research. They were different groups of hill tribes including: 1 Yao, 1 Leesor, 5 Mong students, and 1 prostitute at-risk student. Their science grade point average in the former semester was 1.1.

Teacher B who participated in the research was in her late 40s. She was the head of the science department in the school. She received a B. Ed., having majored in biology. At the time of the research, she had been teaching science for 26 years and teaching biology for 10 years.

The researcher prepared the teacher for teaching the GIU in the ordering of a social constructivist perspective, GIU activities, and teaching and learning genetics based on social constructivist perspectives. A month before implementing the GIU in

school B, the researcher had a conference with teacher B in changing the ideas concerning the teaching with the GIU based on a social constructivist perspective. Three weeks before implementing the GIU in school B, the researcher had another discussion with teacher B in order to adjust some activities for the students of that school. Two weeks before implementing the GIU in school B, the researcher and research advisor met teacher B. They discussed about doing teaching and learning research based on social constructivist perspectives, which was suitable for the variety of backgrounds of the students in the school B.

The Implementation of Genetic Instructional Units (GIU) in Case II

For the whole implementation, it appeared that teacher B taught by basing her teaching on a social constructivist perspective. Normally, teacher B followed everything in the GIUe, except when using a Power Point program. In some units, she typed the information from the units onto the Power Point program and showed it to the students after asking questions. Then, she answered her own questions, which she had already prepared in her slides. Thus, the answers did not come from the students. Moreover, the teaching and learning of the whole unit were less natural sometimes. Teacher B concentrated to follow the GIU and back to the former part, when she realized that she had skipped that part.

1. Unit 1

The teacher adapted some parts of the unit, by using videotapes of cells and chromosomes, before following the instructions of the unit. Even though she could teach the units on time, sometimes she answered her own questions when students did not respond. She used analogies combined with her own explanations, such as a train being the analogy of DNA and the containers on the train as an analogy of genes. She could solve instant problems, which included a damaged fuse in the overhead projector, by passing the OHPs to the students. She tried to link knowledge in the unit with real life situations, such as after finishing this part students could help Dr. Pornthip to proving DNA of people.

2. Unit 2

Teacher B had suffered from a cough in this unit. She left students to read some information and went out from the classroom to cough outside. She tried to link some parts of the unit to students' prior knowledge. However, some parts could not be related to the former unit. Moreover, some students in the next class played guitars, which could be heard by the students and the teacher.

3. Unit 3

Teacher B and the researcher discussed last time to add knowledge of chemical structure of DNA to the students. Teacher B followed most of the unit, except the activity worksheets. She gave the DNA plastic model to students and told them to compose the pieces together. Most of all she answered her own questions and did not have wait for students' answers. She used Power Point slide to show the right answers of the activity worksheets. She spent one less period than scheduled for teaching this unit.

The researcher asked her to follow the unit without showing the right answers to the students. The answers should come from the students themselves. She replied that the students in this school did not have much self-confidence. The researcher told her to keep trying and to wait for their responses in the next unit.

4. Unit 4

Teacher B told students to invent DNA models by separating into two groups. She planned for the students to show and present these models in the school fair. The students had about a week to invent the models. She asked the students to set the criterion for marking their models. She did not wait for students' planning, but told them to keep it as homework. She told students to come to see her in her free time for advice on their models. She spent 25 minutes less than planned for the teaching of this unit.

5. Unit 5

Teacher B mixed this unit with Unit 12 (Mini Molecular Genetics Fair) in an academic day of school B.

6. Unit 6

Teacher B adjusted some parts of this unit, such as letting the students read information from additional sheets in the back of the students' handbook before learning. Students moved their hands and heads when listening to the genomic music. Teacher B motivated students' learning by allowing them to sing karaoke after class, if they could answer her questions. Students paid attention to her teaching. However, she was not familiar with the music on the CD and turned on the wrong song in the beginning. She hurried the finish of the unit with a small conclusion.

7. Unit 7

Teacher B did not properly introduce the students into this unit. Most of all she replied to her own questions and did not wait for the students' answers. She used Power Point slides to show the right answers of the activity sheets. She used the complete DNA replication model like a template and let the students combine their DNA models to be the same as her model. Teacher B let the students answer her questions sometimes. However, she explained to students about DNA replication and concluded the concept of the unit by herself. The researcher asked her to follow the GIU and let students do the activities in the activity sheet. Teacher B thought that her students did not have the ability to do the activities without her help.

8. Unit 8

During the last period, the researcher talked to some students and told them that their Thai accents were good. The researcher could not identify that they were hill tribes, if she only listened to their accents. It seems they felt confident

enough to answer questions both in Thai and English (especially BM6). Teacher B used Power Point slides to show the right answers or to communicate with the students. She waited for students' answers, but she prepared her own slides beforehand. She tried to link students' answers to her slide.

9. Unit 9

Teacher B decorated the classroom by using DNA paper models and DNA replication models, which the students had made . She revised students' knowledge of codons, anticodons, mRNA, and tRNA. Students paid attention to the DNA and protein synthesis videotape and made notes in their books as well. The teacher played the entire videotape for the first round, and asked questions. She then turned on the videotape again, students answered the questions, and she explained to fulfill students' understanding. She focused on the important points, such as codons, anticodons, stop codons, ribosomes, methionine, transcription, and translation.

10. Unit 10

The teacher linked the knowledge in Unit 9 to introduce students to learning 'The monkey face child'. Students paid attention and were interested in the VCD. They had a small group discussion and a whole class discussion. Students had more roles to answer and to discuss. She did not use the white board, which the researcher had prepared for writing students' answers. She did not teach reading the genetic codes table before asking question about the worksheet. When students could not answer, she taught how to read the table. She waited for students' answers, but she had prepared her own slide beforehand. She believed that without her slides, students could not understand the objectives of the units.

11. Unit 11

Teacher B denied using the white board, which the researcher had prepared for writing students' answers. She told the researcher that she did not like

writing. When the researcher asked teacher B to let students answers her questions, she said that they could not reply. She told the researcher that her students did not have the confidence to answer questions in all subjects. She sat in front of the class all period. Students enjoyed playing their roles during the situations. They realized not only the importance of the advantages and disadvantages of genetic engineering, but also the values needed to live with others in the same society.

12. Unit 12

The students had the chance to present their knowledge in topics of their choice. Teacher B set the science fair during an academic day of School B. In the room, students decorated the classroom with DNA paper models and their own models, which were made from vegetables. Students paid attention to their presentations. Each group had a presentation board. They invited the school B administrator and other students in school B to their presentations.

Examples of the Teaching and Learning During the Implementation of the GIU in Case II

In the case II, Unit 10 (see detail in Unit 10 of Appendix C) provides a representative example of teaching and learning genetics for disadvantaged students that incorporated the social constructivist ideas of linking to student prior knowledge and promoting student understanding through classroom interactions using social context in a variety of teaching and learning. The following dialogues were examples of the teacher who started teaching by asking questions of students' prior knowledge.

Teacher: What is genetic material?
Students: DNA.
Teacher: What is DNA?
Students: DNA is genetic material which can transfer from generation to next generation.
…

Teacher: How many types of bases?

Students: Four.

Teacher: What are they?

Students: Adenine, Guanine, Cytosine, and Guanine.

Teacher: From the previous unit, you know that DNA is a genetic materials and as a template in protein synthesis. Could you tell me the steps in protein synthesis?

Students: First, DNA copy themselves…

Students: Replication.

Teacher: Then…

Students: DNA transcription…RNA was created.

Teacher: And…

Students: Translation…from RNA to protein.

Teacher: OK, from your knowledge, today we will learn about how the things you learned before link to our real life.

The teacher called one student to read the story of mutates plant which looked like a head of big snake. Then, other student read the story of pork on the aluminum pan (famous foods for teenagers in Thailand). The teacher raised students' thinking by using questions.

Teacher: What is/are the cause(s) of the mutate plant?

Students: The plant ate something.

Teacher: What's else?

Students: The plant has got something from the nature…something it consumed…

Students: Ray…Sun…

Teacher: Such as?

Students: Umm…Ultraviolet…or other ray.

Teacher: Ok…and look the worksheet no.15 'The cause of mutation'…Please notice base ordering and amino acids. We will answer together.

An example of using GIU, which were presented in inquiry and the students' handbook of that GIU, were shown in Unit 3. For Unit 3, each student did the activity of composing their own nucleotide by using pieces of plastic models. Then, they had to create polynucleotides and DNA strands. They enjoyed themselves and felt free to do the activity. They helped each other to compose the models by following the activity sheet. In the students' handbook of the GIU, the researcher noticed the underlines and highlights both in worksheets, activity sheets and extra readings at the back of the books. They told the researcher in unstructured interviews that they liked the GIU handbook, because it was not difficult to understand and was easy to follow. They did not have enough money to buy the expensive handbook in the book store and school B did not provide internet usage for students. Then, normally if they could not find more information from the old handbooks in the library, they had to abandon their investigation, despite the fact that they would have liked to have known more.

The whole class discussion was another effective way to confirm students' understanding in the classroom with mixed ability students. The step of discussing from small groups to the whole class was a way to develop students' learning and understanding. The students could understand the words of their peers more than the teacher's words. When some students did not understand the meaning of the teachers' words, the teacher asked other students to explain. Sometimes they communicated to each other using hill tribe languages. Even though they came from different groups of hill tribes and could not speak the language of the other hill tribes, they could understand the language used when they listened to students from other tribes.

The communication skills are parts of scaffolding which could promote students' understanding in genetics. Both Unit 10 above and Unit 1 as following are interesting examples of using a variety of flexible activities in GIU were used and could raise students' attention in genetics. According to students' background, seven from eight students in this case were hill tribe students. They had limitation of speaking Thai accent. In the beginning of GIU implementation, they did not answer teachers much. After the researcher talked to them and let them know that their

accent is quite good, they answered more when teacher asked questions. The following example of Unit 1 was differing from the example of Unit 10 in the former part.

Teacher: From this picture, where is the position of DNA in human body?
Students: Umm…
Teacher: From the picture, what is the relationship between DNA and chromosome?
Students: …
Teacher: Hmm…where is the position of DNA in human body?
Students: …

However, the dialogues below showed the limitation of teacher's waiting time in some units. The examples of teacher and student conversations in the genome unit were shown as follows.

After the teacher had explained to the students that each note of the music came from each of the bases in living things, she played the two songs. However, the first time she played the wrong songs.

Teacher: If the music had notes which derived from base ordering in dogs and shrimps, do you think that the songs were similar or different?
Student: …
Teacher: Similar or different?
Student: …
Teacher: Hmm…What do you think?
Student: …
Teacher: Different.

Grouping techniques, such as small mixed ability cooperative groupings and cross-sex and mixed ability pairings were used in this case to promote the learning of disadvantaged students. However, because there were only eight students in the class the groups were largely unchanged over the unit. A variety of dynamic assessment techniques were applied as in the GIU unit outline. The teacher's PowerPoint affected the way the students answered, which were the students did not answer but waited for the answer in next teacher slide of the PowerPoint.

From the former examples, the researcher concluded the implications of using the GIU in case II were as follows. The significance of teachers' ability in teaching genetics was presented in adaptation of the GIU to fit with their students. For example, the researcher found alternative conceptions of students in school B and told the teacher about the alternative conceptions they held, such as 'sporting ability can be transferred from parents to their offspring', 'inheritance traits can only be transferred from a mother to her children', and that 'dimples were not an inheritance trait'. Teacher B discussed with the researcher about finding ways to fulfill the students' understanding, such as by using a videotape, which was produced by the Com-Link company and the General Education Department with a biology expert acting as a consultant. The videotape consisted of two stories, which were 'Chromosomes and Human Genders' and 'Cell Components'. The researcher asked to see the videotapes before the teacher used them, but this was postponed until the actual teaching time. Even though some parts of the video raised students' interest, the researcher found some alternative conceptions on the tape, such as 'DNA is a part of genes'. The researcher discussed with teacher B how to correct this concept in the next period.

1. Teaching Results

The teacher B realized the importance of finding students' prior knowledge before teaching the new concepts. She also realized that to correct students' alternative conceptions before teaching new concepts could contribute students learning genetics. From the unstructured interview and teacher's journals

showed that ‘it seems to take time for correct students’ prior knowledge, but this way could safe teaching time along teaching and learning following the GIU’.

In each class, teacher B tried to follow the instructions of the GIU by correcting students’ prior knowledge by using the introductory worksheets; asking questions to students for small group discussions; introducing students to work with the activity sheets; and asking questions for whole class discussions.

To use inquiries should be an effective way to raise students’ thinking. However, for most of the implementation in school B, teacher B explained the scientific conceptions to students by herself. Her waiting time for students’ answers was limited. Most of the how and why questions, which the teacher asked came from the GIU. She told the researcher that a big limitation of students in this school was the ability to answer questions. It showed the teacher’s lacked of belief in the students’ abilities.

After teacher B answered her own questions many times, the students no longer made attempts to answer. It seemed that they knew they would eventually receive the correct answers from teacher B. Moreover, while teacher B paid attention in following the GIU, at times she did not detect students’ answers.

In school B, investigation was an effective teaching method as showed in Unit 3. The small group discussions and whole class discussion were an interesting strategy to develop students’ participation and communication skills. They felt comfortable to share their ideas with peers who had the same problems in language accents.

2. Learning Results

2.1 Students’ Prior Knowledge

The prior knowledge in 7 genetic concepts of the disadvantaged students in school B is shown in Table 6.5 below.

Table 6.5 Prior Knowledge of Students in School B in 7 Genetic Concepts

Concepts	Group of Concepts	Number of Students
1. Inheritance Traits	Scientific conception (S)	2
	Partial understanding (P)	3
	Alternative conception (A)	3
	No conception (N)	-
2. Gene	S	-
	P	1
	A	7
	N	-
3. Chromosome	S	-
	P	-
	A	8
	N	-
4. Dominant and Recessive Alleles	S	3
	P	2
	A	2
	N	1
5. Genetic Diseases	S	-
	P	2
	A	6
	N	-
6. Sex Chromosome	S	-
	P	4
	A	3
	N	1
7. Genetic Engineering	S	-
	P	3
	A	3
	N	2

From Table 6.5 above, most students did not have scientific conceptions in five concepts out seven concepts. Most of them had ‘alternative conceptions’ in inheritance traits, genes, chromosomes, genetic diseases, and genetic engineering concepts; and ‘partial understanding’ in inheritance traits, sex chromosomes, and genetic engineering concepts. Three of the students had ‘scientific conceptions’ in dominant and recessive alleles.

2.2 Implementation of GIU

Most of the students in school B were from hill tribes and thus they did not feel confident to communicate in the Thai language. They thought that their accents were not good enough and they did not want to be embarrassed. These reasons affected the setting of questions and the answers of the students in the GIU.

Students who attended the GIU had the ability to set questions in the class. However, the limitation of students' communication skills was an important factor in answering and setting questions. These were the examples of students' questions in Unit 1 (DNA definition and significance):

a. What is DNA?
b. Where is DNA located?
c. What is the function of DNA?

Even though the students did not want to participate in the inquiry techniques, the GIU promoted students' investigation in every unit. The students investigated information for increasing their knowledge by answering teachers' questions, and answering in extra reading documents. When students could give answers by constructing their own knowledge, they were proud of themselves and felt free to share their knowledge with others. The students had more confidence when they explained their understandings to the teacher and the teacher gave feedback to them.

The step of discussing in small groups to discussing as a whole class was a way to develop students' communication skills. Sometimes they communicated to each other by using the languages of their hill tribes. It was a way to support their ideas before showed their ideas to the whole class. In the later units, the students felt free to discuss both in small groups and as a whole class.

The GIU also encouraged students to be participants in the classroom and promoted students' communication skills, including mixed ability students who did not have confidence in their communication skills. They had more chances to read (both in class and in extra reading documents), to write (in students' journals, on the board, in worksheets), to discuss (with peers and teacher) and present their ideas to their groups and to the whole class.

The students showed positive feelings in the units, which were shown in their journals as follows:

"I like to learn, because I did not felt any stress" (BF03 in unit 1)

"I like biology more" (BF04 in Unit 3)

"I enjoy in the lesson" (BM07 in unit 4)

"I want to learn like this for a long time" (BM06 in unit 6)

"I can use the knowledge in my life" (BF08 in unit 10)

2.3 Students' Advanced Genetic Concepts

The results of the advanced genetics' survey showed 11 advanced genetic 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. The Number and percentages of students in school B, categorized by each genetic concept, is shown in Table 6.6 below.

Table 6.6 Number of Students in School B Categorized by Advanced Concepts

Concepts	Group of Concepts	Number of Students School B (n=8)
1. DNA function	Scientific conception (S)	**5**
	Partial understanding (P)	3
	Alternative conception (A)	-
	No conception (N)	-
2. DNA position	S	1
	P	3
	A	-
	N	**4**
3. Nucleotide	S	**6**
	P	2
	A	-
	N	-
4. Chemical components of DNA	S	3
	P	**4**
	A	1
	N	-
5. DNA structure	S	2
	P	**6**
	A	-
	N	-
6. DNA replication	S	-
	P	**8**
	A	-
	N	-
7. DNA transcription	S	2
	P	**5**
	A	-
	N	1
8. DNA translation	S	1
	P	**4**
	A	3
	N	-
9. Genome	S	**5**
	P	1
	A	-
	N	2
10. Mutation	S	**4**
	P	**4**
	A	-
	N	-
11. Genetic engineering	S	2
	P	**5**
	A	1
	N	-

From Table 6.6 above, the mode of students' conception groups was quite similar. However, students in school B seemed to have less alternative conceptions than school A in each concept. DNA function, DNA position, nucleotide,

DNA structure, DNA replication, DNA transcription, genome, and mutation concepts did not have students' alternative conceptions. The results showed alternative conceptions in the Chemical components of DNA, DNA translation, and genetic engineering. The results of students' alternative conceptions were shown as follows.

A. The Chemical Components of DNA

Most students in school B had a partial understanding of the chemical components of DNA. However, the results showed a small amount of alternative conceptions, such as 'DNA was not composed of two strands of polynucleotides'.

B. DNA Translation

The results showed that some students in school B did not have the ability to identify DNA translation models when shown different pictures and the alternative conception was that 'DNA translation is DNA transcription'. The alternative conceptions were related to Marbach-Ad and Stavy (2000), who found that students lacked understanding of the translation process.

C. Genetic engineering

A student in school B had an alternative conception, which was that 'an advantage of genetic engineering is surgery', and 'an advantage of genetic engineering was to connect organs'. The results showed different genetic engineering alternative conceptions from Hill and O'Sullivan (1998), who found misunderstandings about how gene therapy can be a cause of cystic fibrosis.

3. Problems and Solving Problems of the Implementation

The implementation of the GIU in school B had problems which were solved as follows:

A. Teaching and Learning Process

The teacher B was very strict in keeping to the questions for inquiry in the GIU. She read the questions from the GIU teacher handbook. Sometimes she skipped some questions, and then she asked the skipped question when she knew that she missed it. However, sometimes the questions in the handbook should be adaptable to the students' answers. To follow all questions in the handbook in the exact order might not work in some situations. After discussing this problem with the researcher, the teacher used better questions, which were more suitable to the students' answers.

The limitation of teachers in school B affected the teachers' responsibilities. The teachers would switch some classes or arrange extra periods for teaching extra contents. Teacher B did not teach biology to the GIU class during the semester that the GIU were implemented. However, she was the teacher who taught the difficult parts of biology in this school. Thus, at times she was not sure about what content details the students learned. She solved the problem by asking the biology teacher who taught biology to the GIU group in that particular semester.

The limitation of students' communication skills affected the learning activities of the GIU, such as inquires, small group discussions, and the whole class discussions. Teacher B and the researcher had to give positive feedback to the students about their accents. Their communication skills were thus developed step-by-step.

B. Place

The classrooms which used for implementing the GIU were changed twice. This situation happened when the teacher had to teach students out of routine time table. She tried to find a classroom which was convenient for using the equipment specified for the GIU.

C. Timing

The time for implementing the GIU was outside of the routine time table. Teacher B had to teach on the weekends and in the evenings after the normal time table.

D. Instruments

The overhead projector of the classroom was out of order. Teacher B had to move the class to another room where the projector was available. Moreover, she transferred information in the GIU teacher handbook to the Power Point program and showed the slides to students on a widescreen television.

Teacher B agreed that using the GIU could promote students' learning in a number of ways. To implement the GIU, the teacher should adapt some parts or activities that are suitable for the genetic prior knowledge and genetic alternative conceptions which students bring into the classroom. Every student who attended the implementation in school B had many responsibilities, such as being head students and belonging to committees. To teach them after class affected some activities in the school. Moreover, their responsibilities in the school affected the implementation. Sometimes, the implementation started late in the evening, and the students seemed very tired as they had previously had to control younger students in taking a bath or watering trees. Even though these students were very busy, they wanted to attend the implementation classes. They said that it was rare to have an interesting class free of charge.

Cross Cases

This section presents the context of the schools, teachers, and students; along with the teaching results; learning results; problems of the implementation; and conclusions.

The Context of the Schools, Teachers, and Students

From the two cases, the different contexts of school, teacher, and students affected the implementation of the GIU. For the school context, the school objectives were different as they had different categories of disadvantaged students. The teacher who implemented the GIU in school A had less experience in teaching disadvantaged students, but as the researcher for this study she were more familiar with the GIU than the teacher in school B. This affected the teaching and learning results of the two cases. The students in school A were Grade 10 disadvantaged students who were either financially poor, living with other people who were not their families, had broken homes, or had learning disabilities. The classroom was an inclusive classroom. The students in school B were Grade 12 disadvantaged students who included a prostitute at-risk student, along with students from hill tribes. From a knowledge background, students in school B learned whole biology subjects in the school curriculum except for genetics and evolution topics, such as cell division. The knowledge they had already had could support their learning in the GIU.

Teaching Results

In both two cases, the benefits of checking students' prior knowledge, making inquiries, small group discussions, investigation, and whole class discussions were shown in the teaching following the GIU. The instructional materials were easy to find, easy to use and understand, could be used in a variety of activities and were inexpensive and durable which follows the principles of instructional materials for disadvantaged students. In the both cases, the teachers linked former concepts to new concepts. Along with the activities, the teachers used dynamic assessment to check student understanding. Students had chance to learn through social interaction among peers and between student and teacher. In school A, some units also showed a strong democratic way of learning together. The student seating positions in school A took account of the students' needs, particularly those of a hearing impaired student. The students in both two cases were grouped based on mixed gender and mixed ability

which also follows one of the principles for teaching techniques for disadvantaged students.

In school A, the teacher was quite clear about the aims of the activities in each unit of the GIU, because she had developed them. Thus, her teaching followed the GIU without being too rigid in keeping to the scheduled teaching time of each unit. In school B, teacher B tried to follow the GIU but sometimes she also used her own teaching style of transferring knowledge to the students. To implement the GIU in other classrooms in the future, the researcher will need to further promote the idea of allowing students to find their own answers.

Learning Results

The students showed their learning results through developing genetic concepts and by setting questions, investigating their own answers, inventing concrete models, discussing with peers and teachers, and presenting their ideas using communication skills.

The GIU promoted the genetic concepts of disadvantaged students through social interaction in the activities, which was showed in the students' dialogues and in the advanced genetic concepts survey. The GIU contributed to promoting students' learning in school A, even though the class had a hearing impaired student and an autism student who had problems with communication. In school B, the limitation of the students' languages affected their communications and their participation in the learning activities in which they had to present their ideas, such as inquiries, small group and whole class discussions. However, the GIU showed the significance of encouraging the students in school A and B to develop their communication skills step by step before moving onto undergraduate level, such as started using discussion in small groups before moving towards to the whole class discussion. Some of disadvantaged students who did not familiar to speak out were dare enough to present their idea. Both students in school A and B realized that scientific knowledge can be changed when further knowledge is discovered. Their presentations in the molecular

genetics exhibitions suggest they should now have enough scientific knowledge of genetics to communicate with other people and to present theirs idea in discussions of scientific issues in their daily lives.

Problems of the Implementation

The problems of the implementation the GIU in both schools were finding suitable classrooms and equipment. Normally, welfare schools have budgets supported by the government. However, due to the full workloads of the teachers in these schools, not many had used some of the equipment that was planned for use in the implementation of the GIU. When the teachers wanted to use the equipment, they could not find the equipment and often could not use the equipment. In addition, it was hard to find classrooms that had the equipment.

The teacher was an important factor in the implementation. Teachers who implement the GIU in the future should be well prepared beforehand. They should have a good attitude towards their students so that they could develop their learning ability and transfer knowledge in a variety of ways. The teachers should have both pedagogy and strong knowledge content to draw upon. Moreover, they should study their students' backgrounds and prior knowledge before teaching each class. The variety of students' backgrounds and prior knowledge are important factors in students' learning.

Summary

The results presented in the case studies show that teaching and learning through the GIU based on social constructivist teaching perspectives, which build on students' prior knowledge, include opportunities for sharing and discussion of ideas and experiences related to students' everyday lives can promote interaction with teacher and peers which leads to the development of students' genetic concepts and students' communication skills. The results showed that Thai teachers can scaffold the learning of disadvantaged students by creating meaningful and culturally relevant

activities, using dynamic assessment, and using grouping techniques to promote students' communication skills. Most students were able to use language as an important tool to develop their understanding in genetics.

The implementation of the GIU in the two welfare schools required the teachers to take a involved the teachers in promoting social interactions among peers and between teacher and students as a way to promote students' thinking and learning as suggested by Howe (1996), Lemke (1990), and Driver and Oldham (1986). The data show that these approaches can work for Thai students learning about genetics. The group activities in the GIU were also able to promote a democratic environment in school a, something which is also a part of a social constructivist approach (Gray, 2005). The units included checking students' prior knowledge, motivating students into the lessons, using a flexible variety of teaching strategies which could be promoted social interaction among students and between students and teacher, using practical instructional materials, using a number of periodically dynamic assessment and evaluation instead only summative assessment. A variety of flexible teaching strategies, such as inquiry, small group discussion and whole class discussion with mixed abilities and mixed genders as was recommended by Schwartz (1987) and Gray (2005).

The instructional materials for disadvantaged students, the materials in the GIU were easy to find, easy to use and understand, be used in a variety of activities, be inexpensive, and durable, which were related to Department of Disabilities People (2000). In the class where had hearing impaired student, the teacher also paid attention to seating position, where he could see whiteboard and teachers' mouth (Department of Disabilities People, 2000).

From the students' presentation about DNA model (Unit 5) and in exhibition (Unit 12), it presented their ability to link genetic concepts which they learned from GIU to link with daily lives situations, and development of their communication skills. They understood genetic concepts from learning through the GIU and had an open-minded in implementing genetic concepts with their class. Due to the variety of

students' backgrounds and prior knowledge, the teachers had the ability to adapt some parts of the GIU to suit their students. If teaching equipments in their schools are unavailable, they had ability to adapt the instructional materials in each unit in order to fit with the equipment available at that time.

The student's Zone of Proximal Development (ZPD), which is the distance between the actual development level and the level of potential development of each student when they work with a more expert other, seemed to be developed through learning using GIU. The learning development of the students was presented in advanced genetic concepts survey, videotape recording, students' journals, cassette tape recording, observation forms, and teacher's journal. The results showed that the students developed their genetic concepts through the GIU, which showed in the advanced genetic concepts survey. Furthermore, the disadvantaged students' communication skills were developed through the GIU, which were shown in videotape recording, students' journals, cassette tape recording, observation forms, and teacher's journal.