CHAPTER V

THE INSTRUCTIONAL UNIT

Introduction

This chapter addresses research question 2 which is about how to develop an instructional unit and prepare teachers to use this unit. "The educational reconstruction model" proposed by Duit et al. (1997) was adapted to this study as the guideline for developing a conceptual change-based instructional unit.

There are two sections in this chapter. In the first section, the three components of the educational reconstruction model namely; an analysis of content structure, empirical investigations and the construction of instruction are presented. The second section presents the construction of the instructional unit in this study: In this section, the process of development of an instructional unit, the overview of the instructional unit and the processes of cooperative working with the teachers are explained.

The Educational Reconstruction Model

A number of frameworks have been used to guide the development of research-based teaching units (Linjse, 1995, Duit et al., 1997; Leach and Scott, 2000; Leach et al., 2003). Frameworks, such as the developmental research model (Linjse, 1995) and the education reconstruction idea (Duit et al., 1997) have the same main idea about the need for a cyclical process of conceptual analysis, empirical studies and the development of teaching practices. An adaptation of "the educational reconstruction model" proposed by Duit et al. (1997) provided information to the development of the unit in this study. This framework was chosen because its constructivist perspective, which is underlined by a constructivist conceptual change approach that merges issues of radical and social constructivist positions. This is consistent with the theoretical framework that underpins this study. The educational

reconstruction model has three components: an analysis of content structure, empirical investigations and the construction of instruction.

1. Content Structure Analysis

The analysis of content structure involves an analysis of the subject matter, and a clarification and identification of the educational significance of a particular scientific content. The interconnected set of core ideas of a particular content domain is distilled from the perspectives of the key aims of science instruction. This is necessary because it provides a clear purpose for the instructional unit. In this study it was important to identify the main ideas suitable for describing matter and its properties at a primary level.

2. Empirical Investigation

The empirical investigation component of the educational reconstruction model involves an investigation of students' existing conceptions and the possible development of student ideas towards the intended scientific views. These views may be sourced from the existing literature (for example Pfund and Duit, 1994) or sought directly through interviews or surveys. In this study it was considered important to elicit students' conceptions directly. There is a considerable body of research available on student conceptions of matter and its properties but very little research has been undertaken on the ideas of Thai students. In line with an interpretive approach which values multiple perspectives and with research that indicates that the teacher influences the students' conceptual development in ways that may be lead to an increase in alternative conceptions, it was considered important to survey Thai teachers to gain information on their perceptions of teaching and learning primary science and Thai students about their ideas regarding matter.

2.1 A review of the literature on student conceptions A review of the literature was prepared on the common student conceptions of matter and its properties (See chapter 2). A majority of the research studies reviewed focused on

students' views of the properties of matter in different states and on changes in the state of matter. Other studies investigated students' conceptions of chemical change, mainly with respect to combustion. Dissolving is another concept which many researchers have been interested in. Alternative conceptions associated with abstract ideas, for example, the disappearance of matter, the change in state of matter and dissolving and the formation of new substances in chemical reaction were mostly found. From the review, two underpinning concepts involved in many students' confusions were identified; the particle nature of matter and the conservation of matter (Andersson, 1990; Lee et al., 1993). These were specified included the instruction unit designed in this study.

2.2 The Need to Investigate the Thai Context Only three researchers have studied Thai student conceptions of matter. Savanakunanon (1993) investigated the development of six to thirteen year old children's ideas about matter and non-matter; Chantanapitan (1997) studied high school student conceptions about structure, composition, size, shape, mass, intermolecular force and the energy of molecules and these properties in different phases of matter. Finally, Sanguansin (2004) studied student's conceptions about state and change in state of substances at a higher primary level. The limited number of the research studies contributed to the requirement to investigate Thai student conceptions of matter in this study.

3. The Construction of the Instructional unit

The construction of an instruction unit involves development, piloting and evaluation. In developing an instructional unit or sequence, it is important to consider how learning takes place (Duit et al., 1997; Leach and Scott, 2000; Leach et al., 2003). According to constructivist view, learning is not a process of transmission but rather a process of conceptual change: students construct their own knowledge based on their existing conceptions that they already know. Hence, the development of the instructional unit needed to take into account what was known about student conceptions of matter and its properties and research on what seen as effective teaching process for conceptual change.

4. Evaluation of the Instructional unit

Typically, the effectiveness of an instructional unit is evaluated using pre-survey and post-survey to compare student responses before and after teaching. Leach and Scott (2000) recommend that observation of what happens in the classroom is also important. This allows the researcher to see if student actions and comments fit with those intended (Leach and Scott, 2000). Both of these approaches were adopted in this study. In order to allow for variation between teachers and students, case studies of the implementation of the instructional unit were developed using a combination of surveying, interviews with teachers and students, collection of students' work, and classroom observation.

The Construction of the Instructional Unit in This Study: A Conceptual Change-Based Instructional Unit

The development of the instructional unit in this study was informed by the conceptual change view of learning (See chapter 2) along with research that has sought to implement this view in the classroom. The literature points out that key consideration include the importance of student existing conceptions, ways to encourage students to become aware of their existing conceptions, and ways to help students develop scientific conceptions intentionally. The view of conceptual change that informs this study acknowledges that change or development does not occur solely in a student's head but also changes their relationship with their social world. Affective and social factors are considered as the influences on change. In this study, r conceptual change teaching strategies include the use of analogies and models, role play and problem solving. Issues around language use in science and effective teacher questioning techniques for primary science were also attended to (See chapter 2).

The construction of the instructional unit was based on the National Science Content Standards (IPST, 2002). The literature review and data from the survey in Phase I about teaching and learning about matter and its properties were considered in

developing the instructional unit. Moreover, with regard to the teachers as the key people to develop teaching and learning, the teachers were asked to participate in the process of developing the instructional unit. Ideas of formative assessment which emphasize on assessing the student ideas through out the process of teaching and learning (Cowie, 2002) were kept in mind to track the process of conceptual change in the instructional unit.

This section sets out the development of the instructional unit as it was informed by a content structure analysis of the Thai content standards, the researcher's own empirical investigation of Thai teacher and student views and a review of the existing literature.

1. Content structure analysis

1.1 The curriculum requirements Matter and its properties is the third of eight content standards in the National Content Standards, Thailand (IPST, 2002). These standards delimited the content structure analysis in this study. Matter and its properties are taught in Thai primary schools as part of science. There are five topics within matter and its properties: properties of solids, liquids and gases, the changes in state of matter, solution processes, separation of mixtures, and chemical change. The National Science Content Standards (IPST, 2002) focus on the development of student understanding of scientific conceptions to describe phenomena and to be scientifically literate people.

In this study, the instructional unit was developed by sequencing the learning outcomes and then designing learning activities that were consistent with the learning outcomes. The development process was informed by the literature review on student alternative conceptions and approaches that promote conceptual change and involved number iterations. It was also necessary to source and adapt teaching and learning activities to the Thai context.

2 The Design of the Instructional Unit

A number of materials which have been shown as effective science teaching strategies, to help students learn about matter and its properties were available from the research literature, online and from primary science textbooks. The literature review on student alternative conceptions and approaches that promoted conceptual change informed the selection of activities as the development process went through a number of iterations. The format and the selection of activities was based on the purposes of teaching and learning science and matter and its properties in the National Content Standards, Thailand (IPST, 2002).

The duration of the instructional unit was 15 hours (three hours/ week) and included five sequences; properties of solids, liquids and gases, the changes in state of matter, solution processes, separation of mixtures and chemical change. The selection of activities included a focus on many teaching strategies that promote conceptual change (See Chapter 2): mental models, analogies and metaphors, role play and metacognition. The development of activities also took care of language difficulties, for example; the confusion between science language and everyday language, Thai language confusions and the students' poor reading and writing. All activities and examples were sourced and adapted to the Thai context.

This unit not only included activities but also included notes for the teacher. The teacher guide included a section on scientific conceptions and common student conceptions to provide the teacher with some understanding of the difference between student alternative conceptions and scientific conceptions. The role of teacher in the activities was described so that they might act more as a facilitator who has both content knowledge and knowledge of strategies which challenge students to think about their existing conceptions and to modify these toward the target concepts.

Although the focus on the national science content standard of IPST was retained, the essential issues about matter and its properties such as definition of matter, particle nature of matter and conservation of matter were promoted. The ideas

of student's learning and learning theory based on constructivism and conceptual change perspective were taken into account.

The sequence in each lesson followed the conceptual change process approach namely;

1) The students expressed and considered their prior knowledge.

2) The students were confronted with phenomena which challenged the students to use their prior conceptions to explain the phenomena. After that, the students were introduced to activities which encouraged the students to use scientific conceptions to explain the same phenomena.

3) The students compared their prior conceptions with scientific conceptions as a way of explaining the same activities. They were then able to apply the scientific conceptions to new situations.

A summary of the instructional unit are present in the Table 5.1

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Table 5.1 A Summary of The Conceptual Change Approach-based Instructional Unit

Period	Lesson	Concept	Activities
1	Lesson 1: The change in state of matter 1.1 Particle model of solid liquid and gas.	Solid: The particles of solid are closed together and in order; they vibrate but cannot move from place to place. Liquid: The particles of liquid are less ordered than solid; they collide with each other and move in a disordered manner in all directions through the liquid. Gas: The particles of gas are very far apart; they collide with each other and move in a disordered manner in all directions.	- Using of model called "a jar of sand model" to explain that matter is not continuous but consists of particles. - Role playing to show how particles in solid, liquid and gas behave. - Drawing a picture to show student ideas about particle model of solid, liquid and gas.
2	Lesson 1: The change in state of matter 1.2 Particle model of the change in state of matter.	- The particles of matter will move faster and go further apart when they are added more heat. - The particles of matter will move slowly down and tend to be closed when they are removed heat. - No substance is created or destroyed during the change. - Reversal of the change is occurred by adding or removing heat.	- Observing heating of ice until it changes into water and water vapor. - Drawing analogy between Popeye story and the impact of heat on the changes of particles. - Playing card game for conclusions about the relationship between heat and the change in inter particular forces, arrangements and movements of particles in which leads to the change in state of matter.
3	Lesson 1: The change in state of matter 1.3 Melting and freezing.	Melting: Solid absorbs heat and changes into liquid. The particles of solid lose attraction and move faster and move further apart. Freezing: Liquid changes into solid. The particles of liquid move slowly down and tend to be ordered.	- Observing and weighing ice melt in the zip log bag to show that ice is conserved during the melting process. - To clarify student understanding that ice melting is the reversible process of water freezing and clarify the differences between dissolve and melt. - To do other experiments to confirm that melting and freezing can occur in other substances that is, melting ice, ice cream, candle, wax, and chocolate; and making ice cream.

Table 5.1 (Cont'd)

Period	Lesson	Concept	Activities
4	Lesson 1: The change in state of matter 1.4 Evaporation and condensation	Evaporation: Liquid absorbs heat from the sun and changes into gas at various temperatures. The particles of liquid move faster and move further apart. Condensation: Liquid vapour absorbs heat and changes into liquid. The particles of liquid move slowly down and tend to be closed together.	- Observing a bowl of hot water covered with a saucer containing ice to explain how hot water evaporates into water vapour and water vapour condenses back into water.
5	Lesson 1: The change in state of matter 1.5 Boiling and sublimation	Boiling: Liquid absorbs heat and changes into gas. The particles of liquid move faster and move further apart. - Bubbles are liquid at the bottom of the container which changes into gas when liquid boils and rises to the surface in the form of bubbles. At the surface, water vapour escapes and the liquid level goes down. Sublimation: Some solid change straight into a gas but do not change into a liquid. The particles of solid move faster and move further apart.	- Observing boiling water in the beaker and explain the formation of bubbles and give the reason of level of water going down. - Observing heating of camphor and differentiate between sublimation and other processes of change such as evaporation.
6	Lesson 2: Solution process 2.1 Soluble and insoluble	- One substance (solute) mixes homogeneously with another substance (solvent), a solution is formed. - Any substance is not created or destroyed during the dissolving.	- Observing and describing sugar dissolving in water. - Testing and explaining the solubility of salt, sand, soil, oil, pepper, fish sauce, alcohol, cleaning solution, glucose electrolyte and potassium permanganate. - Clarifying the solute and solvent in the solution.
7	Lesson 2: Solution process 2.2 Solution properties	- The particles of solute are spreading out among the particles of solvent. - The properties of solution are the same thorough the solution.	- Presenting the particle model of sugar in water. - Finding out the way to prove the existing of sugar in water. - Evaporating water from sugar and using benedict solution to test a substance which is presented (sugar).

Table 5.1 (Cont'd)

Period	Lesson	Concept	Activities
8	Lesson 3: Separation of mixture	- The method to separate mixture depends on the properties of the substances involved namely 1. sifting is the method for separating mixture of solid and solid 2. filtration is the method for separating mixture of liquid and solid 3. sedimentation is the method for separating mixture of liquid and solid (suspension) 4. sublimation is the method for separating mixture of solid and solid 5. evaporation is the method for separating mixture of solid from liquid	- Doing activities to select the method suit to each mixture, the methods are o Picking o Filtration o Sedimentation o Sublimation o Evaporation - Brainstorming to select the methods above to separate the mixtures namely o Camphor and salt. o Differences types of coins. o Mud in water. o Salt in water. o Orange dregs in orange juice. o Diesel gasoline and water. o Tea dregs in tea.
9	Lesson 4: Chemical reaction 4.1 Chemical reaction and indicators	- New substances are formed during the chemical reaction. - It is difficult to reverse chemical reaction. Sometime, it is impossible.	- Observing and explaining the changes in the ways of the formation of new substances and the irreversible process namely o Baking powder and vinegar. o Vinegar and mussel-shell creeper flower. o Salt and water. o Oil and water. o Burning sugar.

Table 5.1 (Cont'd)

Period	Lesson	Concept	Activities
10	Lesson 4: Chemical reaction 4.2 The effect of chemical reaction in everyday life	There are both advantages and disadvantages from chemical reaction in everyday life.	- Searching for news or own experiences about advantages and disadvantages from chemical reaction in everyday life. - Confronting with an example of chemical reaction in everyday life (cooking Hockey Pokey)
11	Lesson 5: The changes in everyday life	There are two kinds of change in everyday life; physical change (change in state and solution process) and chemical change.	Doing research about the changes in everyday life namely o Change in state o Dissolving o Chemical reaction
12	Lesson 5: The changes in everyday life Students presentation of their research		Presenting the research by o Demonstration or o Role play or o Science project or o Etc.

3. The Implementation and Evaluation Process

These section sets out key aspects of the instructional unit implementation and evaluation process. The instructional unit was implemented in three different schools by the Grade 6 teachers in each school who volunteer to participate in this study. All teachers participate in the teacher conferences. The details of teacher conferences are presented in the next section. All classroom activities were observed by the researcher and students' responses to the worksheets and students' work were analysed. The teachers and some students were interviewed after each lesson.

4. Teacher Conferences

The teacher conference sessions were used to introduce a conceptual change – base instructional unit to the teachers involved in its implementation. The teachers (Ms Pailin, Ms Chujai and Mr. Mana) who participated in the study were involved in the conferences to clarify understanding of the objectives of this study and the instructional unit and its adaption to suit their class. The teachers' conferences took place four times in the second semester of the academic year 2004. The research advisor participated in the 1st and the 4th teachers' conference to discuss with the teachers about teaching science based on constructivist view of learning.

4.1 The Processes of Teacher Conferences

The sequence in teacher conference provided the activities for the teacher to develop their understanding in teaching science compare with how student learn science.

4.1.1 To encourage the teachers to think that they were similar to the students who attended the class with their own ideas. The sequences in promoting conceptual change in teaching science had the same ideas as the strategies to promote student conceptual change.

4.1.2 Each teacher was probed into their prior concepts of teaching science and their expectations in teaching science.

4.1.3 The main ideas of teaching for conceptual change were presented to the teachers about to aware of student prior knowledge, of how student learnt, of how to help the student realize the limitation of alternative conceptions and of how to encourage the students to understand the scientific conceptions.

4.1.4 Many teaching strategies to promote the students to develop their conceptions towards those of scientists were introduced. The effective factors such as motivational beliefs also established as the important factors which promote the increase of students' learning.

4.1.5 The teachers had opportunities to reflect their ideas about their own changes and to present the advantages from their changes into teaching and learning in their classes.

4.2 The Activities of Each Teachers' Conference

The activities from each teacher conference are presented as follows:

4.2.1 The 1st teachers' conference (29 - 30 January, 2005)

1) Introduce the research objectives, the overview of the research study, the findings from the exploration surveys about student conceptions in Phase I, and the development of the instructional unit based on the National Science Curriculum (IPST, 2002) and the conceptual change perspective.

2) Ask for permission for the researcher to work collaboratively with the teachers and to be a participant observer in the classrooms.

3) Introduce the idea of learning science based on a constructivist view introduced by a science educator.

4) Introduce the instructional unit and the teacher's guide and ask for the teachers' suggestions on the instructional unit.

5) Practice how to use science instruments and to teach science experiments.

4.2.2 The 2nd teachers' conference and the 3rd teachers' conference (5 February 2005 and 13 March 2005)

1) Introduce the instructional unit, the teacher's guide and to ask for the teachers' suggestions on the instructional unit (continued).
2) Teacher reflections on their teaching.
3) Student responses to the instructional unit.
4) Problems in implementing the instructional unit.

4.2.3 The 4th teachers' conference (26 March 2005)

1) Teachers' reflections on their teaching.
2) Student responses to the instructional unit.
3) Problems in implementing the instructional unit.
4) Evaluation of the instructional unit.
5) Summary of the implementation process.

Teacher feedbacks on the instructional unit were important for the researcher to develop the unit to suit the students. The summaries of teacher feedbacks are presented below in three topics. Overview of the instructional unit, the science content about matter in the instructional unit, and activities in the instructional unit.

4.3 Overview of the Instructional Unit The teachers thought the instructional unit and the teacher' guide were understandable and helpful. They said that the lesson plans provided sample questions, and details of the activities for them. Although the teachers said they were unfamiliar with different ways of assessment, the instructional unit introduced them to a number of teaching assessment strategies for example, group discussions, student interviews, and science projects. The three teachers said they were interested in teaching for conceptual change and realized the importance of the development of student ideas based on student prior conceptions. However, the teachers gave feedback on language in the instructional unit. They suggested changes to some parts of the unit to make it more understandable for the students, for example, to use short, clear and easy terms for the questions in worksheets. Another problem which was brought up by the three teachers was time constraints. They said their schools had already too many extra activities for both teachers and students and that they did not have enough time to teach relying exclusively on the instructional unit. They suggested decreasing the time allocated to some activities.

4.4 The Science Content about Matter in the Instructional Unit The three teachers accepted that the content in the instructional unit covered the content in the National Science Content Curriculum (IPST, 2002). However, at the beginning, most teachers said the particle model of matter was too difficult for them and their students. Regarding the change in state of matter, they said that the advantages of the particle model were to help the students understand the reasons of changes in state in terms of the arrangement and movement of particles. For the content of the change in state of matter, one teacher said some concepts were unfamiliar for her, for example, sublimation and condensation. Similarly, the terms solute, solvent, and mixture in the content of solution process were unfamiliar for this teacher. However, she tried to study more by herself and discuss with the researcher and other teachers to develop her understanding all the time.

4.5 Activities in the Instructional Unit The teachers said most of activities in the instructional unit were interesting and would encourage students to learn and apply science in the students' everyday life. The teachers suggested changing some

activities to suit the students' context. For example, the uses of mussel-shell creeper flower instead of red cabbage to test chemical reactions and to introduce some desserts to use as examples for crystallized sugar. The teachers said most students liked to do science experiments and all hands-on activities. The teachers commented that there were too many worksheets in the instructional unit, especially for the first part of lesson 1 about the particle model. The teachers said most students said that they did not want to write.

4.6 <u>Evaluations of the Unit</u> The case study was the method used to study the teaching and learning about matter and its properties in the science classrooms in three primary schools. Data was collected from surveys, classroom observations including researcher field notes, audio-tape and video recordings, teacher and student interviews, and students' work samples. The pre concept survey was implemented before the beginning of the instructional unit to determine student prior conceptions of matter and its properties in five key concepts; properties of matter, the change in state of matter, solution process, separating of mixtures and chemical change. After fifteen periods of instructional unit, the post concept survey was implemented to examine the development of student conceptions about matter and its properties in the same key concepts as the pre survey.

The comments from the teachers were they said the students liked to do science experiment, make presentations and show their abilities in doing activities to the class. The teachers said the instructional unit also encouraged the students to work cooperatively. Moreover, the teachers thought they had ideas about how to assess the students through many strategies of assessment. For example, one teacher said her students who could not respond to the worksheets or surveys could do a science project.

The researcher was a participant observer in all three primary science classrooms. The researcher asked for permission from the teachers and the students to observe their class and collect data. Building rapport with teachers and students in the classes was very important, especially for young students. The researcher went to the classrooms before the time of collecting data. She explained to the students about her

role and what she was writing in her notebook and what the audio-taping and video-taping was for. The researcher did not act as a teacher but she stayed in class and observed the interactions between students and the teacher in the class. The researcher would give suggestions to the students if they requested some help. Referring to what the teacher had said and suggesting them to ask the teacher for help. The students allowed the researcher to photocopy their worksheets and other kinds of written work. The student work samples were the evidence of the student conceptional development during the instructional unit that was implemented.

Summary

A conceptual change-based instructional unit was developed and evaluated through the framework for the development of research-based teaching units recommended by Duit et al (1997), which is called "the educational reconstruction model". The data from the literature review about teaching and learning matter, the surveys of the existing situation of teaching and learning about matter, and Thai curriculum requirements were used as the important information in the development of the instructional unit. The lessons in the instructional unit were designed based on a conceptual change approach to facilitate the teachers teaching and to progress students through the conceptual change process. Teacher conferences were provided to prepare the teachers to use the instructional unit. They also established a cooperative working relationship with the teachers. The results from implementing this instructional unit are presented in Chapter 6.