CHAPTER IV

THE EXISTING SITUATIONS OF GENETICS IN WELFARE SCHOOLS OF THAILAND

Introduction

According to Longden (1982), different teaching strategies can affect students' learning, which are important parts of understanding science. The researcher concerned the existing situations of teaching and learning genetics of disadvantaged students in welfare schools, and genetic concepts which they held. To study the existing situations could contribute researcher understanding the teaching and learning genetic for disadvantaged students, and could find instructional strategies to help them learn genetics. This chapter presents results of the research in two parts, which are 1) existing situations of teaching and learning genetics in welfare schools of Thailand; and 2) basic genetic concepts and alternative conceptions in those schools in 2004 academic year.

Existing Situations of Teaching and Learning Genetics in Welfare Schools of Thailand

The purposes of this part are presenting teachers' and students' perceptions about teaching and learning genetics in disadvantaged Thai high schools in respect to 1) difficult genetic concepts for teaching and learning 2) teaching and learning strategies 3) instructional materials 4) assessment and 5) problems and solving problems in teaching and learning genetics.

The researcher used two questionnaires for biology teachers and science students. Each questionnaire had two parts, which were respondent background information and their perceptions of teaching and learning genetics in their schools. Therefore the first research question was:

What are the current situations of teaching and learning genetics to disadvantaged high school science students in welfare schools in Thailand?

The results were summarized under the headings of the background information of respondent biology teachers and science students in welfare schools; teachers' and students' perceptions of teaching and learning genetics in welfare schools; and the congruence between teachers' and students' perceptions.

Background Information of Biology Teachers and Science Students in Welfare Schools

The results are showed in two parts, which are teachers' and students' parts.

1. Background Information of Respondent Biology Teachers

Eighteen biology teachers, who taught in the genetics section at high school level, completed the teacher's questionnaire. They were 13 females and 5 males. The majority of the teachers' responses were as follows: about a half of the group were 21 to 30 years old, three quarters of the group had graduated with a bachelor's degree, about a half of the group had graduated from a Biology major, about a half of the group had less than 5 years of teaching experience, a half of the group had less than 5 years experience in teaching biology, and three quarters of the group had less than 5 years experience in teaching biology at welfare schools.

About half of the biology teachers had teaching experience in both biology and the other science subjects. Seven of them had or currently taught biology, other sciences subjects, and non-sciences subjects. Only one teacher taught biology in one grade. Another teacher taught only biology, albeit across different grades.

In the first semester of the 2004 academic year, when the biology teachers answered the questionnaire, their teaching responsibilities were as follows: twelve of them taught both biology and other sciences subject(s); three of them taught only biology, albeit in different grades; two of them taught biology, other sciences subjects and other non-sciences subjects; one teacher taught a non-science subject. Seventeen from 18 biology teachers had other work loads which included the academic section (40 percent), students' affairs section (40 percent), administration section (10 percent), and service section (8.0 percent).

In the last two years, 10 biology teachers attended in professional development program which included the following sections; teaching strategies (24.2 percent of the responses), science contents (15.2 percent), instructional material (12.1 percent), teacher professional development (12.1 percent), assessment and evaluation (6.1 percent), curriculum (6.1 percent), learning theory (3.0 percent), and non-academic topics (21.2 percent). This part was also reported in percentage, because some of them had participated in more than one training program.

2. Background Information of Respondent Science Students

There were 129 respondents to the science students' questionnaire. There were 97 female and 32 male respondents from Grade 10 to 12, who studied genetics, depending on each school's curriculum. They were 15 to 20 years old; including 17 years old (41.9 percent), 18 years old (31.8 percent), 16 years old (17.0 percent), 19 years old (5.4 percent), 15 years old (3.1 percent), and 20 years old (0.8 percent). The students were studying in Grade 11 (48.0 percent), Grade 12 (35.7 percent), and in Grade 10 (16.3 percent).

Teachers' and Students' Perception of Teaching and Learning Genetics in Welfare Schools

The results were shown in two parts, which were teachers' and students' parts.

1. Teachers' Perception of Teaching and Learning Genetics in Welfare Schools

The results of the teachers' perceptions were shown in seven sections, which are difficult genetic concepts for teaching, teaching and learning strategies, instructional materials, assessment, problems and solving problems, teacher professional development conferences, and suggestions.

1.1 Difficult Genetic concepts for Teaching

The conclusions of teachers' opinions in genetics about teaching are showed in the Table 4.1.

Table 4.1 Number of Teacher Responses to the Level of Difficulty of Each Genetic Concept in Teaching

(N=18)

Genetic concepts	Number of Responses			
	MD*	D*	M*	E*
Genetic Traits	**-**	3	**8**	7
Dominant and Recessive	**-**	**-**	**10**	8
Homozygous and Heterozygous	**-**	2	**10**	6
Genotype and Phenotype	1	4	**9**	4
Law of Segregation and Law of Independent Assortment	1	7	**8**	2
Alleles	-	6	**11**	1
Multiple Genes or Polygenes	1	7	**9**	1
Chromosome**	1	3	**13**	**-**
Relationship between Gene and Chromosome	2	3	**12**	1
Chemical Structure of DNA**	4	**7**	6	**-**
DNA Properties and DNA Synthesis	5	**9**	4	-
DNA and RNA in Protein Synthesis	4	**12**	2	-
Genetic Codes	3	**11**	4	-
DNA in Prokaryote and Eukaryote	1	4	**11**	2
Mutation	-	1	**14**	3
Genetic Engineering and Applications	**-**	**8**	**8**	2
Total (286)	23	87	139	37

Note: * MD =Most difficult, D =Difficult, M =Moderate, E =Easy

**Total number came from 17 responses

From the results of Table 4.1; most teachers thought that 11 out of 16 concepts were moderately difficult concepts, including 'Genetic Traits', 'Dominant and Recessive', 'Homozygous and Heterozygous', 'Genotype and Phenotype', 'Law of Segregation and Law of Independent Assortment', 'Alleles', 'Multiple Genes or

Polygenes', 'Chromosome', 'Relationship between Gene and Chromosome', 'DNA in Prokaryote and Eukaryote', and 'Mutation'. The concepts that most teachers (more than 50 percent) thought were moderately difficult from high to low frequencies were 'Mutation', 'Chromosome', 'Relationship between Gene and Chromosome', 'Alleles', 'DNA in Prokaryote and Eukaryote', 'Dominant and Recessive', and 'Homozygous and Heterozygous'.

Most teachers thought that 4 concepts out of 16 concepts were difficult, which included 'Chemical Structure of DNA', 'DNA Properties and DNA Synthesis', 'DNA and RNA in Protein Synthesis', and 'Genetic Codes'. They thought moderate difficult concepts from high to low frequencies were 'DNA and RNA in Protein Synthesis' (66.7 percent), 'Genetic Codes' (61.1 percent), and 'DNA Properties and DNA Synthesis' (50.0 percent). Most of them thought that 'Genetic Engineering and Applications' concepts were moderate to difficult concepts.

1.2 Teaching and Learning Strategies

Teaching strategies which most teachers thought had contributed to their success in genetic teaching are shown in Table 4.2 below.

Table 4.2 Number of Teacher Responses to the Genetic Teaching Strategies

(N=18)

Teaching strategies	Number
Teacher demonstration	-
Students do report	2
Teacher explanation	8
Students do project	1
Teacher ask questions to let student think	5
Teacher and students use CAI	1
Student presentation	6
Students do experiment	7
Teacher set equipments and some students demonstrate	-
Students study from information sheets and worksheets	7
Role play	-
Field trip	-
Teacher and student discussion	7
Debate	-
Problem-based learning	-
Expert explanation	-
Group work	7

Table 4.2 (Continued)

Teaching strategies	Number
Student discussion	5
Concept map	1
Student ask questions	2
Study from learning center bases	1
Study from videotape	2
Total	62

Teaching and learning strategies which teachers thought that were successful when teaching genetics were teachers' explanations (8 teachers); students' study from information sheets and worksheets (7 teachers); teacher and student discussions (7 teachers); students doing experiments by themselves (7 teachers); group work (7 teachers); students' presentations (6 teachers); and asking questions to raise students' thinking (5 teachers).

From the examples, teachers gave for their success teaching, were explanation mixed with students using worksheets, presenting in front of class, and students and teacher discussion. Teachers created hands-on activities in the classroom and using questions for classroom discussion. For example, many start by exploring students' prior knowledge, using a pre-test, then persuade students into the lesson. Students would then study each learning base (DNA structuring model, ordering of nucleotides in DNA, DNA structure song), and would then be assessed by tests.

1.3 Instructional Materials

More than half of teachers who reported that their successful teaching methods included using information sheets, picture charts and worksheets.

1.4 Assessment

More than half of teachers thought that teachers should assess students from students' activities, using tests, and from students' worksheets. They used tests and practical sheets as well to assess students' achievements.

1.5 Problems and Solving Problems

More than half of teachers thought that the problems in teaching genetics were as follows:

1.5.1 Students

Students had less basic knowledge; lacked memory and the understanding of technical terms, such as heterozygous, genotype, phenotype, gene, and chromosome; lacked concentration and learning intention; and did not fully cooperate in groups.

1.5.2 Genetic Contents

Genetics had more details and difficult contents; it was hard to find proper experiment activities; and was not suitable with the sequencing of the curriculum.

1.5.3 Instructional Materials

Instructional materials were out of date and could not work in the modern classroom. Most of instructional materials used were pictures in teacher and student handbooks.

1.5.4 Teachers

Teachers did not have enough time to help students and could not answer students' questions, such as in genetic engineering concepts.

Teachers reported that they solved the problems by changing teaching strategies and developing some instructional materials themselves.

1.6 Teacher Professional Development Needs

Topics in teaching and learning genetics which teachers needed to attend to in teacher professional development programs were shown in Table 4.3

Table 4.3 Topics in Teaching and Learning in Professional Development Program which Teachers Needed to Attend

(N=18)

Topics	Number (Percentage)
1. Genetic contents	8 (17.8)
2. Teaching and learning theories	7 (15.6)
3. Teaching strategies	15 (33.3)
4. Genetics instructional materials	15 (33.3)
Total	45 (100)

From Table 4.3 above, it showed that most teachers (15 teachers) needed to develop their professional skills especially in the area of teaching strategies and how to develop instructional materials. Half of them needed to develop their professional skills in the sections of genetic contents and learning theories. Some teachers would like to attend to all four topics.

1.7 Suggestions

From open-ended questions, teachers suggestions were grouped into three sections; which were students' contents, genetic instructional materials, and teacher professional development.

1.7.1 Students' Contents

In some concepts teachers thought that students should have mathematical concepts, such as multiple genes. The teachers thought that students' grade levels related to their understanding of concepts. For example, Grade 12 students can learn more rapidly than Grade 10 students. The teachers also suggested that students should have chances to do some experiments.

1.7.2 Genetic Instructional Materials

Teachers needed to have some departments responsible for developing genetics instructional materials, such as cartoons on videotapes. Schools should supply other equipment which suit the instructional materials, and support taking students to laboratories in universities.

1.7.3 Teacher Professional Development

Teachers should have chances to develop their profession in genetic teaching. One of them suggested allowing him to teach in his own major.

From the teachers' point of view, showed that biology teachers in welfare schools of Thailand taught genetics followed the National Education Act (1999), which tried to promote students' learning by using a variety of teaching strategies to raise students' learning.

2. Students' Perception of Teaching and Learning Genetics in Welfare Schools

The results of the students' perceptions are shown in seven sections, which are difficult genetic concepts for understanding in learning, teaching and learning strategies, instructional materials, assessment and evaluation, problems and solving problems in teaching, benefits of learning genetics in their daily lives, and suggestions.

2.1 Difficult Genetic Concepts for Learning

The conclusions of students' responses to the level of difficulty of each genetic concept for learning are showed in the Table 4.4.

Table 4.4 Number and Percentage of Student Responses to the Level of Difficulty of Each Genetic Concept for Learning

(N=129)

Genetic concepts	Number of Responses (Percent)				No Response
	MD*	D*	M*	E*	
Genetic Traits	5 (3.9)	51 (40.2)	**60 (47.2)**	11 (8.7)	2
Dominant and Recessive	5 (3.9)	14 (10.9)	**88 (68.8)**	21 (16.4)	1
Homozygous and Heterozygous	7 (5.6)	31 (24.1)	**77 (61.6)**	11 (8.7)	3
Genotype and Phenotype	5 (3.9)	45 (35.2)	**59 (46.1)**	19 (14.8)	1
Law of Segregation and Law of Independent Assortment	20 (15.8)	**68 (53.5)**	35 (27.6)	4 (3.1)	2
Alleles	23 (18.0)	**67 (52.3)**	31 (24.2)	7 (5.5)	1
Multiple Genes or Polygenes	28 (22.6)	**66 (53.2)**	27 (21.8)	3 (2.4)	5
Chromosome	9 (7.0)	34 (26.6)	**75 (58.6)**	10 (7.8)	1
Relationship between Gene and Chromosome	15 (11.7)	53 (41.4)	**55 (43.0)**	5 (3.9)	1
Chemical Structure of DNA	30 (23.3)	**58 (45.0)**	38 (29.4)	3 (2.3)	0
DNA Properties and DNA Synthesis	24 (19.0)	**61 (48.4)**	40 (31.8)	1 (0.8)	3
DNA and RNA in Protein Synthesis	22 (17.0)	**70 (54.3)**	35 (27.1)	2 (1.6)	0
Genetic Codes	38 (29.5)	**55 (42.6)**	32 (24.8)	4 (3.1)	0
DNA in Prokaryote and Eukaryote	42 (32.5)	**58 (45.0)**	28 (21.7)	1 (0.8)	0
Mutation	27 (21.3)	**45 (35.4)**	43 (33.9)	12 (9.4)	2
Genetic Engineering and Applications	24 (18.9)	**48 (37.8)**	47 (37.0)	8 (6.3)	2
Total (Percentage)	324 (15.9)	824 (40.4)	770 (37.7)	122 (6.0)	24

Note: * MD =Most difficult, D =Difficult, M =Moderate, E =Easy

From the results of Table 4.4; most students thought that 10 out of 16 concepts were difficult, which were ‘DNA and RNA in Protein Synthesis’ (54.3 percent), ‘Law of Segregation and Law of Independent Assortment’ (53.5 percent), ‘Multiple genes or Polygenes’ (53.2 percent), ‘Alleles’ (52.3 percent), ‘DNA Properties and DNA Synthesis’ (48.4 percent), ‘Chemical Structure of DNA’ and ‘DNA in Prokaryote and Eukaryote’ (45.0 percent) each, ‘Genetic Codes’ (42.6

percent), ‘Genetic Engineering and Applications’ (37.8 percent), and ‘Mutation’ (35.4 percent).

Most students thought that 6 out of 16 concepts were moderately difficult concepts, which were ‘Dominant and Recessive’ (68.8 percent), ‘Homozygous and Heterozygous’ (61.6 percent), ‘Chromosome’ (58.6 percent), ‘Genetic traits’ (47.2 percent), ‘Genotype and phenotype’ (46.1 percent), and ‘Relationship between Gene and Chromosome’ (43.0 percent).

2.2 Teaching and Learning Strategies

The conclusions of student responses of existing teaching and learning genetics were shown in Table 4.5.

Table 4.5 Number and Percentage of Student Responses to the Frequencies of Existing Teaching and Learning Genetics

Teaching strategies	Number of Responses (Percentage)			
	Never	Some	Most	All
Teacher demonstration	16 (12.7)	**59** **(46.8)**	38 (30.2)	13 (10.3)
Students do report	8 (6.3)	**91** **(71.1)**	24 (18.8)	5 (3.9)
Teacher explanation	1 (0.8)	8 (6.3)	37 (29.1)	**81** **(63.8)**
Students do project	32 (25.0)	**82** **(64.1)**	12 (9.4)	2 (1.6)
Teacher using questions to let student think (Inquiry)	3 (2.3)	23 (18.0)	**61** **(47.7)**	41 (32.0)
Teacher and students use CAI	**83** **(65.4)**	35 (27.6)	6 (4.7)	3 (2.4)
Student presentation	6 (4.7)	**70** **(54.3)**	40 (31.0)	13 (10.1)
Students do experiment	24 (19.0)	**61** **(48.4)**	32 (25.4)	9 (7.1)
Teacher sets equipment and some students demonstrate	36 (27.9)	**64** **(49.6)**	22 (17.1)	7 (5.4)
Students read and ask questions to the teacher	8 (6.2)	**56** **(43.4)**	45 (34.9)	20 (15.5)
Role play	30 (23.4)	**74** **(57.8)**	21 (16.4)	3 (2.3)
Field trip	46 (35.9)	**64** **(50.0)**	16 (12.5)	2 (1.6)

Table 4.5 (Continued)

Teaching strategies	Number of Responses (Percentage)			
	Never	Some	Most	All
Teacher and student discussion	4 (3.1)	45 (34.9)	**57** **(44.2)**	23 (17.8)
Debate	**88** **(68.8)**	29 (22.7)	8 (6.3)	3 (2.3)
Problem-based learning	20 (15.5)	**76** **(58.9)**	26 (20.2)	7 (5.4)
Expert explanation	**94** **(72.9)**	25 (19.4)	7 (5.4)	3 (2.3)
Total (2,048)	499	862	452	235
Percentage (100)	(24.4)	(42.1)	(22.1)	(11.5)

Most students reported that teaching and learning genetics strategies were as following. All genetic topics were taught by using ‘teacher explanations’. Most genetic topics were taught by using ‘inquiries’ and the ‘discussion of teacher and students’. Some genetic topics were taught by using ‘teacher demonstrations’, ‘students doing reports’, ‘students doing projects’, ‘student presentations’, ‘student doing experiments’, ‘teachers setting up equipment and some students demonstrating’, ‘students reading and asking questions to the teacher’, ‘role play’, ‘field trip’, and ‘problem-based learning’. Those teaching and learning genetics strategies that were never taught in genetic topics included ‘teacher and students using CAI’, ‘debating’, and ‘expert explanation’.

2.3 Instructional Materials

Most students reported that teachers had some extra teaching documents, but most of them came from students’ workbooks. The students needed to have more books, pictures, and educational technologies, such as videotapes, for genetic learning.

2.4 Assessment and Evaluation

Most students identified that teachers assessed their learning using tests and practical worksheets.

2.5 Problems in Teaching and Learning and Solving Problems

The problems of students were as following.

2.5.1 Students

They thought they had intellectual limitations, such as not being able to remember, think, or understand concepts. They had preparation problems before learning, such as less knowledge or lack of sleep. They did not concentrate in class. They did not revise lessons after class.

2.5.2 Genetic content

Genetics was difficult content, too much detail and complicated, and had biological terminology in English.

2.5.3 Instructional materials

Schools did not have enough instructional materials.

2.5.4 Teachers

Teachers did not teach all the topics, did not teach the details of the content and did not give clear explanations. The students thought that the problems came from the limitation of teachers' knowledge.

2.5.5 Teaching and learning strategies

Teachers read books when teaching and no experiments had been done in their class.

2.5.6 Time

The time for learning genetics was limited.

2.6 Benefits of Learning Genetics in Students' Daily Lives

Students reported that learning genetics was beneficial for them as follows: they could identify and understand human traits; forecast genetic traits of their children; do entrance university examinations; communicated their understanding to other people; lived with a genetic disabilities person; found extra money by setting up projects, doing research or developing plants and animal genetics. They could be useful in industrials, such as making medicine; checked DNA for curing and protecting genetic diseases; set plans for having a family; chose partners; plan before having children; protect against genetic diseases which can transfer from inheritance; and make decisions for choosing Genetically Modified Organisms (GMOs) products. Students' ideas showed some jnteresting concept about the benefits of learning genetics in their daily lives, such as for fermenting beer, developing their genetics, and choosing the sex of their children.

2.7 Suggestions

Students suggestions for learning genetics were grouped into six sections; which were genetic contents, genetic instructional materials, teachers, teaching strategies, assessment and evaluation, and time.

2.7.1 Genetic Contents

Students thought that they wanted to learn more modern content knowledge that they could adapt to usage in their daily lives.

2.7.2 Genetic Instructional Materials

Students wanted to have more books and pictures; and educational technologies, such as internet and videotape.

2.7.3 Teachers

Students paid attention to both teachers' characteristics and knowledge. Teacher should be friendly with students, not moody, respect students' intellect, pay attention to students, have time for students, have strong contents, and have good pedagogies. Teachers should ask questions, give examples, and teach all genetic contents in detail.

2.7.4 Teaching Strategies

Students wanted to learn genetics by participating in learning activities, such as field trips, doing experiments, doing projects in groups, classroom discussions, role plays, debates, group work, expert explanation, hands-on activities, thinking analysis, genetics camping, doing reports, and doing exercises. They need a variety of teaching strategies in genetic learning.

2.7.5 Assessment

Students needed to have tests more often with various forms of assessment.

2.7.6 Time

Students needed extended time for learning genetics.

<u>The Congruence between Teachers' and Students' Perceptions about Teaching and Learning Genetics</u>

The results of the congruence between teachers' and students' perceptions were counted from only 12 schools, which sent both teachers' and students' responses back to the researcher. Thirteen biology teachers and 120 high school science students from 12 disadvantaged schools were selected to answer the teacher's and student's questionnaires consecutively. The data were analyzed using percentage and content analysis.

The results were grouped into six sections, which were difficult genetic concepts for understanding in teaching and learning, teaching and learning strategies, instructional materials, assessment and evaluation, problems and problem solving , and suggestions.

1. Difficult Genetic Concepts for Understanding in Teaching and Learning

Teachers' perception about difficult genetic concepts for understanding in teaching and learning are shown in Table 4.6 below.

<u>Table 4.6</u> Number and Percentage of Teacher Responses to the Level of Difficulty of Each Genetic Concept for Teaching

(N=13)

Genetic concepts	Number of Responses (Percent)			
	MD*	D*	M*	E*
Genetic traits		1 (7.7)	**6 (46.2)**	**6 (46.2)**
Dominant and Recessive			**7 (53.8)**	6 (46.2)
Homozygous and Heterozygous		2 (15.4)	**7 (53.8)**	4 (30.8)
Genotype and phenotype		1 (7.7)	**9 (69.2)**	3 (23.1)
Law of Segregation and Law of Independent Assortment		5 (38.4)	**6 (46.2)**	2 (15.4)
Alleles		3 (23.0)	**9 (69.2)**	1 (7.7)
Multiple genes or Polygenes	1 (7.7)	4 (30.8)	**7 (53.8)**	1 (7.7)
Chromosome**		3 (25.0)	**9 (75.0)**	
Relationship between Gene and Chromosome	1 (7.7)	2 (15.4)	**9 (69.2)**	1 (7.7)
Chemical Structure of DNA**	3 (25.0)	**5 (41.7)**	4 (33.3)	
DNA properties and DNA synthesis	4 (30.8)	**7 (53.8)**	2 (15.4)	
DNA and RNA in Protein Synthesis	3 (23.1)	**9 (69.2)**	1 (7.7)	

Table 4.6 (Continued)

Genetic concepts	Number of Responses (Percent)			
	MD*	D*	M*	E*
Genetic Codes	2 (15.4)	**7 (53.8)**	4 (30.8)	
DNA in Prokaryote and Eukaryote	1 (7.7)	2 (15.4)	**9 (69.2)**	1 (7.7)
Mutation		1 (7.7)	**11 (84.6)**	1 (7.7)
Genetic Engineering and Applications		**6 (46.2)**	**6 (46.2)**	1 (7.7)
Total	15 (7.3)	58 (28.1)	106 (51.5)	27 (13.1)

Note: * MD =Most difficult, D =Difficult, M =Moderate, E =Easy

**Responses came from only 12 teachers

Students' perception about difficult genetic concepts for understanding in teaching and learning are shown in Table 4.7.

Table 4.7 Number and Percentage of Student Responses to the Level of Difficulty of Each Genetic Concept for Learning

Genetic concepts	Number of Responses (Percent)				No Response
	MD	D	M	E	
Genetic Traits	5 (4.2)	50 (41.7)	**54 (45.0)**	11 (9.2)	9
Dominant and Recessive	5 (4.2)	14 (11.7)	**80 (67.2)**	20 (16.8)	10
Homozygous and Heterozygous	7 (6.0)	30 (25.6)	**70 (59.8)**	10 (8.6)	12
Genotype and Phenotype	5 (4.2)	44 (37.0)	**52 (43.7)**	18 (15.1)	10
Law of Segregation and Law of Independent Assortment	20 (17.0)	**60 (50.8)**	34 (28.8)	4 (3.4)	11
Alleles	23 (19.3)	**62 (52.1)**	28 (23.5)	6 (5.0)	10
Multiple Genes or Polygenes	28 (24.4)	**62 (53.9)**	22 (19.1)	3 (2.6)	14
Chromosome	9 (7.6)	32 (26.9)	**68 (57.1)**	10 (8.4)	10
Relationship between Gene and Chromosome	15 (12.6)	48 (40.3)	**51 (43.0)**	5 (4.2)	10
Chemical Structure of DNA	30 (25.0)	**52 (43.3)**	35 (29.2)	3 (2.5)	9
DNA Properties and DNA Synthesis	24 (20.5)	**56 (47.9)**	36 (30.8)	1 (0.9)	12
DNA and RNA in Protein Synthesis	22 (18.5)	**62 (52.1)**	33 (27.7)	2 (1.7)	10
Genetic Codes	38 (31.7)	**49 (40.8)**	29 (24.2)	4 (3.3)	9
DNA in Prokaryote and Eukaryote	42 (35.0)	**52 (43.3)**	25 (20.8)	1 (0.8)	9
Mutation	27 (22.9)	**43 (36.4)**	36 (30.5)	12 (10.2)	11
Genetic Engineering and Applications	24 (20.3)	**45 (38.1)**	42 (35.6)	7 (5.9)	11
Total	324 (17.1)	761 (40.1)	695 (36.6)	117 (6.2)	167

Table 4.6 and Table 4.7 showed that 9 out of 16 concepts were in the same level of difficulty in both teachers' and students' perceptions. These included; 'Dominant and Recessive', 'Homozygous and Heterozygous', 'Genotype and phenotype', 'Chromosome', 'Relationship between Gene and Chromosome', 'Chemical Structure of DNA', 'DNA Properties and DNA Synthesis', 'DNA and RNA in Protein Synthesis', and 'Genetic Codes'. Seven concepts which students showed a higher level of difficulty than teachers' were; 'Genetic traits', 'Law of Segregation and Law of Independent Assortment', 'Alleles', 'Multiple genes or Polygenes', 'DNA in Prokaryote and Eukaryote', and 'Mutation', and 'Genetic Engineering and Applications'.

The difficult concepts for teaching and learning which teachers and students agreed upon were 'Chemical Structure of DNA', 'DNA Properties and DNA Synthesis', 'DNA and RNA in Protein Synthesis', and 'Genetic Codes'. The data was related to students' alternative conceptions in these concepts. Buntting et al. (2003) found alternative conceptions in DNA functions, which was a part of DNA properties in university students. Wood (1996:58), and Marbach-Ad and Stavy (2000) found students' difficulties in learning DNA replication. Lewis et al. (2000a), Marbach-Ad and Stavy (2000), Fisher (1983) and Fisher (1985) showed alternative conceptions of the functions of DNA and RNA in protein synthesis. Lewis et al. (2000a-b) presented alternative conceptions of genetic codes.

Teachers' and students' perceptions about difficult genetic concepts for understanding in teaching and learning are shown in Table 4.8 below.

Table 4.8 Overview of Comparison between Teachers' and Students' Perceptions about Difficult Genetic concepts for Understanding in Teaching and Learning

Perception	Most Difficult	Difficult	Moderate	Easy
Teacher	7.3	28.1	**51.5**	13.1
Student	17.1	**40.1**	36.6	6.2

From Table 4.8 above, most students thought that genetics was difficult for learning, but teachers thought it was moderately difficult for teaching. This information is interesting to genetic teachers in welfare schools. It showed that sometimes students think in a different way from teachers, even though they were in the same classroom. In Thailand, it had limitation of research studied about genetics alternative conceptions of disadvantaged students in welfare schools.

2. Teaching and Learning Strategies

The data from teachers and students is related to each other. Even though most genetics' teaching and learning strategies were teacher explanations, students had chances to discuss and present in their classrooms. Students wanted to learn genetics by expert explanation, using CAI, and debate; even if they did not learn by these strategies.

Teachers' perception of successful teaching in genetics was related to some parts of student centered approach as a target of welfare education department and learning reform in Thailand, which promoting education to fulfill students' capability based on individual differences (Welfare Education Department, 2001: 112-118). However, in the actual classroom, students had low grade point averages in science (Welfare Education Department, 2002). Mungsing's (1993: 131-138, 162-164) data is related to Longden (1982), which argued that different teaching strategies affect students' learning. Therefore, it is necessary to develop a variety of teaching and learning genetics which is suitable for the students' need and the general environment at welfare schools. To use teaching and learning strategies, which are based on social constructivist approach, was related to student centered approach and should help disadvantaged students learning genetics. The results also showed that the teachers wanted to develop their professional skills, especially in genetic contents and teaching strategies. It presented enthusiastic of the teachers that need to develop themselves and to help students learning. Even though some teachers identified doing activities in group as a part of successful teaching and learning genetics, small mixed ability cooperative groupings, solving problems independently, helping each others development skills, and cross-sex and mixed ability parings which were suitable strategies for teaching disadvantaged students (Schwartz, 1987) did not present in the results. The results showed the necessity of developing teaching and learning strategies which can be promote student learning.

3. Instructional Materials

Teachers thought that information sheets, work sheets, and picture charts promoted their success in teaching genetics. However, students argued that those instructional materials were from the students' handbook. Both teachers and students need to have more interesting instructional materials. Teachers requested some departments to develop genetics instructional materials, which were related to educational technologies in their schools. Students requested some technologies, such as videotapes, for instructional material.

Teachers needed to attend professional development programs for developing genetics' instructional materials. It showed the significance of genetics instructional materials, which were important in teaching and learning genetics. Then, teachers in different schools should exchange their knowledge for developing genetics instructional materials. From the results, the instructional materials for teaching and learning genetics in welfare schools did not related to teaching and learning disadvantages students, which should use physical or concrete instructional material that easy to find, easy to use and understand, be used in a variety of activities, be inexpensive, and durable (Division of Disability People, 2000: 14, 102, 117, and 119) for helping disadvantaged students learning. Moreover, people who are concerned should support developing genetics instructional materials and take chances to try out in volunteer schools.

4. Assessment and Evaluation

The data of assessment and evaluation from teachers and students was congruent to each other. Both teachers and students identified that most of the assessment and evaluation procedures used were from tests and practical worksheets. Even so, the teachers' response showed that using tests and practical sheets with students' activities were parts of successful genetic teaching, but students did not identify these activities in assessment and evaluation. Students asked for having tests in a variety forms more often. It seemed the students need some kinds of dynamic assessment to assess their learning periodically, which was a kind of scaffolding in social constructivist teaching and learning, is thus influenced by Vygotsky's notion of 'zone of proximal development' (Kozulin et al., 2003: 7-8; Gindis, 2003: 207-217).

These results were related to some parts of the policy of welfare education department, which most welfare schools had student center approach (Welfare Education Department, 2001: 112-118). Therefore, people who are concerned with teacher professional development should promote a number of assessments and evaluations, and let the assessment and evaluation contribute to students' learning development. To assess students learning periodically such as formative assessment rather than summative assessment should be a way to help students adjust their alternative conceptions and to prevent using the existing alternative conceptions linking to the new concept as such a kind of scaffolding (Palincsar, 1998; Kiraly, 2000; Bauer et al., 2001).

5. Problems and Solving Problems

Most teachers and students thought that the problems in teaching genetics were students, genetics contents, instructional materials, and teachers. The biggest problem for students was their basic knowledge of genetics and their attention in learning. Students thought that they had limitation in their intellect for learning. Genetics is difficult content, too much detail and complicated. Schools did not have modern instructional materials and were also lacking in the number of materials that they had available. Teachers did not have enough time and did not have strong genetic content available, so they did not feel confident in answering students' questions. However, students added two more problems, which were that teaching strategies included reading information from books without doing experiments, and the limited amount time for learning about genetics.

Teachers with lack of content and pedagogy affected their students' learning. For example, a high school biology teacher at a welfare school did not graduate from a science major. He did not show any significant problems in genetic contents and teaching strategies, but students' responses revealed that he had skipped some genetic contents. Moreover, he could not answer students' questions. Therefore, the school administrator should be concerned about the quality of students' learning before setting teachers to teach in each subject. Teachers should have chances to teach in subjects which they had ability in promoting students' learning.

Teachers reported that they solved the problems in teaching by changing teaching strategies and developing some instructional materials. Students solved their learning problems by searching for extra information by themselves or by asking teachers. These problems showed the necessity of developing teaching and learning genetics which are suitable for disadvantaged Thai high school students in welfare schools. The problem of the limitation of basic knowledge of genetics should solve by surveying students' prior knowledge before teaching for finding some ways to develop students' basic understanding before moving to new concept. For the problem of students' attention, teachers should motivate students into the lesson using a variety of situations that students familiar with them in daily lives. The enormous genetic contents in the limitation time of teaching and learning, which was a huge problem for the teachers and students may solve by adding the extra reading handouts which students can read outside the class and can link into each concepts of genetics. For the problem of the out dating genetics instructional materials, teacher should develop the new practical instructional materials. The problem of without doing experiment or practical activities in genetics classroom should solve by promoting practical activities with practical instructional materials. Some teachers identified practical activities and some practical instructional materials, such as using model for teaching DNA structure. From the results above, science educators should have contribution to help teachers teaching and students learning by developing instructional units in genetics, which were composed of checking students' prior knowledge, motivating students into the lessons, having extra reading, promoting using instructional materials, creating practical activities, and using dynamic assessment.

6. Suggestions

Most teachers and students suggested the same topics for teaching and learning genetics, which were genetic contents, genetic instructional materials, and teachers. Even though students accepted that genetics has too much detail and is difficult, they need to know more details which can be used in their daily lives. However, teachers argued that genetics was difficult because students had prior knowledge limitation in biology and mathematics. Students needed to have up-to-date instructional materials, but teachers needed some departments to create genetics instructional materials for them. Teachers need to develop their professional skills and wanted to teach in their major area. Students thought that teachers should have good intellects and good pedagogical content knowledge. Furthermore, students needed more time to learn genetics.

The other responsibilities of teachers in welfare schools could be affected to their teaching. They had to paid respect to daily life of students, such as food, clothes, and dormitory. Moreover, disadvantaged students were children who had limitation in their background. Most of disadvantaged students had physical problems, mental problems, intellectual problems, or social problems. After the researcher surveyed the situations of teaching and learning genetics in welfare schools, the basic genetic concepts of disadvantaged students were explored for providing genetics education which suit for disadvantaged students in welfare schools of Thailand. To accomplish genetics education as 1999 National Education Act, the researcher would use the information of teaching and learning genetics of disadvantaged students in welfare schools in developing genetic instructional units for disadvantaged students which based on social constructivism.

In summary, from the results of the survey, the researcher would develop genetic instructional units by motivating students into the lesson by using a variety of situations, such as social issues at that time; checking students' prior knowledge before teaching the new concept; using a variety of teaching strategies to let student thinking and constructing their own knowledge through social interactions; developing practical instructional materials; using a variety of dynamic assessment. The genetic instructional units which based on social constructivist approach are related to Thailand learning reform and should help disadvantage students learning genetics as a part of science content standard of Thailand.

Basic Genetic Concepts of Disadvantaged High School Students in Welfare Schools

The purpose of this part was to explore genetic concepts of disadvantaged Thai high school students in the 2004 academic year. This part will present the existing prior knowledge which students carried into genetic class. It was found that students had alternative conceptions in many topics. The information from this part was beneficial in developing genetic instructional units to fulfill students' learning in advanced genetics. The instrument was the basic genetic concepts 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 read, coded, and interpreted. This part will present the answers to the second research question:

What are the basic genetics concepts of disadvantaged high school science students in welfare schools of Thailand in the second semester of the 2004 academic year?

The results were revealed under two headings: background information of respondent science students; and basic genetic conceptions of the disadvantaged high school students.

The Background of Respondent Science Students

The 157 participants were 14-21 years old students from 16 disadvantaged schools which aimed to educate children in particularly difficult circumstances, such as orphans and minority groups. There were 68 males and 89 females. Most of the students were 16 years old. According to the different genetics curriculum in each school, 91 students were studying in Grade 10, two students were studying in Grade 11, and 64 students were studying in Grade 12.

The different age of students is one of the educational problems in welfare schools. Some students had to stop studying in order to work to find some money for their families. Some of them had to start their study later than other average students. Some had to change their schools many times to follow their parents who changed their workplaces. The data gatherings showed the necessity of finding out students' prior knowledge before teaching, because disadvantaged students who learned in the same class had a variety of knowledge backgrounds. Pashley (1994) and Wood-Robinson (1994) argued that finding out students' prior knowledge before teaching is necessary and helpful for effective teaching.

Basic Genetic Conceptions of Disadvantaged High School Students

The results showed basic genetic conceptions of disadvantaged high school students in seven concept surveys; which are inheritance traits, gene, chromosome, dominant and recessive alleles, genetic diseases, sex chromosome, and genetic engineering. The responses were classified into 4 groups which were 'sound understanding', 'partial understanding', 'alternative conceptions', and 'no response or no understanding or no conception' and interpret answer (Marek et al., 1990; Haidar and Abraham, 1991; and Brickhouse et al., 2000).

Peterson and Treagust (1989) argued that the benefit of using two-tier multiple choices in practical teaching situations was that it could investigate students' concepts in the a limited amount of time. In case of two-tier multiple choices, the categories came from answers in both two parts: multiple choices and writing explanation. Students who had scientific understanding in the concept had to have scientific understanding in both multiple choices and in the open-ended explanation. If one concept had more than one question, the categories came from answers of both questions. Students who had scientific understanding in the concept had to have scientific understanding in both questions. The number and percentage of students categorized by each genetic concept are shown in Table 4.9 below.

Table 4.9 Number and Percentage of Students Categorized by their Genetic Concepts (N=157)

Concepts	Categories	Number of Students (Percent)
1. Inheritance Traits	Scientific conception (S)	4 (2.5)
	Partial understanding (P)	**102 (65.0)**
	Alternative conception (A)	51 (32.5)
	No conception (N)	-
2. Gene	S	-
	P	4 (8.9)
	A	**141 (89.8)**
	N	2 (1.3)
3. Chromosome	S	-
	P	15(9.6)
	A	**133(84.7)**
	N	9(5.7)
4. Dominant and Recessive Alleles	S	-
	P	-
	A	**129 (82.2)**
	N	28 (17.8)
5. Genetic Diseases	S	9 (5.7)
	P	44 (28.0)
	A	**86 (54.8)**
	N	18 (11.5)
6. Sex Chromosome	S	5 (3.2)
	P	**63 (40.1)**
	A	47 (30.0)
	N	42 (26.7)
7. Genetic Engineering	S	1 (0.6)
	P	19 (12.1)
	A	39 (24.8)
	N	**98 (62.4)**

The results indicated that the majority of students had: ‘Alternative Conceptions’ in gene, chromosome, dominant and recessive alleles, and genetic diseases concepts; ‘Partial Understanding’ in inheritance traits and sex chromosome concepts; and ‘No Conception’ in genetic engineering concepts.

The students’ alternative conceptions from highest to lowest frequency were as follows: ‘Gene’ (89.8 percent), ‘Chromosome’ (84.7 percent), ‘Dominant and Recessive Alleles’ (82.2 percent), ‘Genetic Diseases’ (54.8 percent), ‘Inheritance Traits’ (32.5 percent), ‘Sex Chromosome’ (30.0 percent), and ‘Genetic Engineering’ (24.8 percent).

1. Inheritance Traits

Question 1: Which traits can be transferred by inheritance?

Question 1 is two-tier multiple choices, in which the respondent had to explain their answers. The choices were composed of eyelids, reading ability, eyes color, dimples, flattened or prominent nose, running ability, and hair color.

Question 5: Suppose that Paradorn and Tammy are famous tennis players who had trained before playing a game. If they get married to each other, will their children have ability in tennis when they are born? Why do you think like that?

The scientific conception of inheritance traits is that ‘Inheritance traits can transfer from parents to offspring’. From Table 4.9 above, most students (65.0 percent) had partial understanding in inheritance traits.

A few respondents (2.5 percent) had scientific understanding. However, 32.5 percent of the students had alternative conceptions. The alternative conceptions of students were they could not identify the inheritance traits and non-inheritance traits, and transferability from whom to whom. Examples of students’ responses are as follows:

1.1 Reading ability and sporting abilities, such as running ability or playing tennis can be transferred from parents to offspring.

1.2 The number of eyelids, eye colors, dimples, flattened or prominent nose, or hair color cannot be transferred from parents to offspring.

1.3 Inheritance traits can be transferred from older brother to elder sister; or transferred only from mother to children; or from relatives, such as from an uncle.

The alternative conceptions of students about the inheritance traits and non-inheritance traits in this research were related to Hackling and Treagust (1984) and Ramorogo and Wood-Robinson (1995).

2. Gene

Question 2: What controls curled or straight hair of humans? Why do you think like that?

Question 4: Suwanan have a couple of dogs. The male dog has curled hair and falling ears. The female dog has smooth hair and standing ears. If their puppy or puppies have curled hair and standing ears, what is the thing that control the traits? And how can the traits be transferred from the parent dogs to the puppy or to the puppy’s future litter?

Question 3: From ‘Question 2’, where is/are the place of the thing(s) which control that trait? Please explain the reasons of your choice(s). The choices were chromosome, nucleus, every cell around sculpt, and every cell which has nucleus in the body.

Question 14: What are the relationships of structure or function among DNA, gene, and chromosome?

Scientific conceptions of genes are that ‘Genes or genetic units, which control the traits of living organisms, come from both father and mother. Genes are a part of the DNA on a chromosome which is in the nucleus of each cell’.

For genes, a few students had partial understanding (8.9 percent) and no understanding (1.3 percent). No student had scientific understanding. Most students (89.8 percent) had alternative conceptions in four questions (Q2, Q4, Q3 and Q14) as follows:

For interesting information, most students (83.4 percent) did not identify the relationship of genes as a part of DNA, but some of them had partial understanding that genes are on the chromosome. Gene concepts could separate in each 4 sub-concepts which were 2.1-2.4.

2.1 The gene or genetic unit is the unit that controls the traits of living organisms. The alternative conceptions of students were:

2.1.1 Students identified other things apart from genes for controlling the traits of living organisms, such as ‘chromosomes’ or ‘DNA’ or ‘nucleus’ or ‘cells’ or ‘genes or chromosomes’ or ‘genes or chromosomes or DNA’.

2.1.2 Students identified something outside the body for controlling the traits of living organisms, such as ‘Curled or straighten hair being dependent on hair gel and curled hair equipments’.

2.2 Each genetic unit which presents a trait comes from both father and mother. The alternative conceptions of students were:

2.2.1 The cause of offspring traits, which look similar to father and mother, is genetic variation.

2.2.2 Some offspring traits come from the father, but some from the mother.

2.2.3 Some offspring traits were transferred from the father's sperm and the mothers' womb.

2.2.4 Offspring traits were similar to the father or the mother who transferred more chromosomes to the offspring.

2.2.5 Offspring received some kind of agent from the father more than the mother.

2.2.6 Offspring traits depended on chromosomes or genes, which were separated from the parent's chromosomes or genes.

2.3 Genes are on the chromosome (which is in nucleus of each cell).

2.4 Genes are a part of DNA.

For sub-concepts 2.3 and 2.4, some students could identify 'genes are on the chromosome', but most students did not identify that 'genes are a part of DNA'. The alternative conception was 'Genes are chemical agents, which are called DNA'.

Most students had alternative conceptions about the function of genes, which corresponded to the studies of Stewart and Dale (1981), Lewis et al. (2000a), and Marbach-Ad and Stavy (2000). Students' identified 'DNA' or 'chromosome' or 'nucleus' or 'gene or DNA or chromosome' in term of 'gene'. It showed the significance of adapting students' prior knowledge before teaching DNA. In particular, item 2.1.7 showed the necessity of adapting to the students' prior knowledge before teaching the next concept. Item 2.2.2 was related to Wood (1996:

63). Item 2.2.4 was related to Mungsing (1993: 131-138, 162-164) and Wood (1996: 63).

3. Chromosome(s)

Question 4: Suwanan have a couple of dogs. The male dog has curled hair and falling ears. The female dog has smooth hair and standing ears. If their puppy or puppies have curled hair and standing ears, what is the thing that control the traits? And how can the traits be transferred from the parent dogs to the puppies or to the puppies future litters?

Question 13: Apaporn has an ox and a cow. What is the opportunity of the gender of their offspring? And why do you think like that?

Question 7: Do the living organisms which have the same chromosome number necessary have to be the same living organisms? Why?

Question 8: Are there the same number of chromosomes in sex cells that there are in somatic cells? If not, what is the ratio of chromosome numbers in sex cells and in somatic cells? Why do you think like that?

Question 6: Where is/are the position of chromosomes in the body? Why do you think like that?

Question 9: What are the component(s) of chromosomes? Why are they important?

Question 14: What are the relationships of structure or function among DNA, genes, and chromosomes?

Scientific conceptions of chromosome(s) are: 1) chromosomes come in pairs; 2) some organisms can have the same number of chromosomes, albeit in different shapes; 3) the number of chromosomes in a reproductive cell (sex cell) is half that of a body cell (somatic cell); 4) the chromosome is in the nucleus of each cell; and 5) chromosomes are composed of DNA and protein.

For chromosomes, a few students had partial understanding (9.6 percent) and no understanding (5.7 percent), but nobody had scientific understanding. Most students (84.7 percent) had alternative conceptions in seven questions (Q4, Q13, Q7, Q8, Q6, Q9 and Q14).

These were the sub-concepts and alternative conceptions of the chromosomes concept.

3.1 Chromosomes come in pairs. Most students (68.8 percent) had no understanding on this sub-concept. The response came from questions 4 and 13. The alternative conceptions of students were that the sex chromosome of an ox or a cow is ‘x’ or ‘y’ or ‘X’ or ‘Y’.

3.2 Some organisms can have the same number of chromosomes, even if they are in different shapes; most students (40.1 percent) had alternative conceptions on this sub-concept. The alternative conceptions of students were:

3.2.1 Each organism has the different number of chromosomes. If some organisms have the same number of chromosome, they have to be the same species.

3.2.2 The same species does not necessary to have same number of chromosomes. It depends on the transferability of father and mother.

3.2.3 The number of chromosomes do not link to living organisms. We may not find chromosomes in living organisms, but at the same time, we may find them in non-living organisms.

3.2.4 The size of chromosomes depends on the size of the trait, which it has to control.

3.2.5 The number of chromosomes depends on animal size. For example, large animals have a greater number of chromosomes than small animals.

3.2.6 Chromosomes have a variety types. Each animal has different types of chromosomes.

3.3 The number of chromosomes in a reproductive cell (sex cell) is half that of a body cell (somatic cell). Most students (57.3 percent) had alternative conceptions on this sub-concept. Students were confused about genetic terminology, such as ‘chromosomes in the body’ and ‘body cell’ or ‘sex chromosomes’ and ‘reproductive cells’. The alternative conceptions of students were:

3.3.1 The number of chromosomes in a reproductive cell is equal to that of a body cell.

3.3.2 The number of chromosomes in a reproductive cell is 22 times that in a body cell.

3.3.3 A person has different numbers of chromosomes in their reproductive cells.

3.3.4 The number of chromosomes in a reproductive cell is not half that of a body cell (somatic cell).

3.4 The chromosome is in the nucleus of each cell. Most students (49.0 percent) had alternative conceptions on this sub-concept. The alternative conceptions of students were:

3.4.1 Chromosomes can be found in all body parts.

3.4.2 Chromosomes can be found in some organs or systems, such as skin, brain, face, head, hairs, or reproductive cells.

3.4.3 Chromosomes can be found in some parts of the body, where we can easily feel or notice.

3.4.4 Chromosomes can not be found in hairs, because hair does not have feeling.

3.4.5 Chromosomes are composed of nucleus or blood or blood cells or cells.

3.4.6 Cells can be separated from chromosomes.

3.5 Chromosomes are composed of DNA and protein. Most students (58.0 percent) had alternative conceptions on this sub-concept. Most students (57.3 percent) had alternative conceptions of 'chromosomes are composed of DNA and protein' (Q9), but most of them had no understanding that chromosomes are composed of DNA (Q14). The results might have been affected by the question asked. Question 14 may not raise students' thinking about the position of DNA on chromosomes.

The alternative conceptions of sub-concept 3.1 were related to Hackling and Treagust (1984). They found that some students did not understand that chromosomes come in pairs. The alternative conception items 3.3.2 and 3.3.3 are related to Lewis et al. (2000b). They found that the number of chromosomes in a reproductive cell are more than that in a body cell. The alternative conception of sub-concepts 3.4 and 3.5 are related to Lewis et al. (2000a). They found that students' were confused about the position of gene-DNA-chromosome-cells. Nevertheless, some alternative conceptions are interesting for developing genetic teaching for students' understanding in future study.

4. Dominant and Recessive Alleles

Question 10: Somsri has a black male cat and a white female cat. When they have kitties, all of them are black. How can you explain this situation? Why do you think like that? (You can show your ideas by drawing, making charts or explaining)

Scientific conceptions of dominant and recessive alleles are: Dominant alleles are forms of gene which will present traits of the allele when coming into contact with recessive alleles.

For dominant and recessive alleles, most students (82.2 percent) had alternative conceptions and 17.8 percent had no conceptions in questions 10 (Q10).

Even though the results did not show any alternative conception of dominant and recessive alleles like Allchin (2000), one hundred percent of no conception in disadvantaged students can refer to some problems in teaching and learning in the area of dominant and recessive alleles in the welfare schools of Thailand. The results showed that most students used ‘dominant and recessive genes’ as ‘dominant and recessive alleles’. The interesting reason is that the students’ handbook of The Institute for the Promotion of Teaching Science and Technology (IPST, 2000) used ‘dominant and recessive genes’ in terms of ‘dominant and recessive alleles’. This study relates to Mungsing (1993: 172), who found alternative conceptions between the terms of ‘gene’ and ‘allelle’ in Thai general students.

Moreover, this study showed interesting alternative conceptions of students, which were:

4.1 Dominant genes will present traits when coming into contact with recessive genes.

4.2 Dominant traits will present traits when coming into contact with recessive traits.

From the answers of Question 10, which purposed to survey students' dominant and recessive alleles concepts, the students' answers showed more genetic alternative conceptions which were:

a) Black cats have more genes than white cats.

b) Genetic traits which can see from outside come from only male cats.

c) Black male cats have black dominant genes and white recessive genes, but white cats have white dominant genes and black recessive genes.

d) Male cats have more dominant genes than female cats.

e) Black cats have more power than white cats.

f) The cells of a male cat are stronger than that of female cats.

g) The sperm of male cats control the female's womb.

h) Male cats are stronger than female cats.

These alternative conceptions came from students' explanation of 'the cause of black kittens of a black male cat grouped with a white female cat'.

5. Genetic Diseases

Question 11: Chatchai and Sinjai are a couple who have the thalassemia gene. Thalassemia is a genetic disease. Both of them are normal people without any symptom of thalassemia disease. Do their children have a chance of developing thalassemia disease? Why do you think like that?

Question 12: If Chatchai gets married with one of his relatives, what is the chance of their children having thalassemia disease?

Scientific conceptions of genetic diseases are: 1) If the abnormal recessive gene is in the normal person, the genetic unit can show in the offspring; and 2) Marriage between relatives increases the opportunity of wrong traits in their offspring.

For genetic diseases, some of them had partial understanding (28.0 percent) and no conception (11.5 percent). A few of the students had a scientific understanding (5.7 percent). Most students (54.8 percent) had alternative conceptions in two questions (Q11 and Q12).

5.1 If the abnormal recessive gene is in the normal person, the genetic unit can show in the offspring. For sub-concept 5.1, most students (44.0 percent) had partial understanding in Question 11. The alternative conceptions of students were:

5.1.1 The children of the father and mother who have thalassemia genes will not develop thalassemia disease.

5.1.2 People who have thalassemia genes have to have thalassemia germ.

5.1.3 People who have thalassemia genes will definitely develop thalassemia disease.

5.1.4 If parents have thalassemia disease, their children will develop thalassemia disease as well.

5.1.5 If parents have thalassemia genes, their children will definitely develop thalassemia disease

5.1.6 If parents have thalassemia genes, their fourth child will have thalassemia disease.

5.1.7 If parents have thalassemia genes, their children have a 50 percent chance of developing thalassemia disease.

5.1.8 If parents have thalassemia genes, the recessive trait (disease) is obviously or clearly presented in their children.

5.1.9 If parents have thalassemia genes, their children will develop thalassemia disease if they have the dominant gene.

5.1.10 Thalassemia disease is only on the X chromosome, so only a male child can develop thalassemia disease.

5.1.11 Thalassemia disease can be transferred from father to son.

5.2 Marriage between relatives increases the opportunity of the wrong traits in their offspring. For sub-concept 5.2, most students (47.8 percent) had alternative conceptions in Questions 12. Some students did not concern about thalassemia disease of the father's relative, who will married with him. The alternative conceptions of students were:

5.2.1 Parents who are relatives have a greater chance of having children who will develop thalassemia disease than parents who have the thalassemia gene.

5.2.2 The opportunity of children developing thalassemia disease is dependent on how much genes they receive from either their father or mother.

Even though it had the limitation of only studying genetic disease alternative conceptions, the results of this survey showed the same students' alternative conceptions of the relationship between genetic diseases and relatives as in the Quest journal (MDA: 2001). However, the results showed a different variety of genetic disease alternative conceptions more than the Quest journal, such as that students did not understand the difference between having the gene of a genetic disease and actually having the symptons of the genetic disease.

6. Sex Chromosome

Question 13: Apaporn has an ox and a cow. What is the gender of their offspring? And why do you think like that?

Scientific conceptions of sex chromosomes are: 1) The gender of a baby depends on the pair of sex chromosomes; 2) Females have the XX chromosome; and 3) Males have the XY chromosome. Question 13 investigated students' conceptions of sex chromosomes.

For sex chromosomes, most students (40.1 percent) had partial understanding. A few of the students had scientific understanding (3.2 percent). Some of them had no conception (26.7 percent) and alternative conceptions (30.0 percent). The sub-concepts and alternative conceptions of each sub-concept were shown as following:

6.1 The gender of baby depends on the pair of sex chromosomes. The rates of 'partial understanding', 'alternative conceptions', and 'no understanding' were almost the same, which were 28.0, 29.9, and 27.4 percent respectfully. However, most students (29.9 percent) had alternative conceptions in Question 13 (Answer 13.1). The alternative conceptions of students were:

6.1.1 The gender of a baby depends on the 'quantity of inheritance' or 'how many of their chromosomes came from their father or mother' or 'the ability of sperm to show gender' or 'dominance of gender' or 'the quantity of the parents' sperm'.

6.1.2 The gender of a baby cow/ox depends on the feeder or the owner of the cow and the ox, such as 'depends on the cell transferability from the owner to the baby cow/ox' or 'depends on the way the owner treated their ox or cow'.

6.1.3 The gender of a baby cow/ox depends on other things apart from chromosomes, such as on the 'colors of the parents' or 'the gestures of an ox and a cow' or 'the cells controlling the parents' transfer' or that 'gender does not depend on genetic inheritance'.

6.1.4 The gender of a baby has to be either male or female.

6.2 The female has the XX chromosome. The alternative conception of students was that the sex chromosome of a female is 'X' or 'Z'.

6.3 The male has the XY chromosome. The alternative conception of students was that the sex chromosome of a male is 'Y'.

For 6.1, the alternative conceptions of the role of sex chromosomes were related to Lewis et al. (2000b) and Wood-Robinson (1994). This study did not find some traits of human, which transferred from the same gender to the same gender in the next generation like Wood-Robinson.

However, this study found alternative conceptions on the relationship of the owner to the cow or ox, along with the parents' outside traits or an ox's or a cow's gestures, that had influenced the gender of the children. In addition, the gender of the children did not depend on genetic inheritance, which can be interesting information for the future teaching of sex chromosomes and related concepts.

For sub-concepts 6.2 and 6.3, Hackling and Treagust (1984) found alternative conceptions of students about sex chromosomes and gender identification, but the chromosomes were in still believed to be in pairs. However, this study revealed alternative conceptions that chromosomes were single, such as only ‘X’ or ‘Y’.

For question 13, which asked for sub-concepts 6.2 and 6.3, most students (more than 90 percent) had no understanding.

7. Genetic Engineering

Question 15: Have you ever heard about ‘genetic engineering’? If you have, where did you hear about it? And what do you know about ‘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 enzyme. Then, ligating with vector by DNA ligase, and introducing the recombinant DNA to the host cell for amplification. The recombinant DNA, which transformed into a cell, has to replicate itself. Question 15 was the question for investigating students’ conceptions of genetic engineering.

For genetic engineering, most students (62.4 percent) had no conception. Only 0.6 percent of students had scientific understanding of genetic engineering. Some of them had partial understanding (12.1 percent) and alternative conceptions (24.8 percent) in genetic engineering. The alternative conceptions of students were:

7.1 Genetic engineering is related to ‘traits’, the ‘structure of traits’, ‘transferred traits’, ‘connected tissue’, ‘gender’, ‘body function’, or ‘mutation’.

7.2 Genetic engineering is ‘cutting and pasting tissue’ or ‘cutting and pasting cells’.

7.3 Genetic engineering is the research or study of mixing things, such as nucleus or birth.

7.4 Genetic engineering is the model of creation or the synthesis of something.

7.5 Genetic engineering is a component of ‘inheritance’ or the ‘thinking of each part in the body’.

The merits of genetic engineering are constantly debated in the modern global era, but few researches have been published about genetic engineering concepts. For example, Hill and O’Sullivan (1998) presented alternative conceptions of genetic engineering applications. The research for this thesis supports the findings of Hill and O’Sullivan that many people still have genetic engineering alternative conceptions.

The results showed students’ neglect of news and situations in the world that have been broadcasted by the media. It had some influence on the scientific understanding of genetic engineering by the students, yet there were less than 1 percentage of students with scientific conceptions in this study. The results indicated that the majority of students had: ‘Alternative Conceptions’ in 4 concepts; ‘Partial Understanding’ in 2 concepts; and ‘No Conception’ in 1 concept. Some of the alternative conceptions were related to other literatures, some of them were not. The results showed necessity to check students’ prior knowledge before teaching new concepts, because a variety of students in the class came with a variety of genetic concepts they held. It might not fare to start the new lesson with the concepts that teachers supposed that every students knew about it from the learning objectives of former lesson. It showed the importance of developing instructional units, which can help disadvantaged students understanding genetics, which they can use their knowledge to communicate to others and developing their quality of lives by checking students’ prior knowledge before teaching new concept.

Summary

The survey results of teaching and learning genetics for disadvantaged students, showed congruence between teacher and student perceptions. The difficult concepts for teaching and learning which teachers and students agreed upon were ‘Chemical Structure of DNA’, ‘DNA Properties and DNA Synthesis’, ‘DNA and RNA in Protein Synthesis’, and ‘Genetic Codes’. The teaching and learning strategies which the teachers used often in genetic classroom were teacher explanations, students had chances to discuss and present in their classrooms. Even though the instructional materials which the teachers used and felt success in teaching genetics were information sheets, work sheets, and picture charts. The students reported that they need up to date instructional materials. The teachers’ results showed they used tests and practical worksheets for the assessment, the students need more often of assessment with a variety of assessment. The problems in teaching and learning genetics in welfare schools were students’ intention and knowledge, the too much details and difficulty of genetics contents, old fashionable of instructional materials, and teachers’ knowledge in genetics. Both the teachers and students solved their problem by themselves. The students tried to convince with more capable experts when they had problems in learning genetics.

The data on student basic genetic conceptions suggests that basic genetic concepts of the students needed to be correct before moving to the new concepts. The results showed that the students had alternative conceptions in all seven concept surveys; which are inheritance traits, gene, chromosome, dominant and recessive alleles, genetic diseases, sex chromosome, and genetic engineering. According to the results that students would ask more capable peers who could be both teacher and other students, showed the importance of developing students’ communication skills through classroom activities which promoting interaction among peers and between teacher and students. From the problems of both genetic concepts and teaching and learning genetics situations in welfare schools, the researcher as a teacher in welfare school need to find some ways to help the disadvantaged students accomplish the educational goals before graduating from high school level, which were genetic concepts and communication skills. The researcher would develop genetic instructional units, which could help disadvantaged students developed their genetic concepts and communication skills as showed in Chapter 5.