CHAPTER VI

RESULTS AND DISCUSSION

Introduction

"I am not stupid, am I?" (Duangkeaw, 2004). This student's question reminds us that students' progression towards understanding scientific conceptions involves consideration of what is the central point of developing students' understanding. What is the boundary of teachers' responsibilities? Do teachers need to assess their students only based on the achievement test? Who is responsible for students' motivation to learn? This study introduces alternative ways of teaching to answer these questions including Duangkeaw's questions.

This chapter presents the results and discussion of this study. There are two sections in the chapter. The first section describes the data which are used to answer research questions 3. The backgrounds of the participants in each case are presented. The way the instructional unit was adopted into the teaching and learning in of each of the three case study classes is presented. The teachers' change in their teaching and students' change in their understanding are presented. The favorable impacts on student learning of teaching strategies based on a conceptual change approach and teacher teaching are presented to argue that using a conceptual approach can be successful. The second section, a cross case analysis of the three case studies includes a summary and discussion of the changes in the teaching and learning of matter deriving from the use of the instructional unit.

Teaching and Learning about Matter and Its Properties Using the Conceptual Change Approach-Based Instructional Unit

This section includes the multiple case studies of changing the students' understanding about matter. The three case studies about the changes in student understanding of matter that occurred throughout the implementation of the instructional unit designed on the concept of substance and it properties are showed. Each case consists of a description of the school and classroom contexts, teacher and student background, teachers' change during the unit and the change in students' understanding about matter and its properties. The investigation of interactions between teachers and students and their meanings in natural settings where the instructional unit was being implemented were outlined.

1 Case Study I: School TK

1.1 School and Classroom Context

1.1.1 The School Context

School TK was a small government primary school in a rural area of Saraburi province in the central part of Thailand. The school was sharing a location with a temple in the centre of a village. There were around 100 families in this village. Most of the people were farmers, employees and construction workers. The economic situation generates average income for the village.

There were the facilities in the school for the students such as laboratory rooms, a library, a playground, and a cafeteria. However, these places are old and untidy. There are not many books in the library and even though the laboratory room has many new science instruments, most of these had never been used.

There was a kindergarten and grade 1 to 6 are taught; there is one class for each grade. There were 113 students and 8 teachers. Each teacher was responsible for one classroom. The teachers teach all subjects in their own classes. This school has been implementing the old curriculum, Thai Primary National Curriculum (Ministry of Education, 1978 and ensuring version 1990) in which science was integrated into life experience subjects (social studies and science) for grade 6. Science was taught for three periods per week and 48 periods per semester (one period lasts one hour).

1.1.2 The Classroom Context

Science learning took place in the classroom and in the laboratory room. In the first week of the unit, the students learned science in the classroom. They did not work in groups. Ms Chujai said she rarely used the laboratory room because she was worried about the expensive science instruments. However, she moved her class to the laboratory room in the second week of the study because it was convenient for conducting experiments. Both the classroom and the laboratory room were clean and well organized. Student work was displayed around the rooms. In the laboratory room the desks were arranged so that the students could work in groups. There was enough quality science equipment in this room so that all students had access to the required instruments. However, most TK students and also Ms Chujai did not have any experiences in using the science equipment. For example, this was the first time the students used an alcohol burner. They were very excited about it.

1.2 Teacher background

Ms Chujai was 40 years old. Her formal qualification was a Bachelors degree in Thai language. She had taught at a primary level for 11 years. Her main experiences in teaching science were for grade one. This was her second year of teaching science in grade six. She won a teaching award in moral studies teaching in 2000 and had enrolled in the science teacher evaluation course provided by IPST in

2004. Her roles in school besides teaching were assistant director of academic division; and taking care of the first-aid rooms, science laboratory room and computer room. She said that primary students should have a chance to play, draw and learn what they were interested in. She had introduced and considered the importance of group work because students found it was enjoyable and they could help each other to learn.

Ms Chujai was not confident in teaching science experiments and some of the more abstract concepts such as state of gas, the change of solid into gas (sublimation). She felt that she lacked some of the skills needed to use science instruments and to do experiment and that she did not have enough content knowledge in science. Although she accepted that science was important and related to the everyday life of primary students, she considered most experiments were dangerous and difficult to teach. She thought learning from real things and practical works were important. Overall, she found teaching science a challenge because of her perceived inadequate knowledge and skills. Despite this, Ms Chujai had volunteered to be one of the participants in this study. She said she would like to develop her understanding and skills in teaching science.

1.3 Students' background

Twenty two Grade 6 students (12-13 years old), 13 boys and 9 girls, were involved in the study. Most of them came from middle income to poor families and their parents were employees and construction workers. School student data, from grade 1 until grade 5, showed that the students were not skillful in science although two girls had consistently gained higher scores in science than the other students. Five students in the class were incompetent in language, both reading and writing.

1.4 Teaching and Learning in Case Study I

This section presents the teaching and learning in school TK. In section 1.4.1, the examples of successes teaching strategies based on conceptual change approach were provided. Three teaching strategies namely problem solving, experiment and analogy and model were presented how Ms Chujai brought these strategies into her class and how these strategies helped TK students to learn. The section 1.4.2 explores ways of TK students learning. The evidences from students' journals and classroom discussion transcripts were used to support that the TK students thought that the teaching strategies in the instructional unit such as the experiments help them to learn science.

1.4.1 Teacher Teaching

Positive impacts from the teaching strategies based on the conceptual change approach were found on student learning and teacher teaching in school TK. In this section, the notable results in this school are presented. The use of the particle model in the solution process, the use of a problem solving strategy in the separation of mixtures and the conduct of an experiment for chemical reaction were the most successful teaching strategies used. The using of these teaching strategies in school TK are presented in detail in this section.

(1) Problem Solving for the Separation of Mixtures

The problem solving teaching strategy was used to enhance students' abilities in using scientific conceptions to solve the problems or explain phenomena. . This teaching strategy was chose for the topic of separation of mixture because this topic encouraged the students to search for an appropriate way for separating mixtures based on the physical properties of the substance in the mixtures. The students were asked to explain the reason why they choose the strategies and to identify the advantages of separating mixtures in everyday life.

The lesson began with the teacher reminding the students that in the previous lesson (solution process) they had separated sugar from water. After that the teacher asked the students to think how and why they could separate oil and water, and soil from water.

Ms Chujai:	Do you remember, how can we separate sugar from water in the previous lesson?
FS1:	We put heat on the sugar solution and then the water evaporated.
Ms Chujai:	Great! What are other ideas?
……………….	
Ms Chujai:	Look at these samples. How can you separate soil from water and oil from water? (Ms Chujai shows beakers of a mixture of soil and water, and a mixture of oil and water)
MS1:	Pour the water from oil.
Ms Chujai:	What about soil and water?
FS2:	We should wait until the soil falls to the bottom of the beaker and then pour off the water.
Ms Chujai:	Do others students agree with MS1 and FS2?
SS:	Yes.
Ms Chujai:	Why do you use different ways for separating different substances from water?
MS2:	They are not the same substances.
MS3:	We chose the easiest way for separating each substance.

In the above sequence Ms Chujai worked to link the students' understanding about solution processes into new ideas about mixtures and their separation. She then probed the students for different ways to separate different mixtures to focus on the idea that each separation method needed to be appropriate to the specific mixture. Next, Ms Chujai asked the students to compare the three mixtures.

Ms Chujai: Can you see any similarities and differences among sugar in water, oil in water and soil in water?

FS1: Sugar dissolves but soil and oil do not.

FS2: I think soil dissolves but oil does not…..Um…but when we leave soil and water for a while soil does not dissolve anymore.

The above excerpt shows that Ms Chujai tried to encourage the students to develop the idea that different mixtures (a substance mixes with water) need different methods for separation depending on the properties of each substance. Ms Chujai then introduced the term "mixture" to the students. The students did worksheets and discussed many methods for separating mixtures, namely picking, filtration, sedimentation, sublimation, and evaporation. After this the students were provided with an opportunity to do an experiment and explain the way to separate mixtures in everyday life. "A Problem Solving Case" was introduced to each group of student, one case per group. The following is an example of a case:

Case 5: Is It Sweet?

Auntie Toy gives you a jug of orange juice. She asks you to taste it and tell her whether it is sweet. She will come back in 1 hour to get an answer from you. Unfortunately, you cannot drink it because there is a lot of fibre inside the orange juice.

Separate the fibre and describe your method.

Figure 6.1 An Example of A Problem Solving Case

One group of students chose filtration to separate the fibre from the orange juice. They prepared many instruments for doing this such as different size of strainers and filter cloth. Figure 6.2 illustrates one approach using a cloth to sieve fibre from orange juice

Figure 6.2 The students used a cloth to sieve fibre from orange juice.

In this activity the students not only had a chance to practice their skills in separating mixtures but also in working cooperatively with others and increasing their confidence in reflecting on their ideas about science and doing science. They needed to share their ideas with friends and together to make a group decision as to which method was appropriate for their problem.

(2) Experiments and Discussions Relating to Everyday Life Chemical Reactions

Experiment and discussion are the most successful teaching strategies because they can motivate most students to learn and encourage students' science process skills. TK students had no experience in doing science before, so Ms Chujai tried to introduce them to know science instruments and brief clearly how to do an experiment. Then, before every experiment, she asked for a group of volunteers to present how to use the science instruments involved in the activity. Although sometimes the students had no ideas about science instrument, Ms Chujai encouraged them that everyone had ability so they should be proud to be the selected volunteer. Next, Ms Chujai and students discussed how to do the activity and made sure that each group member knew what their responsibility was.

The understanding of chemical reaction that was included in this study was that the students could explain the differences between physical change and chemical change in terms of the occurrences of a new substance and a difficult to reverse reaction. It was also intended that students would have opportunities to understand the effects of chemical reactions in everyday life. The experiments and discussion activities were selected for this topic because to allow students to observe real chemical reactions and to explain them. The classroom observations supported the inclusion of these sorts of activities. The students' discussions helped the students to distinguish between physical change and chemical change.

The lesson on chemical reaction began with the students discussing the use of three different situations: the solution process, change in state of matter and chemical change. The following are examples of student discussion to explain their understandings about the difference among these processes of change.

Ms Chujai:	The time is up. What are different among these three situations [burning, sugar dissolves and ice melts]?
FS1:	I think I could get the sugar back from water as we used to do in that activity [solution process lesson].
Ms Chujai:	Does anyone remember that activity?
Ss:	Yes.
FS2:	We heat water and evaporated it, then we got the sugar back.
Ms Pailin:	How this situation different from other?
FS 3:	We also get the ice back, just put it [water] into the refrigerator.
MS1:	Sugar dissolving and ice melting are similar because we can get sugar and ice again.
Ms Pailin:	Nice answers, you can get the sugar and the ice back. But there is some change which we cannot get the substances back. We call this change as chemical change or chemical reaction. What do you think about burning paper? Can you get the paper back?
FS 3:	It is ash.
Ms Pailin:	That's right. It is a chemical reaction. What about ice melting and

dissolving of sugar?

FS 4: We can get them [sugar and ice] back. It does not change like that change [burning].

From this transcript, FS1 began to respond to the teacher's question by linking to her prior experiences from the solution process lesson. Her idea to use the criteria of getting the initial substance, such as sugar, back helped other students to use the same criteria to differentiate among the three situations. For example, FS3 explained that she could get the ice back by putting melting ice into the refrigerator. Ms Chujai made sure that the students understood the difference between these three processes and then giving the students a scientific term "chemical reaction" to name the situation where new substances were formed and the process was irreversible.

Next, the students were introduced to an experiment on chemical reactions in everyday life, namely vinegar with baking powder, vinegar with purple flowers and the burning of sugar. The roles of each group of students were to observe and identify the indicators in each chemical reaction. For example, the formation of bubbles is indicator in the reaction between baking powder and vinegar.

Figture 6.3 The TK student experiments of burning sugar, changing of flower color, cooking Hokey-Pokey, and the reaction between baking power and vinegar.

The students were introduced to the influences of chemical reaction to their lives via discussion about chemical reactions found from everyday life or news items. They talked about the advantages or some of dangers. The teacher probed for them to clarify how did they knew a chemical reaction had occurred and what was an indicator of a chemical reaction in each case. All the news items that the TK students brought to the class were about dangers from everyday life. For example, the explosion of a petrol gas tank in a student's home town. Although TK students could identify chemical reactions and their indicators they showed that they perceived chemical reactions as something that was dangerous. This result supports the existing situation study (Chapter 5) that indicated Thai students think that all chemical reactions are dangerous.

An experiment of making Hokey-Pokey aimed to encourage the students to become aware that some chemical reactions are not dangerous. In this activity the advantage of the formation of bubbles in a solid is used in making Hokey-Pokey. The successful results of this activity could found in student comments; all students said this activity helped them to understand that some chemical reactions are not dangerous. Moreover, based on student interviews and student journals, the students said they loved to do this kind of activity. Most students said they loved the Hokey-Pokey activity the most. The students said experiments in this lesson were related to their real life and were more fun, and gave them opportunities to use many science instruments. The details about these students' opinions will present in the section 1.4.2.

Up to this point, from this case study, experiments and discussions have shown advantages in enhancing student understanding of chemical reactions and ability to relate scientific conceptions to everyday life. In selecting experiments for the reaction of substances it was important they came from everyday life, for example, burning of sugar. The success of the Hokey-Pokey activity showed that all students love to learn in this way.

(3) A Particle Model for Solution Process

This section sets out data from the solution process lesson, to illustrate the impact of the use of analogies and models on teaching and learning. One purpose of solution process lesson was to encourage students to explain how sugar exists and behaves in a solution. A particle model was used to help the students to visualize sugar in the solution because it was too small to be seen.

Before the students learned about using a particle model, they had learnt about the differences between soluble and insoluble substances and give a definition of a mixture and a solution. The students were provided examples of solutions including a sugar solution, alcohol, a mixture of oil and water and a salt solution and asked which one was a solution and why. Finally, Ms Chujai asked the students to compare and contrast a solution and a heterogeneous mixture, and to give some examples of each.

For the next step, the students did an experiment to prove that sugar existed in the sugar solution using the benedicts solution test. Even when the students had done this activity they still had problems explaining invisible sugar in water. They had no idea about what sugar looked like in a sugar solution. To help the students to explain how sugar exists in a sugar-water solution Ms Chujai introduced the particle model to the students. Before Ms Chujai linked a particle model to the solution process she probed the students' understanding to make sure they had enough background on the particle model for each state of matter. She asked about the particle model for sugar as a solid and water as a liquid.

Ms Chujai: What about sugar particles?
FS 1: Sugar particles stay the same. Sugar has a fixed volume.
Ms Chujai: What is about water particles?
FS 1: Water particles do not crowd like sugar particles.
Ms Chujai: What do you mean by that?
FS 1: Sugar is solid so their particles are crowding but water is liquid, its particles are not crowded.

In the discussion above, Ms Chujai asked FS1 to make sure that she had the right concepts about particles of matter in each state. FS1 could identify the states and explain the different arrangement of particles in water and sugar.

After putting sugar in water, Ms Chujai asked the students to explain how they thought sugar might behave in solution.

Ms Chujai: How can you explain about the arrangement and attractions of sugar and water particles?
FS 2: Sugar particles in water have low attractions.

Ms Chujai: And then….

MS 1: Sugar particles are not close together.

Ms Chujai: Why?

SS: It dissolves. They [sugar and water] mix. Sugar spreads out in water.

After this discussion, Ms Chujai asked her students to draw their version of the particle model of sugar in water. After each of the students had drawn their own model they discussed in a group to come to an agreement about a group model. Each group of students then drew their model on the blackboard (see their pictures below). Then the class had a discussion about which model was could the most plausible.

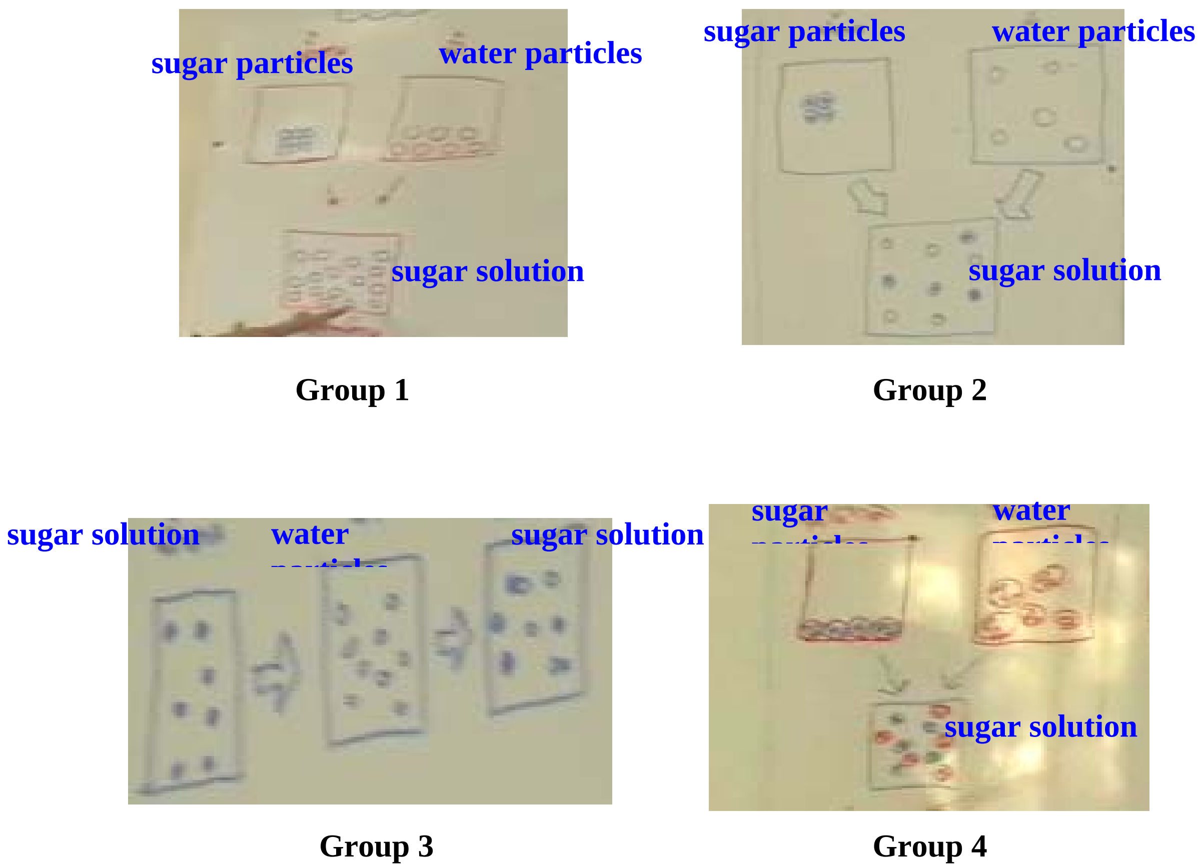
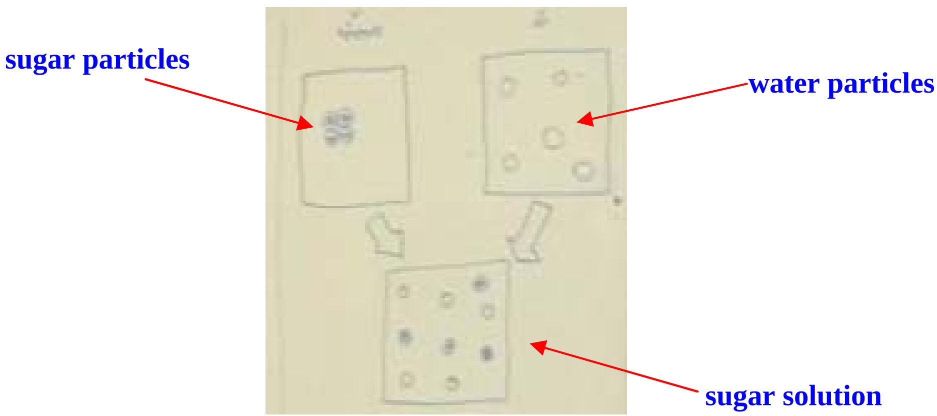


Figure 6.4 The Students' Models of Sugar Solution

Each group tried to use their knowledge about the solution process and evidence from a benedicts solution test activity to explain their model. For example student group 2's model showed that they realized that number and size of sugar and water particles in a solution did not changed. Ms Chujai asked the students to give a reason for why they drew the sugar and water particles arrangement as they did. In this case, the students reasoned that all part of the sugar solution was sweet because sugar particles spread out among water particles.

Ms Chujai:	Can you explain your model?
Ss group2:	Yes, sugar particles spread out in water particles.
Ms Chujai:	Why do you think sugar particle spread out in water?
Ss:	A solution is sweet. We can get the sugar back by evaporating water.
Ms Chujai:	Are the sugar particles disappeared?
Ss:	No.



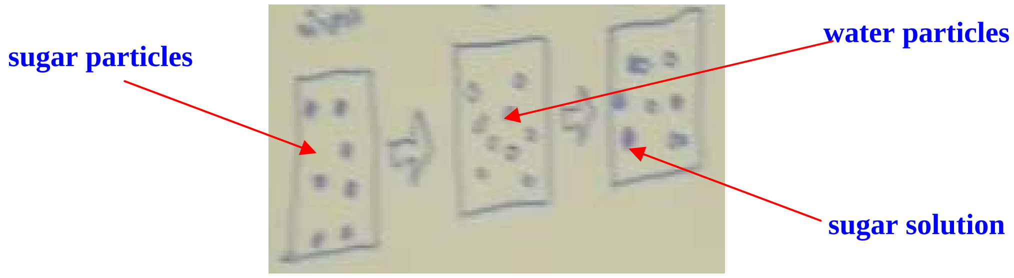
<u>Figure 6.5</u> A group 2' Models of Sugar Solution

Ms Chujai encouraged the students to think about the differences between and the plausibility of each model. For example, she asked the class to talk about student group 3's model, Ms Chujai: Look at the arrangement of the sugar and water in group 3's model, is it true?

Ss: No

Ms Chujai: What is wrong with it?

Ss: Sugar is solid; the particles should be in order.



.

Figure 6.6 A group 3' Models of Sugar Solution

All students had opportunities to reflect on and share their ideas with friends. Some of them developed or changed their ideas when they gained more evidence from other groups. For example students group 4 asked Ms Chujai about changing their model. Initially, they drew water and sugar model using the same size and same color for water and sugar particles. After discussion, they used a different color for water and sugar particles and also made the sizes different so that they could classify which was which.

Ss group 4: Can our group correct our model?

Ms Chujai: Why?

Ss group 4: We can not classify which are sugar particles and water particles.

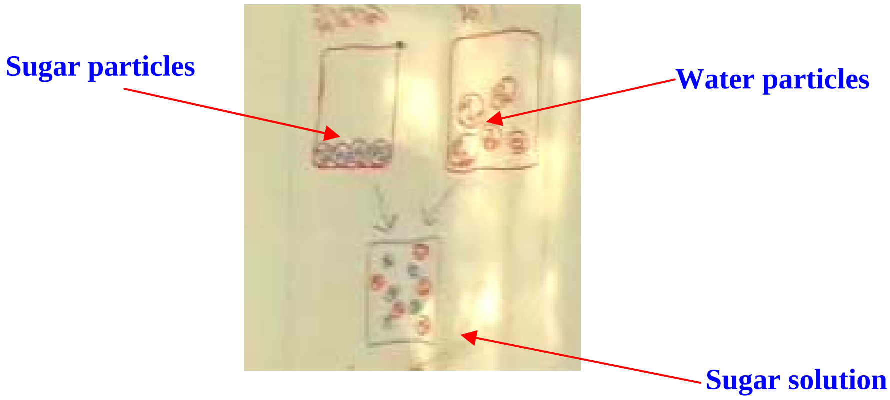


Figure 6.7 A group 4' Models of Sugar Solution

To review, in this example, Ms Chujai probed to make sure the students were competent in applying the particle model to explain the solution process. Her purpose in investigating the students' competencies was to check whether the students truly understood the solution process. From this she found that the students had the idea that sugar does not disappear and that all parts of a sugar solution are sweet. The particle model allowed the students to present their understanding in concrete way. Through this process, Ms Chujai showed her ability to promote student conceptual change. She gave her students opportunities to consider their prior knowledge and to experience the scientific ideas through an activity. She always asked her students to make comparisons amongst their knowledge and with scientific knowledge using the results from an activity and then to make decisions to use scientific knowledge to explain the phenomena.

1.4.2 Student Learning

The positive effects of a conceptual-based instructional unit on student learning in school TK were evidenced by the increase in student use of scientific conceptions and their relating science into their everyday life. The students' thoughts about teaching matter using an instructional unit via student interview and student journals supported the idea that the students considered that the instructional unit helped them to learn science in many ways as is illustrated by the following comment.

(1) Thinking of Science and Doing Experiments

Figure 6.8 Student TK 1's journal

> "I have chance to do science experiment with Ms Chujai. I am so happy and have fun when doing experiment" (TK 1-Journal)

TK 1 was a quite shy boy at the beginning of the teaching. His science achievement was in the middle range. From the observation data, his nervousness and embarrassed manner decreased throughout the unit. He showed that he loved to participate with the class and surprisingly, he volunteered to give an interview after his post-survey, something that also showed his increased in self confidence in his ability. TK 1 is an example of a TK student who said that this was his first time to do science experiments. From his journal he said he liked to do science. Observation data on TK 1 confirmed that as he increased his participation in the classroom learning process, in parallel he increased his understanding in science. For example, in solution process lesson about the conservation of matter, the following excerpts are the comparison of his pre and post survey responses.

"[it is impossible to get the sugar back] sugar disappears." (TK 1- pre survey)

"[it is possible to get the sugar back] sugar exists in water. We will see sugar again by evaporation and leave it for one night." (TK 1- post survey)

TK 21 was another student who enjoyed the unit. She was one of the high achievement students and a leader in the class. Her comment was about science related to her life.

(2) Touching and Observing Real Things

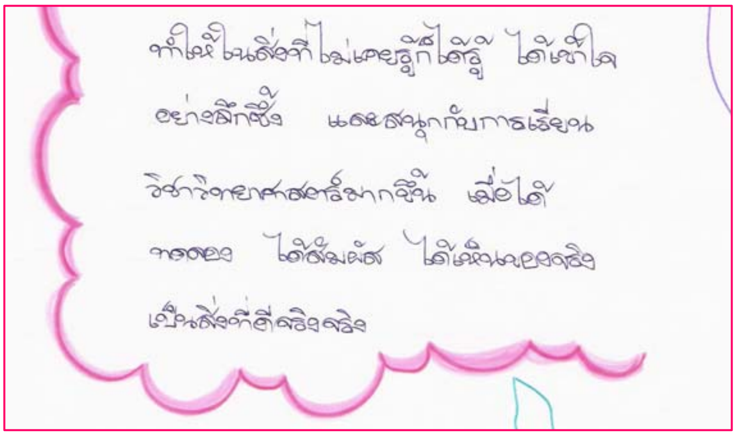


Figure 6.9 Student TK 21's journal

"…I learned many things that I have never known before from learning science. I think deeply and understand in science and have more fun. I like to do science experiments, touching and observing real thing" (TK 21-Jornal)

TK 21's understanding in science definitely increased throughout the unit. More over, TK 21 realized that science was not only a school subject but it was related to everyday life. From her journal above, she believed that learning through experiments and from real things helped her to understand more about science and she had fun. TK students predominantly had a strong belief in their own ability. They were easy to encourage trying to do new things. During the implementation of the unit, the TK students showed their abilities to learn, to do science and also to identify what kinds of learning activities helped them to learn.

1.5 The Teacher's Change during The Unit

When she implemented the unit, Ms Chujai followed the lesson plans and concentrated on the objectives of the unit. Over the course of the unit her confidence in teaching science increased and she came to realize the importance of surveying the students' prior knowledge. She asked probing questions and she motivated her students to work in groups and to discuss their ideas. In this section changes in her confidence are discussed as an appropriate signal of the changes involved in her teaching strategies during using the unit.

1.5.1 The Teacher's Confidence in Teaching Science

At the beginning of the unit, Ms Chujai felt uncomfortable using the activities included in the unit. Her lack of confidence in content knowledge was signaled by the fact that she was holding the lesson plan throughout each teaching period for the first two weeks. Her alternative conceptions were evident in her teaching, especially those related to the particle model and the changes in state of matter (lesson 1). For example, she got stuck when explaining how heat was transferred among particles of water and she confused the terms evaporation and sublimation. Also, she had a problem with time management although she could manage her timing from the third week onwards.

During the unit, Ms Chujai showed a willingness and ability to develop her understanding of the content and science process skills. She usually had questions and/or interesting suggestions for the researcher. For examples, she did not understand how to conduct a class discussion to promote the scientific model when each student had their own model, and she did not understand why she needed to survey the students' prior knowledge. Discussions with the researcher and the conferences with the other two teachers in this research helped her to understand and to solve her problems. Ms Chujai contributed many suggestions and ideas to the unit teaching and both her class and this research benefited from these. For example, she commented that some lesson plans, especially lesson 1, included too many worksheets. She felt it was unnecessary to use all the worksheets with the students and so she discussed some of worksheets with the class rather than asking every student to do each one. She said this strategy not only helped her students to have more fun but also helped students with writing. Another idea she raised was that all the activities in the unit were interesting and appropriate for students. She suggested to the researcher that it was very difficult for a teacher in real life teaching to prepare such activities because of a lack of time and money.

Finally, Ms Chujai said she felt happy when using the unit because it helped her students to understand science better. She found that each of her students developed themselves to understand the concepts, to feel happy, and to have more skills to do science. Besides, she herself had more confidence in her ability in teaching science. She said that from now on she would have confidence and be more prepared to learn new things.

1.5.2 The Teacher's Beliefs about Students

Although Ms Chujai believed in her students' responsibilities to learn, she said they did not know much about science and she was not sure that her students' understanding could change from low to high by learning from the instructional unit.

The students were good at paying attention in learning but they had little motivation to answer questions asked by the teacher or to get a good grade. Ms Chujai said:

> "…. They [the students] don't know much about science because our school does not emphasize science and we don't have specialized science teachers…"

However, as a result of the research, Ms Chujai concluded she had underestimated her students' knowledge in science and their ability in learning. Ms Chujai initially said the research pre survey was quite difficult, pointing out that most of questions were open-ended which was unfamiliar to her students. For example, she thought the volume of a substance was a difficult concept because it had been discussed as difficult in a teacher conference. Surprisingly, most of students could response to the pre survey and explain that volume was similar to quantity. The students said they knew this from mathematics lessons. Ms Chujai said she was proud of her students that they could apply knowledge from other area to science. She said the results from the pre survey were a good start for her students.

During implementation of the unit, Ms Chujai's confidence in her students' abilities increased. For example, Ms Chujai said at the research conference session that she was worried about the particle model lesson. She said 'model' was not a word which her students were familiar with. After the lesson she changed her mind because the students had given examples of a car model and a miniature city. These examples from the students helped Ms Chujai to explain how the particle model was used by scientists. Ms Chujais' beliefs about her students' ideas changed . At the end she said she was satisfied that her students had enough basic knowledge to learn some of the more difficult science concepts.

1.5.3 Teacher Realization of the Importance of Student Prior Knowledge

At the beginning of the unit, Ms Chujai said she did not understand why surveying students' prior knowledge was important. Her behavior before implement the instructional unit showed that she emphasized only on true-false answers and was not interested in eliciting student's prior knowledge. However, she realized the value of understanding students' prior knowledge throughout the unit when she knew more about how important the students' prior knowledge was. Ms Chujai understood that the students could develop their understanding based on their prior knowledge. Her realizations about the importance of eliciting students' prior knowledge were found. For example, before the students learned about the effect of heat on particle behavior they needed some basic knowledge about states and the properties (volume and shape) of substances. She used questions like "Is sweating solid, liquid or gas?" (The particles in each state of water lesson), "do the particles change when they get more heat?"(The change in state of substances lesson) for assessing students' prior knowledge. From the observation data, Ms Chujai increased her realization in probing students' prior knowledge throughout the instructional unit and used it as a way for promoting students to learn from each different beginning.

1.5.4 <u>The Use of Probing Questions</u>

Ms Chujai had considerable ability in the use of probing questions. Even when the lesson plans had examples of questions to probe student understanding Ms Chujai developed and used her own probing technique. She used probing questions in all parts of a class period. For instance, she used probing questions and encouraged the students to talk when briefing them about an experiment. While she introduced science instruments to the class she probed student understandings using questions such as "Do you know why we use this instrument?" or "Do you know what this instrument is used for?" Ms Chujai also used questions as a starting point for student discussions. For example, she used questions to help the students summarize their ideas about chemical reactions:

Ms Chujai:	What did we learn about last week?
Ss:	Chemical reaction / chemical change.
Ms Chujai:	What has happened to the substances which changed in the reaction? Will someone please answer me?
MS1:	Uh…such as we put Eno into water.

Ms Chujai:	Was happening to the substances in the reaction?
MS1:	There was the forming of a lot of bubbles.
Ms Chujai:	What about other ideas….look at me, answer me please.
FS1:	The substances in chemical reactions change.
Ms Chujai:	How do they change?
FS2:	There was a new substance occurring after the reaction.
Ms Chujai:	How do you know that? What about other ideas?
FS2:	When we burn paper, ash will occur.
Ms Chujai:	You think the ash is a new substance?
FS2:	Yes.
Ms Chujai:	What about other ideas?
FS3:	We cannot get the same paper back.
Ms Chujai:	Why?
FS1:	It has changed already.

Ms Chujai probed to find out whether her students understood the key ideas about chemical reaction as an irreversible reaction and the formation of new substances. She made sure that her students could explain and give examples of chemical reactions. She used this same technique to elicit examples of mixtures:

Ms Chujai:	Give me some examples of mixture in every life, each group.
Ss group1:	Coca cola and salt.
Ms Chujai:	What do you use it for?
FS3:	To cure when we suffer from diarrhea.
Ms Chujai:	Why do you think it is mixture?
FS1:	Coca cola is mixed with salt.
Ms Chujai:	What about other ideas?
Ms1:	I think it is solution. You don’t see salt in Coca cola, do you?
Ms Chujai:	Ok, if it is mixture, we will see salt separate from coca cola, right?
Ss:	No, we can not see it.
Ms Chujai:	Please help me to classify the examples in this worksheet and tell

me which is a solution, which is a mixture and why do you think that?

As the dialogue above shows, Ms Chujai confirmed the students' understanding about solutions (homogeneous substances) and mixtures (heterogeneous substances) by asking students to give examples of mixtures. In doing so, she found that some of her students had an alternative conception about solution. She used this alternative conception as a way to convince the students to learn together and help each other to clarify their ideas. For example, Boy 1 tried to explain to the class and students in group 1 that he thought substances in solutions should mix homogeneously. In conclusion, Ms Chujai was not only used probing questions to clarify the students' understanding. She also used them as the ways to promote students' curiosities and interests in doing tasks or worksheets.

1.5.5 <u>Ways to Motivate Student Learning</u>

Ms Chujai was deeply committed to relating the unit to everyday life because she said she could motivate the students to learn when relating learning to things that the students were familiar with. She always gave examples involving the students' everyday life. For instance, in lesson 3 (the dissolving process) the students were asked to evaporate water from a sugar solution. The objective of this lesson was to get the sugar back. Ms Chujai suggested to the researcher that she would use an example to show this process in everyday life. The example was a local dessert called "Kai-Hong". This dessert is made of flour and coated with concentrated syrup and then left to dry for one day. She suggested that this dessert could be a good example for students to show that sugar (in the syrup) did not disappear, but coated around the flour.

She also used everyday local news as motivating tools to introduce a lesson. For example, in the lesson on chemical reaction, the students were asked to find some news that related to chemical reaction and to present the news to the class. This news related to students' everyday life and was about a fire accident at a petrol station in this town. Ms Chujai used this kind of news to persuade and motivate the students to learn. She used the questions like "How is this news related to chemical reaction?", "What kind of chemical reaction is in this news?" and "What new substance is mentioned in this news?"

Ms Chujai always accepted student ideas and encouraged the students to express their ideas. She never forgot to praise students who asked questions or who shared ideas. She set the boundaries and gave opportunities to her students to make choices about their work. For example, when students asked questions or reflected on their ideas, Ms Chujai encouraged the students by paying attention to their ideas as the following dialogue illustrates:

FS 1:	Teacher, can I try to evaporate water from alum solution?
Ms Chujai:	Why do you want to try this?
FS 1:	We evaporated water from a sugar solution and we got the sugar back. I think this will be the same.
Ms Chujai:	Why do you think that?
FS 1:	Alum dissolves in water the same as sugar dissolves in water.
Ms Chujai:	What's about others' ideas? Do you want to know this?
Ss:	Yes.
Ms Chujai:	Do you agree with FS1? Do you want to try this?

Due to the attention Ms Chujai paid to all students' ideas, female student 1 had enough confidence to present her ideas during the class. Ms Chujai shared female student 1's idea with the class to show her attention and recognition of the idea. After that she let Girl 1's group try to prove Girl 1's hypothesis. Her consideration of student ideas encouraged the students and increased their confidence to present their ideas to the class and to be proud of themselves. The classroom observations suggested that ideas which arose from students were interesting and easily understood by other students.

As part of encouraging students to share their knowledgeable with the class Ms Chujai emphasized that nobody could be good at everything. She encouraged those students who had problems in writing and reading to do other activities. After they showed their abilities, they were accepted by their friends.

Over the period of the unit, the students were very positive and were motivated to complete their work. They looked happy when they had some control over what they were doing and not everything was based on the teacher's command.

Ms Chujai found out that everyday situations were effective ways to motivate the students to success the tasks and develop their conceptions. Moreover, she showed her respect on the students' ideas and each student's abilities. These encouraged the students' belief in own abilities to learn and to be success the task.

1.5.6 Adapting Tasks to Suit the Class

Ms Chujai studied each lesson plan before teaching and tried to understand the objectives. When she had a problem, she discussed this and suggested new ideas to the researcher. When teaching she generally followed the lesson plans but she changed some tasks to suit her students. For example, lesson 3 was designed for groups of students to search for methods to separate different mixtures and present these to the class. In the event, Ms Chujai allowed more than one period for this. She said that she had allocated more than one period because it helped the students to understand many of the separation methods. The students were all proud to present their methods to the class. The strategies that Ms Chujai used for adapting the tasks in the unit was to provide the circumstances relied on the objectives of each lesson and acclimatized the activities to suit her students.

1.5.7 Student Assessment

Ms Chujai accepted that the unit helped her to assess students in the aspects of understanding concepts, attitude and skills. She learned that assessment could be informal, based on hands on activities, classroom discussions and teachers' observations. She noted that through this form of assessment she had learned more about individual student differences. She realized students had different strengths:

> "As a teacher, I realized that each student had different specializations. Some students who could not write could do a good job in hands on activities."

Based on the researcher's classroom observations, Ms Chujai increased her attention to student differences and understood that assessing students as a specific group or individual could be done during lesson time within activities. She also gave feedback on the students' works and let the students give opinions about their own works and their friends' works.

1.5.8 Classroom Management

Ms Chujai had a good rapport with her students. Her classroom had a warm atmosphere. She paid attentions to all students and made sure they were all involved. Her class had class rules which had emerged from an agreement between her and the students. The rules came from a review of teacher and students expectations during the first period of the year. Most of the rules were about student involvement in hands on tasks in a class, for examples, students were to help the teacher to prepare the science instruments and the desk and to clean up and store the science instruments after use. The class accepted that they all needed to follow the class rules because they were all created these rules. Also, the review of students' expectations helped Ms Chujai to know what the students expected from this subject.

1.5.9 Group Organization Strategies

Ms Chujai preferred to have students work in groups. She said group work helped the students to get experience in leadership, working with others, taking responsibility and helping each other. Ms Chujai tried to encourage the students to discuss in their group and then to present their ideas. Each group had opportunities to compare their ideas with those of other groups. Long debates happened sometimes. For example lesson 2 (solution process), each group of students had their own model about sugar in water.

Ms Chujai: Look at group 3's model, is it reasonable?
Ss: No
Ms Chujai: Why?
FS 1 group 2: Sugar is solid; the particles should be in order.
Ms Chujai: So, for sugar particle which group is plausible?
MS 1 group 4: Teacher, can I correct our model?
Ms Chujai: Why?
MS 1 group 4: We can not classify which are sugar particles or water particles.
Ms Chujai: OK
(Students correct their model by using different colors for water particles and sugar particles)
Ms Chujai: Can other people explain more about this point?
FS 2 group 2: They are not clear. Sugar is not disappearing.
Ms Chujai: So, which model is plausible?
Ss: Group 2's model.
Ms group 4: Teacher please tells us, which model is reasonable.
Ms Chujai: You should give me your reasons. What about the number of sugar and water particles in Group 2's model?
Ms group 2: Stay the same when dissolve?

The students compared and contrasted their own model with others. During these debates, Ms Chujai maintained control of the class and helped the students link their ideas more directly to the objectives of the lessons.

During the unit, Ms Chujai set up mixed ability and gender groups. She said each student was good at in different tasks and they could help each other. She realized that some students were not happy to work with some group members and that students responded well when they were in their preferred group. To address this issue Ms Chujai set up an agreement with the students. This was that the students had to change group every period and each group would include boys and girls. The students also had the chance to give a name to their group. These strategies made the students felt happier in their set groups. Ms Chujai's problem solving about students' groups organizations showed her consideration in students' collaborative groups.

As a conclusion, Ms Chujai was an enthusiastic teacher. She showed her attempt to develop herself both in her teaching strategies and her content knowledge. Her confidence in teaching science increased throughout the unit and corresponded to her ability to do science and to understand science. Ms Chujai's beliefs about students also changed during the class. Before the implementation of the unit Ms Chujai said her students took responsibilities but she was not sure that they could learn using the instructional unit. She perceived that the contents and activities in the unit were too difficult for her students. She said her students did not know much about science. Her underestimation of her students came from her emphasis on measuring her students' abilities to learn about content knowledge based on the multiple choices test. After Ms Chujai enrolled in the teacher conferences and began to use the instructional unit, her realization on students' learning had changed. Ms Chujai recognized the important of exploring students' prior knowledge. She increased her interaction with the students for probing their ideas. She said she agreed that each student develop their ideas from what they knew and each student had different interests and abilities. She said a variety of activities could help students promote their learning. Ms Chujai had skills to adapt the tasks in the unit to suit her students. She said the students would be interested in the activities which relate to their life. Ms Chujai's relied on the objectives of the unit and tried to apply the activities to the students by adding or relating to the students' interest or students' everyday life. Her view of assessment had changed all over the unit. She enjoyed giving feedback to the students in all activities. This helped her to trace students' development of ideas and encouraged the students to learn. Ms Chujai had good a rapport with her students and did not have any problem in classroom management. She refused to give order to the students, but she always had discussion and made agreements with the students for every thing, such as organizing groups of students. The students intentionally did everything based on reasonable discussions with the teacher and friends.

1.6 The Changing of TK Student Understandings about Matter and Its Properties

This section is the last part of case study I. The students' responses from the survey, classroom observations, students' interviews and students' work were analyzed and put into groups. The groups of students' responses were categorized into seven categories which were adapted from the categorization concepts of Andersson (1990), Tytler and Peterson (2000) and Tytler (2003) as following:

Table 6.1 Students' Categories of Responses

Category	Descriptions	Examples
Perceptual (P)	Responses that included the explanation on what was happening only.	Water disappears.
Association (A)	Responses that included the associative thinking or incorrect used of terms.	Ice evaporates into water, or wind causes ice change into water.
Displacement (D)	Responses that included the substances had been displaced.	Sun sucks the water into the cloud.

Table 6.1 (Cont'd)

Category	Descriptions	Examples
Modification 1 (M 1)	Responses that included the substances continue to be the same substances but the appearances had been changed. (scientific conception for solution process and separation of mixtures)	Small pieces of sugar spreading out in water. Filter is used to separate sand from water.
Modification 2 (M 2)	Responses that included referring the effect of heat differences in modification. (scientific conception for changes of state)	Water absorbs heat and change into gas, water particles get move quickly.
Transmutation (T)	Responses that included the substances changed into others.	Heat changes into bubbles.
Chemical reaction (C)	Responses that included the new substances were formed from the irreversible reaction. (scientific conception for chemical change)	Rust is formed because water reacts with oxygen, and iron nail.

The results of TK students' conceptions in this section will be organized into four topics, the changes in state, solution process, separation of mixture and chemical reactions as following. Each of them will present the development of the students' conception prior to instruction until after instruction.

1.6.1 Change in State of Substances

A number of students' ideas about the change in state of substances including melting, freezing, evaporation, condensation, boiling and sublimation were probed. The instances in pre survey were used for preliminary teaching probes namely considering a picture of clothing drying on a line; explaining the change of ice cubes in a closed bottle; explaining the change of water in a closed bottle in the refrigerator, and explaining the changes of boiling water. Many activities in the unit provided to the students included observing and weighing melting ice cubes in a closed bag for the conservation of ice and discussing the different meanings of dissolving and melting ; melting a variety of substances such as ice cream, chocolate, ice, candle and wax and making ice cream; discussing about water evaporating in a field after it rained for one day and where the water went; watching hot water evaporated and observing condensation on the outside of a closed bowl; observing boiling water and using a thermometer, and sublimating camphor in a closed container.

Table 6.2 Number of The Students' Categories of Responses Concerning Change in State of Matter from Pre-Post Survey

(n= 22)

The changes in state of matter		Category							
		P	A	D	M 1	M 2*	T	C	No response
Melting	Pre	-	16	-	3	**2**	-	-	1
	Post	-	13	-	7	**2**	-	-	-
Freezing	Pre	-	2	-	2	**9**	8	-	1
	Post	-	5	-	1	**11**	3	-	2
Evaporation	Pre	5	3	1	-	**8**	-	-	5
	Post	2	3	-	-	**16**	-	-	1
Condensation	Pre	5	-	-	-	**-**	-	-	-
	Post	2	3	-	1	**16**	-	-	-
Boiling	Pre	-	18	-	-	**1**	-	-	3
	Post	-	7	-	-	**13**	-	-	2
Sublimation	Pre	-	-	-	-	**-**	-	-	-
	Post	-	9	-	-	**11**	-	-	2

*Scientific conceptions

The change in state of water can be explained in terms of the differences of heat on changing ice to water, water to vapor and water to ice. The particle model is used to explain the effect of different arrangements and movements of water particle on the change in state.

Before instruction (Table 6.2), the survey indicated that very few students had scientific conceptions or used modification 2 (M 2) category to explain the change in state, for examples, only one student used a category M2 to explain boiling process. Most students used Association (A) category (alternative conception) instead. Most students used a category A when describing the boiling process. They had difficulties giving a reason of the change that they saw, For example, “Heat makes bubbles in water…..bubbles come from heat pressure.”

After instruction, the number of students who presented scientific explanations for the change in state or modification 2 (M 2) category had increased most in the concepts of freezing, evaporation and boiling. For examples, student TK 23 who used association (A) category to explain for boiling in pre survey, changed to modification 2 (M 2) category for post survey. She gave a clear explanation about the decreasing level of boiling water and the appearance of bubbles in boiling water:

> “Heat causes water decrease….a bubble is made from hot water.” (TK 23- pre survey)

> “Heat causes water to change state into vapor and decrease the water level down…. bubbles are water particles that change into gas.” (TK 23- post survey)

The increased use of the students’ scientific conceptions for boiling process might come from their classroom experiences in which the students were encouraged to observe boiling water and used thermometer to measure the temperature change. For examples:

> When temperature increases from 30 degree to high temperature, 98 degree, bubbles and steam are formed while the water level goes down because water is heat…..the bubbles are steam which is created under water and rises up…..the boiling and evaporating processes are different because there are bubbles and steam in boiling water but there is only steam in the evaporating process. (TK 20- post survey)

As the student TK 20's explanation, her basic knowledge about evaporation as a process of heated water, changing into steam, as well as her classroom experiences about observing and measuring water temperatures helped her to develop a reasonable explanation for the boiling process. The students could explain the relationship between heat energy and the decreasing water level. The water changed into gas settled under water and then water vapor raised up to the surface of water and escapes, and the water level goes down. These clear results might have come from the students' basic scientific knowledge about evaporation which they had studied before. Their clear understanding of the evaporation process helped them to conceptualize a similar process like boiling. For example:
Student TK 19: Yes, I said water changes into vapor…but now I say bubbles are air bubbles, I mean there is vapor inside bubbles….when bubbles rise to the water surface it is vapor like in evaporation.

However, there were seven students who still used a category A to explain the boiling process. Their problem was that they thought bubbles were water which changed into gas under water and rose to the surface of water in form of bubbles or bubbles is air/heat/water pressure, heat, or boiling water.

A category M2 (scientific conception) in post survey was mostly used when referring to the concept of boiling which showed an increase of category M2 from one student (pre survey) to 13 students (post survey). This might be because the students had scientifically prior knowledge in evaporation. They had opportunities to observe boiling water in a beaker. The scientific conception in condensation for this group of students was also high (16 students).

The perceptual (P) category, displacement (D) and transmutation (T) category was used less in both pre and post surveys in specific concepts as shown in Table 6.2. For example, the students used perceptual (P) category and displacement (D) category to explain evaporation of water on wet clothes and used transmutation (T) category to explain freezing respectively, "there is no water on the clothes on a clothesline on a sunny day.", "sun sucks the water from wet clothes and keeps it in the cloud as rain.", and "air mixes with water and then expands and changes into ice."

From these results, alternative conceptions about change in state, association (A) category was most commonly used by TK students in both pre and post surveys. This showed student difficulties in finding out a reasonable explanation to support their ideas. The observation of melting activities shows the students consistently using their association categories (A) to explain melting activities. The A category included students explanations of the change of freezing as the effect of coldness, wind, air (which mean coldness) to water. This showed the limitation of student understanding about the effect of heat on substances. The endothermic system was not a problem for the students. They understood that substances absorbed heat and changed or activated substance particles. Meanwhile, the exothermic system was difficult for the students. They could not explain how the heat was released and how the substance got cold. They also used an explanation as substance touching coldness.

According to the ideas of conservation of matter and using a particle model, the students understood that all substances changed form but did not vanish. They could identify the transformation of substances which absorbed or released heat. The students rarely used a particle model to explain the changes in state in the survey even after the instruction. However, they could use a particle model when they were asked to do so either in classroom discussions, student worksheets or interviews. For example:

> "When water gets heat, it changes into gas….their particles spread out because the inter-force between particles decreases." (TK 10- post survey)

Another confusing concept for this group of students is sublimation. The classroom observation and student worksheets confirmed that all students could explain the process of sublimation both in term of macroscopic level and using a particle model. However, Table 6.2 shows that many students used association (A) category to explain sublimation. This was because these students explained that solid matter evaporated or condensed into gas and their particles spread out. From interviews, data showed that these students could explain the sublimation process and referred to their activities about camphor sublimation. Their problem was using the wrong terms.

In summary, it was found that evaporation was the easiest conception for the TK students while melting was still a difficult and problematic conception for this group of students.

1.6.2 Solution Process

The students' ideas of dissolving were examined by pre-post surveys, students' work, interview data and classroom observation data collected which involved scientific conception about the process of dissolving including solution components (solvent and solute), soluble and insoluble substances; conservation of matter (sugar in water); and particle model of solution, the change of solute in solvent and conservation of matter.

From pre survey, the students held a large number of alternative conceptions such as the solute disappeared; new substances were formed in a solution. A small number of students explained that solute existed in solution and there were not new substances formed. After implementing the instructional unit, there was an increasing number of student explanations in the concept of solvent and solute as the components of the solution, the conservation of sugar in water and solution process using particle model.

Table 6.3 Number of The Students' Categories of Responses Concerning Solution Process from Pre-Post Survey

(n = 22)

Solution process		Category							
		P	A	D	M 1*	M 2	T	C	No response
Process of dissolving	Pre	16	1	-	**1**	4	-	-	-
	Post	6	3	-	**10**	-	-	-	3
Solute in solvent	Pre	11	-	-	-	5	5	-	1
	Post	3	1	-	**15**	-	-	-	3
Conservation of matter	Pre	-	1	-	**5**	-	11	-	5
	Post	-	-	-	**15**	-	3	-	4

*scientific conception

From Table 6.3, a problem regarding explanation about dissolving is that 16 and 11 students used perceptual (P) category to explain process of dissolving and the changes of solute in solvent respectively. The responses such "sugar disappears or gets smaller" and "sugar changes into sweet water" were the common observable properties explanations that this group of students used. At the end of the unit, the number of students who used P category decreased from 16 students (pre survey) to 6 students (post survey) for process of dissolving and decreased from 11 students (pre survey) to 3 students (post survey) for the changes of solute in solvent. Another group of students who held alternative conceptions used modification (M2) categories to explain process of dissolving (four students) and the changes of solute in solvent (five students) for pre survey thought that heat or hot water was a necessary factor for dissolving.

Another problem in the solution process was that the students were confusing scientific terms. To the problem was similar to the one affecting the melting process: again, some students confused the terms melting and dissolving, other students tried to use scientific terms such as evaporation and condensation to explain dissolving. As Table 6.3 shows for pre survey, only one student used association (A) category to explain conservation of substance (sugar in water). The excerpts below show her development of using the right term for describing conservation of matter:

> "Sugar changes into syrup, and then let the syrup condensed. The syrup will freeze and change back into sugar."
> (TK 21- pre survey)
>
> "Put heat into sugar solution, the water evaporates and lets the sugar back." (TK 21- post survey)

Student TK 21 had her own cooking experiences about evaporating water from sugar solution to get the sugar back, so she learnt to describe an activity which she used to do.

Similar problem about using scientific terms occurred in the explanation of process of dissolving and the changes of solute in solvent in post survey. Student TK 19's responses below show her confusing melting and dissolving terms to explain the change of sugar (solute) in water (solvent):

> "[dissolving is] to make something disappear or melt….when sugar mixes with water; the sugar will dissolve and disappear."
> (TK 19- pre survey)
>
> "[dissolving is] to make solid, which is sugar to mix with solvent which is water, this process call melting……..the sugar will melt or dissolve." (TK 19- post survey)

Student TK 19's confusion occurred after instruction, she said she thought that melting was a scientific term for dissolving.

Other three students (post survey) who used association (A) category to explain process of dissolving said “dissolving is the process of melting/ evaporation” also hold alternative conceptions for explaining the change in sugar in water for post survey namely, “heat or hot water causes the sugar to dissolve” and “sugar disappear/sugar changes into water”.

However, the number of students who used M1 category (scientific conception) to explain the process of dissolving and the change of solute in solvent increased from one student (pre survey) to 10 students (post survey) and for the process of dissolving increased from 0 student (pre survey) to 15 students (post survey). Interestingly, four out of the 15 students who held M1 category were reported it was possible to give a microscopic explanation of the process of dissolving and the change of solute in solvent using a particle model. They explained that sugar particles penetrated among water particles, but it was unobservable. However, only one student of M1 students explained that sugar did not change its state.

A problem about language not only occurred in the melting and dissolving confusion. Water and liquid are other terms of confusion. For example, student TK 1 explained that “sugar changes into sweet water”. He elaborated during an interview that he meant “sugar does not disappear and does not change to anything, but sugar particles are added to water”. From his understanding, his sweet water is the same meaning as sugar solution.

The number of students who thought that sugar was conserved in solution (M1 category) increased from 5 students (pre survey) to 15 students (post survey). The students explained that sugar existed in water, and it was possible to get the sugar back. An instance to probe the students about conservation of matter is that whether getting the sugar back from sugar solution. The examples of students’ conceptual change about conservation of matter were represented below:

> “[it is impossible to get the sugar back] sugar dissolves and changes into sweet water.” (TK 3- pre survey)

> "[it is possible to get the sugar back] heating and leave the sugar solution for one night." (TK 3- post survey)

> "[it is impossible to get the sugar back] we can not build a grain of sugar, if we put these [sugar solution] in a refrigerator, sweet ice will occur." (TK 16- pre survey)

> "[it is impossible to get the sugar back] evaporating and getting the sugar left." (TK 16- post survey)

The TK students got stuck with language difficulties such as the confusion between melting and dissolving. However, most of them changed their ideas into scientific conception and some of them could use a particle model to explain their ideas correctly.

1.6.3 Separation of Mixture

The purpose of this concept is to probe whether the students can explain how to separate substances from water. The scientifically accepted explanation of this concept is that physical properties of substances are the keys to find out about separation methods. The properties of substances in mixtures are retained whenever some of their properties are changed, for example, salt solution is not a new substance, but is made from salt and water mixes together. Evaporation is a good method to separate a homogeneous mixture which consists of solid dissolved in liquid as salt solution. Before instruction, the students chose filtration as a way to separate sand and water.

The students' responses from pre and post survey were presented in Table 6.4:

Table 6.4 Number of the Students' Categories of Responses Concerning Separation of Mixture from Pre-Post Survey

(n =22)

Separation of mixture		Category						
		P	A	D	M 1*	M 2	T	C
The filter or sieve has efficiency for separation sand and water	Pre	8	-	-	-	-	-	-
	Post	5	-	-	-	-	-	-
I used to try this method	Pre	2	-	-	-	-	-	-
	Post		-	-	-	-	-	-
It is simple, fast and easy method	Pre	3	-	-	-	-	-	-
	Post	2	-	-	-	-	-	-
sand grains are bigger than filter's holes	Pre	2	-	-	-	-	-	-
	Post	4	-	-	-	-	-	-
Sand is solid, has weight and can be separated from liquid	Pre	-	-	-	-	-	-	-
	Post	-	-	-	4	-	-	-
No Response	Pre	7	-	-	-	-	-	-
	Post	7	-	-	-	-	-	-

* Scientific conception

During the activities, the students learnt many types of separation methods namely picking, filtration, sedimentation, sublimation, and evaporation and the ways to choose between these methods to suit substances properties in the mixture. The students were provided with many activities to challenge their abilities to find out appropriate separation methods.

After instructions, the students' responses about separation method remained unchanged (filtration). Interestingly, some students could give some reasonable explanations as shown in table 6.4. Four students explained that water and sand were insoluble. Filtration is an appropriate method to separate sand (solid) from water (liquid). For example:

> "Filtration is an appropriate way to separate sand and water, because sand is solid. It has weight and volume."
> (TK 8- post survey)

This kind of explanation showed the students' understandings of the substances (sand and water) which remain the same but which appearance is changed (mixture). Their M1 category of response showed development of their ideas about mixture.

1.6.4 Chemical Reaction

Three instances were presented in the pre survey for preliminary teaching probes. They involved the reaction of burning paper, rusty nail and fizzy of Eno. The ideas of the irreversible process of chemical reaction and the forming of new substances in the chemical reaction were expected. The results of students' responses are shown in Table 6.5.

Table 6.5 Number of The Students' Categories of Responses Concerning Chemical Reaction from Pre-Post Survey

(n = 22)

Chemical reaction		Category							
		P	A	D	M 1	M 2	T	C*	No response
Burning paper	Pre	-	1	-	1	18	1	1	-
	Post	-	-	-	1	2	3	13	3
Rusty nail	Pre	5	6	7	-	-	-	3	1
	Post	2	3	8	-	-	1	5	3
Eno	Pre	-	-	6	6	-	-	10	-
	Post	-	-	2	4	-	-	16	-

The above several instances about chemical reaction were presented to the students. The key ideas of chemical reaction expected to probe included that chemical reaction was irreversible reaction and that new substances were formed during the reaction. The expected response for burning paper instance was that it was impossible to get white paper back from ash and that it was impossible to reverse the combustion reaction of paper. The rusty nail and chemical reaction of Eno are considered regarding the idea of forming of new substances (rust and bubbles in Eno solution).

The different instances of chemical reaction produced different images as showed in Table 6.5. For pre survey, most students (18 students) used modification 2 (M2) category to explain burning paper. They answered that white paper changed color into dark because of heat. They did not have any idea about chemical reaction, so they described the observable properties of paper themselves. Two students in post survey still held this idea.

The scientifically accepted category for chemical reaction concept is chemical reaction (C) category. The pre survey indicated that only one student, three students and 10 students used this category to explain burning paper, rusty nail and fizzy Eno respectively. After instruction, 13 students, 5 students and 16 students could use C category to explain these instances respectively. As table 6.5, shows the Eno instance was the easiest for this group of students. The use of C category increased from 10 students (pre survey) to 16 students (post survey). Meanwhile, the situation of burning paper shows the most change in students' conceptions. The following example is representative of student conceptual change in burning paper instances:

> "[black material from burning paper is] white paper has burnt and turned into black paper." (TK 19- pre survey)

> "[black material from burning paper is] black and soft new substances which are formed after burning, it is impossible to get the white paper back." (TK 19- post survey)

Student TK 19 changed her mind from using D category to C category. As other students who used C category in post survey, she reached the key ideas of chemical reaction which that it was irreversible reaction and new substances were formed.

Although alternative conception category in post survey decreased for burning paper instance and Eno instance, the trend for rusty nail instance was different. The use of displacement (D) category (alternative conception) increased from seven students (pre survey) to eight students (post survey) for the rusty nail instance. In the pre survey, five students who used D category to explain rusty nail said rust could be in the water before moving to the nail and other two students answered that rust inside the nail would appear when it was put in water. Four students still used D category in the post survey. Their explanation that rust was moved from water into nail was resistant to change. Other three students changed into scientific conception (chemical reaction (C) category).

Moreover, data from classroom observation and interviews presented another facet of some student explanations, for example TK 11. These were his answers from pre and post survey about burning paper.

> "Heat changed white paper into black….it is impossible to change it back because its color has changed already."
> (TK 11- pre survey)

> "Paper has burnt and changed into black substances….it is impossible to get the white paper back because white paper was rotted away."(TK 11- post survey)

Student TK 11's responses about burning paper were unclear both in pre and post surveys. He did not give any key ideas about chemical reactions. His answer did not represent his understanding that black material was a new substance from chemical reaction. Based on student TK 11's profile, he was one of the incompetent students in writing. Moreover, he was quiet boy with low confidence. In the class, he rarely volunteered to express his ideas publicly. Individual interview helped the researcher to get closer with him. A transcript following is represented scientific explanations in burning paper given by student TK 11:

Interviewer:	What do you mean by "it is impossible to get white paper back because the white paper rotted away"?
TK 11:	It has burnt.
Interviewer:	You said it was rotten.
TK 11:	Yes, white paper has burnt, and then ash occurred.
Interviewer:	What are differences between paper and ash?
TK 11:	It is different…paper is white and hard, ash is black and soft.

Concerning chemical reaction, most students showed an improvement in their conceptions from alternative conceptions to scientific conceptions. However, the result also showed the inconsistency of some students' responses in different instances.

1.7 <u>Conclusion for Case Study I: School TK</u>

In conclusion, the TK students' conceptions changed throughout the unit in all concepts. For the changes in state of matter, most students used a category A to explain the process of changes in state, for example, eighteen students used this category to explain the boiling process. Their alternative conceptions were about the understanding that bubbles were made from heat or pressure. However, after instruction, the number of students who used a category M2 (correct answer) increased for the boiling process from one student to thirteen students while the number of students who used a category A decreased. Although most students in post survey could use a category M2 to explain processes of change, namely boiling, evaporation, freezing and condensation, the students' alternative conceptions in the melting process and sublimation were still high (thirteen students and nine students respectively). Regarding the solution process, in pre survey, most students held a category P and T to explain the process of dissolving and the change of solute in solvent and a category A to explain the conservation of matter. Successful results were found in post survey in which the number of students who used a category M1 to explain the solution process had increased in all key ideas. Especially for the conservation of matter the number of students using category M1 increased from five students (pre survey) to fifteen students (post survey). Similarly, for the results of chemical reaction, the number of students who used a category C (correct answer) increased except in the situation about the rusty nail. Most TK students could not accept that rust was a new substance from the interaction between water, nail and air. A low number of students' using scientific conceptions were also found in the concept of separation of mixture. Only four out of twenty-two students mentioned the properties of substances as the criterion to choose the separation strategies.

2 Case Study II: School JF

2.1 School and Classroom Context

2.1.1 School Context

School JF was an average size government primary school in a small town in Saraburi province, Thailand. There was a factory near the school. The school is located on the town's main road. Most families around the school had low incomes. Most of them were employed at the factory and came from many provinces of Thailand. They suffer from money shortage and family problems.

The facilities in the school such as electricity, water supply and learning instruments were sufficient but incomplete. Although water supply was available in every part of this school, the sinks in the laboratory room were out of order. As well, there were some incomplete learning instruments for example, the over head projectors and some science equipment did not work. The students range from Kindergarten to Grade 6 in this school, one class in each grade. There were 184 students and nine teachers in the school. This school had implemented the new science curriculum, based on the National Education Act (ONEC, 1999) and the National Science Content Standards (IPST, 2002). Science was taught for three periods per week and 120 periods per semester (one period is one hour).

2.1.2 Classroom Context

Science teaching and learning took place in a laboratory room. The students worked in groups, 4-5 students per group. Mr. Mana arranged the groups for the students. The student's desks were organized for the students' cooperative group. There were more than 30 desks in the room, so there was not enough space for the students to walk around the room. The science instruments both in good and bad conditions were kept untidy in the cupboard. Many dirty science instruments were put under the sinks. The laboratory room was not clean though some students were responsible for cleaning this room.

2.2 Teacher's Background

Mr. Mana was a thirty one year old teacher who had a bachelor degree in Education (general science). He had taught science in college for eight years. After that he had experience in teaching science to grade 7 to grade 9 students for five years. Mr. Mana was a new teacher at school JF at the time of the implementation of the instructional unit. He worked with grade 6 students for science, computering and Boy Scouts. Because Mr. Mana was a new teacher at school JF, he was assigned many jobs which other teachers did not want to do, for example he was nominated to enroll in seminars or teacher training provided by the government. These meant he had very little time to prepare for teaching and sometimes had to postpone his class. Mr. Mana thought that science was a study about natural phenomena. He considered that science helps people to live within the environment. He believed that students learn by exploring and constructing knowledge by themselves. He thought science knowledge was consistent but the ways to get knowledge could be different.

2.3 Students' Background

Twenty nine JF students participated in the study. They included 13 boys and 16 girls. Most of them came from poor and/or broken families. Their parents were employed at the local factory. Most of them had low competence in science based on their grades from grade 5. Most did not have a plan for their future. Some of them said they did not know what they would do after they finished grade 6. Their lack of clear goals had implications for their learning behavior. They were not motivated to learn. Most did not pay much attention to their studies. Moreover, some of them had writing and reading problems. For examples, one boy had very poor writing skills, a reader had to guess what he meant or to interview him.

The JF students needed a teaching approach that better motivated them to learn. They needed somebody to encourage them to learn and set their goals for the future.

2.4 Teaching and Learning in Case Study II

Teaching and learning in school JF was a good example of teaching and learning science under pressure. First, Mr. Mana was a new teacher at that time and he had no experience in teaching primary level. Second, most JF students had their own personal problems such as they came from broken and poor families. They did not have any idea about their future education. The implementing an instructional unit as a tool to develop students' scientific conceptions was much challenged duty for Mr. Mana. However, he could do it very well.

This section will present the effective of a conceptual change teaching strategies which are using of particle model on JF students. In the second part, the students' learning strategies of JF students were showed. An interesting impact of students' motivational belief on conceptual change was clearly found in this case study.

2.4.1 Teacher Teaching

Mr. Mana was a teacher who had strong content in science. From observation data and teacher conferences showed that he did not have difficulties in understand science. From teacher interviews after implementation the unit, a particulate nature of matter was found as a most difficult topic for other two teachers (Ms Chujai and Ms Pailin) to teach. However, there was no difficulty for Mr. Mana.

A main idea of this topic was introducing a tool, the particle model, to the students for explaining the changes of matter. From a pre survey, the JF students and other two schools had no idea about particles. To help them to understand this abstract idea, many models are introduced to the students to understand that all substances made up of particles.

Mr. Mana relied on the sequences in an instructional unit by beginning with presented the students a jar of sand model. Then he asked the student to observe sand in a jar from a distance and observed up close. An example of JF 7's drawing is in Figure 6.10, number1 from left to right. This student's drawing showed that he thought distance sand looked like one thing, but up close he could saw the individual grains of sand. Then the students did the same with water. Figure 6.10, number 2 from left to right was a drawing of JF 7's observation of water in a jar from a distance and up close. A last drawing is JF'7 imagination about inside water if he had a special glasses. Mr. Mana emphasized the students that they should think differently between what they were looking at and what reality was.

Mr.Mana:	What do you think about your drawing?
Student JF 7:	If you give me a special glass, I think I will see grains of water as I see grains of sand.
Mr.Mana:	Why do you think like that?
Student JF 7:	I can’t see grain of sand from a distance. I think water is the same.
Mr.Mana:	This example shows that although something appears to be made up of one thing, actually it made up of many tiny things which are particles. The particles are the smallest part of thing that could exist and still have properties of this thing.

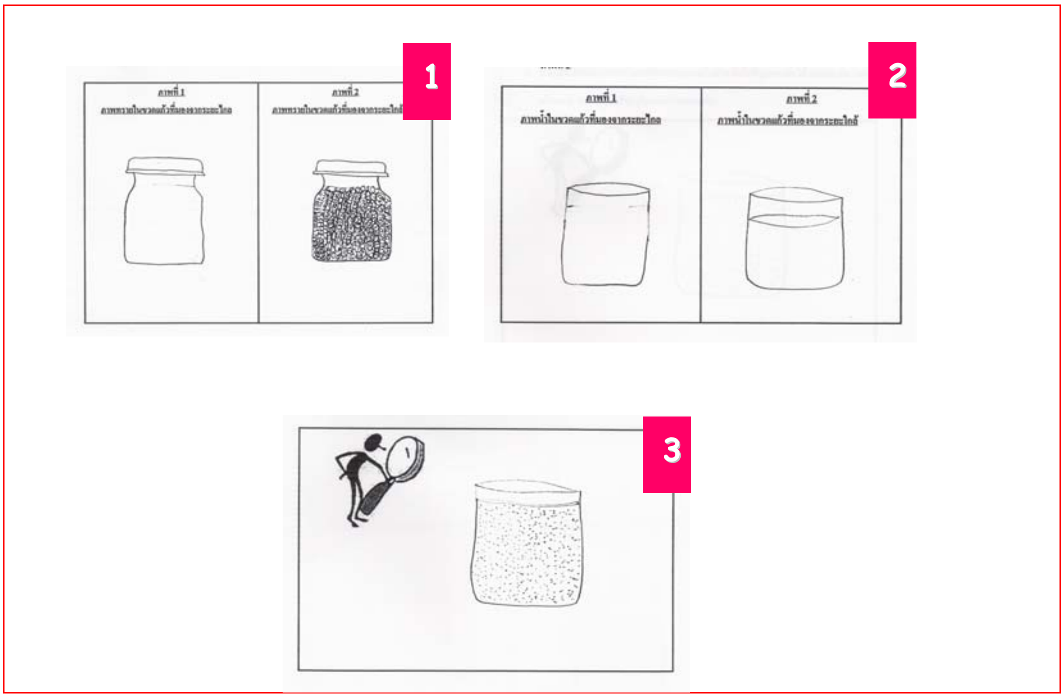


Figure 6.10 Student JF 7’s a jar of sand model

Mr. Mana explanation about the particle was clear and showed his strong understanding in science content. Mr. Mana gave opportunities to JF 7 to clarify his idea in his drawing. JF 7 showed his beginning of acceptance that everything consisted of particles.

After the students realized that everything consisted of particles, Mr. Mana challenged them to think that why water had different state.

Mr.Mana:	Do you think why water has different states?
MS1:	It freezes. Water becomes ice.
Mr.Mana:	What do you think about particles of water?
FS1:	It can not move because it freezes.

Mr. Mana encouraged the students to think how particles behaved in water and then he introduced that the students could represent the arrangement and movement of particles in different states of water. He asked each student to imagine and behave as particles of ice in a container. The students in each group stood inside a line that Mr. Mana drew to represent a container. They get as close to many rows because they had strong inter-force attraction.

Then the student behaved as particles of liquid water and water vapor. After that Mr. Mana used the result from student role-play to make conclusion that the particle of ice lose attraction, move faster and further apart when ice changes into liquid water and water vapor respectively.

Mr. Mana reminded the students to think about the advantages and limitations of each model and found out the most suitable model for their class. The responses below showed the students' thinking about the limitation of a jar of sand model and students' role-play model.

> "It [a jar of sand model] different from water because sand is solid and water is water [liquid]" (JF 12-interview)

> "We are different, some are big but some are small. He

[Mr.Mana] told me that water particles had same size" (JF5-interview)

Mr.Mana introduced that scientists usually used pictures instead of people to explain particles. They use a small circle instead of one student. Then, He asked students to draw particle pictures. A figure below showed an example of student's drawing.

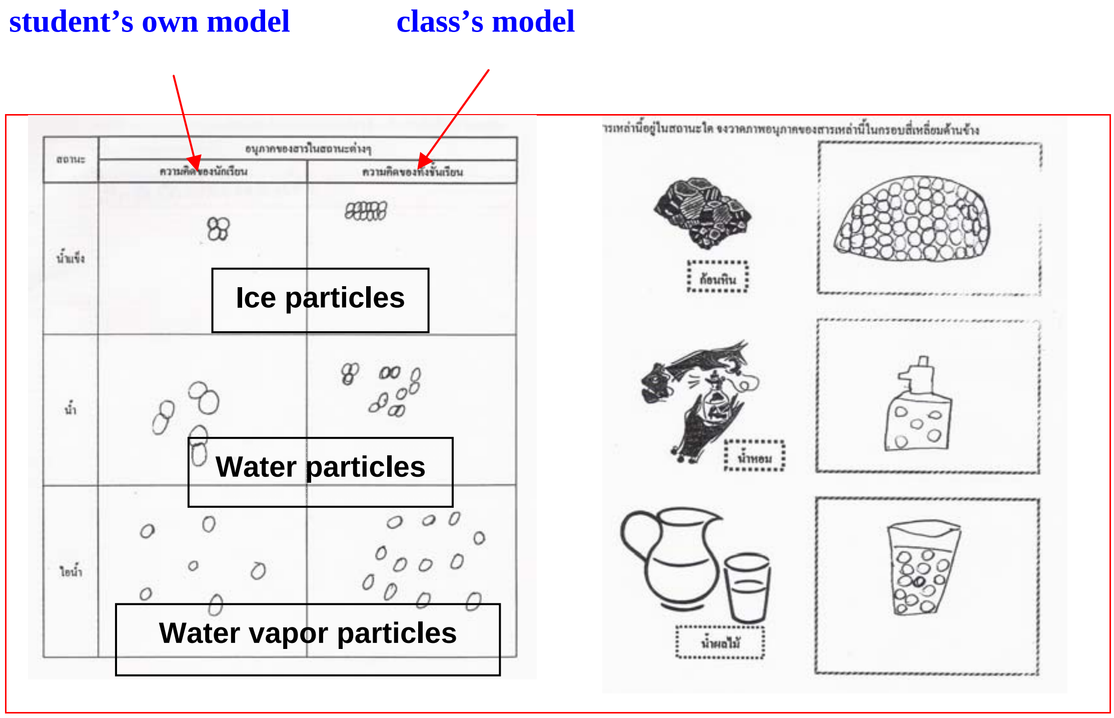


Figure 6.11 Student JF 8's a jar of sand model

After discuss with class, JF 8 found that his model had some mistakes. Mr. Mana came to probe him about what he thought about his model.

Mr.Mana:	What do you think about your model?
JF 8:	It should have same number of particles for water, ice and water vapor.
Mr.Mana:	What's about size of particles?
JF 8:	Um…they should be same size, right?

Mr.Mana: Why?

JF 8: They are water.

Mr. Mana encouraged the students to critique and to compare their own model before and after class discussion. JF 8 was an example of students who found that why his model different form class's model. The right hand work sheet showed JF8's idea about particles of other substances.

Mr. Mana showed his attention to the key ideas of particle model which were the inter-force attraction between particles, number of particles and size of particles. He focused on these key ideas and encouraged the students to think about them. His success of introducing a particle model to JF students showed that his strong content in science was important to run this lesson.

2.4.2 Student Learning

JF students were different from other schools in term of their contexts and backgrounds as presented in the student backgrounds section. Most students had low competence in science. They were not motivated to learn and did not have a plan for their future. To encouraging JF students to learn was not only introducing of scientific conceptions to them, but also encouraging them to participate in class and lessons.

The evidence of successes of implementing a conceptual change-based instructional unit was found from the increasing of students' using of scientific conceptions from pre-survey to post-survey. But before that, the factors which motivated students' learning were found from students' journals and student interviews. JF 28 was an example of students who had low competent in science. He was quiet and did not pay attention in science. His participation in class activities and his scientific understanding increased throughout the unit. From his journal show his positive belief in their own ability and he found that he could do more than he thought.

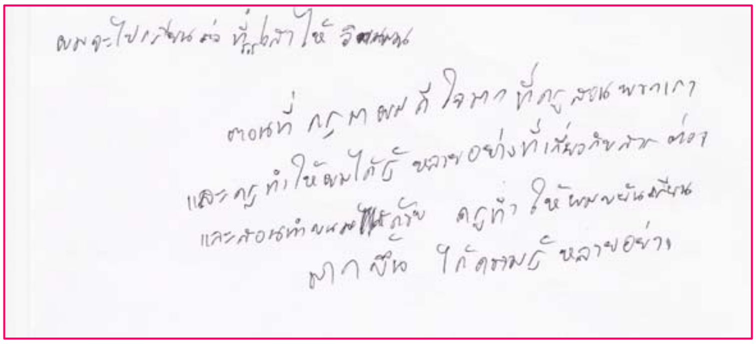


Figure 6.12 Student JF 28's journal

> I plan to study secondary level At SV School [the most popular school in a town]. I was so glad that I have learnt science. You [teacher] helped me to know many things about matter and doing Hockey-Pokey. You [teacher] encourage me to learn and know many things (JF 28-journal)

From JF 28's journal showed his improvement in his goal. He had plan for his future and had more confidence in learning and doing science.

Another evidence of students' development of belief in their own ability was a case of Duangkeaw. Her question "I am not stupid, am I?" is at the beginning of this chapter. Duangkeaw asked the researcher this question at the end of implementing of the unit. She said she thought she was totally stupid because many people told her that. After she learnt with Mr. Mana, she found that she could do many things and she thought she was not stupid anymore.

An important idea from JF students' learning was they could learn and could do anything if they would like to do. This case study evidenced the successes of using a conceptual change-based instructional unit to promote students to increase their confidence in their ability and happy to learn science.

As introduce at the beginning of this section, a case study of school JF is a good example for teaching and learning under pressure. Mr. Mana tried hard to use the instructional unit to promote students learning and to encourage student to learn.

His development in teaching was presented in detail in a next section. While JF students were proved that they were not stupid and hopeless. They could do anything such as increasing their understanding in scientific conception and doing science experiment. Their increasing of using scientific conceptions will present in next two sections.

2.5 The Teachers' Change during the Unit

Throughout the unit, Mr. Mana demonstrated a good understanding of the science content. He could teach every concept confidently. He prepared for the lesson by studying the unit and lesson plans before teaching. His teaching strategies related to the sequences of the unit. He paid attention to the assessment methods which were suggested in the unit and undertook assessment throughout the unit. He questioned the researcher and/or the other teachers in the study when he had any problems in implementing the unit.

This said, Mr. Mana often postponed his class because of the many extra duties he had. He tried hard to finish all concepts of matter and its properties in the unit. He did not make use of any strategies to motivate his students to learn. His ability to control the class was low and he blamed the students as a way of managing the students. Mr. Mana's approach to implementing the unit is presented below.

2.5.1 Adapting Tasks to Suit the Class

Mr. Mana had some strong science content knowledge. He did not have any problems about the science concepts in the instructional unit. He showed that he had studied the instructional unit before teaching. However, his attempts to encourage the students to learn sometimes appeared to bore students and they did not always pay attention. Mr. Mana concentrated on finishing the lesson plans on time and emphasized only the content knowledge. He ignored to motivate his students to learn. His low voice modulation and his slow manner might also not motivate students to learn.

2.5.2 The teacher's Beliefs about Students

Because of Mr. Mana was a new teacher in this school and he was not responsible for grade 6, he did not know much about the group of students in the study. However he attempted to learn and use the students' names. Mr. Mana's overall attitude toward the students appeared to be influenced by the teacher who was responsible for grade 6. He knew from the grade 6 classroom teacher that most of the students came from broken families and had no goals for their education and so they did not pay much attention to learning. Mr. Mana considered the students were naughty. He said his job was helping the students to finish grade 6.

However, over the course of the study he changed his view. He came to consider that most of them were nice kids. He explained this change through an analogy between being a teacher and a painter:

> "These students were white clothes and a teacher was a painter who paints the colors on this white cloth"

This analogy showed his newly developed understanding that rather than all the fault laying with the students, the teacher was an important person, someone who could care for students to help them become good students and could learn. Although most of students were still naughty, at least until the last period, most of them felt that Mr. Mana was concerned about them. This showed from the way many students liked to consult Mr. Mana when they had problems and from what some students wrote in the journal entries to Mr.Mana. For example,

> …I think sometimes Mr. Mana is kind, while sometimes he scared me because he was angry. Anyway, I like him when he teaches us about experiments and lets us to do many science experiments… (Student JF 27's journal)

2.5.3 Student Assessment

Mr. Mana was concerned about the students' limited responses on worksheet and experimental reports and tried to encourage the students to finish all tasks. He said these helped him to follow the development of students' understanding. Mr. Mana followed the formative assessment as suggested in the instructional unit. He realized that the surveying of students' prior knowledge was very important and helped him to know more about how to encourage each student to learn.

Mr. Mana also realized that probing students' understanding one by one was effective. He said in the teacher conferences that:

> …I have observed that the researcher usually talks to the students in the group and walks around the class to observe student work. I think it is a good strategy to participate with the student one by one. It is better than I standing in front of the class. I had tried to do it already. It was great to talk to the students and it helped them when they got stuck with something…

The classroom observation supported his ideas above. Mr. Mana used formative assessment as a way to assess the students throughout the unit. He did not rely on the final examination exclusively. He also considered other factors such as students' abilities to work in groups, students' science process skills which were indicated in the unit as a criterion to assess the students. Moreover, he increased his participation with the students which helped not only the students to learn but also helped Mr. Mana to develop a rapport with his students.

2.5.4 Classroom Management

Classroom management was an issue during the implementation of the unit. Mr.Mana found it difficult to control the class and motivate the students to learn. His opportunities to address these problems were restricted by the way the Grade 6 classroom teacher sought to discipline the class. Her manner decreased the students' respect for Mr. Mana and although he attempted to use the strategies she used (blaming with rough words and loud noise), they did not work for him.

Mr. Mana's lack of classroom management skills had implications for the students' conduct of the work, particularly the experiments. For examples, in the Hokey Pokey lesson (chemical reaction) only two of the six groups prepared the instruments for doing the Hokey Pokey lesson. A similar situation occurred with the last presentation. Again, only two groups of students presented their research about the change of substances. Both groups presented about chemical changes. In one case the group used fire in an unsafe way to demonstrate the change.

This situation highlighted the way classroom management interacts with teaching and learning. Even though Mr Mana tried hard throughout the unit to manage the class he was largely unsuccessful, at least in part because he did not have chance to manage the class by himself.

2.5.5 Group Organization Strategies

Mr. Mana was successful in group organization to set up mixed abilities and mixed gender groups. His strategy was to make an agreement with the students in the first period. He said he would assign students to groups and change these every period. The students agreed to this arrangement. As every student said yes, Mr. Mana did not have any problem about group organization. At the beginning of every period, all students were looking forward to Mr. Mana group arrangements. This group organization strategy of Mr. Mana signaled to him that the problems in the class were not solely from the students. The students were not stupid and naughty as the grade 6 classroom teacher said had told him. This example demonstrated that when a teacher had reasonable discussions and or used some motivational strategies the students would appreciate this and be on tasks.

In conclusion, Mr. Mana's noticeable point which differed from the other two teachers was his strong content knowledge in science and teaching experiments. He studied the unit and tried to rely his teaching on the sequences in the unit. However, he concentrated only on content knowledge and tried to finish the lesson on time and ignore to motive his student to learn or tell the students the reasons for which they needed to do each activity. He hastily did his teaching because he had postponed the class many times. So, he tried hard to finish the lessons in the limited time. Because of he was a new teacher at this school, he needed time to establish a rapport with the students. His belief about the students at the beginning was negative. He perceived this group of students as hopeless in their learning and lack of responsibilities. The Grade 6 classroom teacher had some impact on his belief, his perception of the students and his role in teaching. Mr. Mana's teaching was always interrupted by this teacher. So, he had some problems about classroom management and how to control the class. However, the relationship between Mr. Mana and the students improved over time. His beliefs about the students changed throughout the unit. He estabished a good rapport with the students and was concerned about each student's personal problems such as their families' problems or lack of motivation to learn and absence of opportunities to show their abilities. His students could show development both in concept learning, doing science and their motivations. Mr. Mana showed his ways of assessment by using a variety of methods of assessment and increased his interaction with the students. He did not wait for the final assessment from the summative test but he collect notes for the development of each student during the unit. Finally, Mr. Mana had a good technique to organize groups reaching agreements with the students to set mix abilities and mix gender groups from the first period onward.

2.6 The Changing of JF Students' Understanding about Substances and Its Properties

This section describes the students' conceptual change at JF. The number of students understanding scientific conceptions at school JF increased in every concept: change in state of matter, solution process, separation of mixture and chemical reaction. The students' responses were categorized into seven groups which adapted from the categorization of concepts of Andersson, 1990; Tytler and Peterson, 2000; and Tytler, 2003 as following:

Table 6.6 Students' categories of responses

Categorized	Descriptions	Examples
Perceptual (P)	Responses that included the explanation on what is happening only.	water disappears
Association (A)	Responses that included the associative thinking or incorrect use of terms.	ice evaporates into water, or wind causes ice change into water
Displacement (D)	Responses that included the substances have been displaced.	sun sucks the water into the cloud.
Modification 1 (M 1)	Responses that included the substances continue to be the same substances but the appearances have been changed. (scientific conception for solution process and separation of mixtures)	Small pieces of sugar spreading out in water. Filter is used to separate sand from water.
Modification 2 (M 2)	Responses that included referring the effect of heat differences in modification. (scientific conception for changes of state)	water absorbs heat and change into gas, water particles get move quickly.
Transmutation (T)	Responses that included the substances change into others.	heat changes into bubbles.
Chemical reaction (C)	Responses that included the new substances were formed from the irreversible reaction. (scientific conception for chemical change)	Rust is formed because water reacts with oxygen, and iron nail.

The details of students' conceptual change in each concept were presented as the followings:

2.6.1 Changes in State of Substances

A number of ideas about changes in state of substances involved melting, freezing, evaporation, condensation, boiling and sublimation were probed. A category M2 was accepted as a correct answer which referred to the effect of heat on the change of state. A category M1 was sound scientifically but it did not have the idea of the relationship between heat and the change of state. All the JF students' ideas about change in state are presented in Table 6.7.

<u>Table 6.7</u> Number of The Students' Categories of Responses Concerning Change in State From Pre-Post Survey

(n=28)

The changes in state		Category							
		P	A	D	M 1*	M 2	T	C	No response
Melting	Pre	1	14	-	11	**1**	-	-	1
	Post	-	16	-	9	**3**	-	-	-
Freezing	Pre	-	6	-	1	**11**	7	-	3
	Post	-	6	-	1	**16**	4	-	1
Evaporation	Pre	4	4	-	2	**14**	-	-	4
	Post	1	2	-	-	**22**	-	-	3
Condensation	Pre	-	-	-	-	**-**	-	-	-
	Post	3	9	-	7	**7**	-	-	2
Boiling	Pre	5	18	-	-	2	-	-	3
	Post	2	14	-	1	9	-	-	2
Sublimation	Pre	-	-	-	-	-	-	-	-
	Post	-	-	-	-	-	-	-	-

*Scientific conception

Prior to instruction, the majority of students had alternative conceptions regarding the boiling and melting processes. The category most used for these concepts was a category A. For the boiling process, the high number of students using category A remained after the students had learnt about the boiling process. As Table 6.7 shows, 18 students used a category A in pre survey, and this number decreased to 14 students in post survey about the boiling process.

In the pre survey, the students who used category A explained that water evaporated into water vapor but they could not explain the bubbles in boiling water. Most of them said bubbles came from heat or fire and bubbles were boiling water. Only two students said bubbles came from air or water pressure. Even after the instruction, 17 out of 18 students who used category A did not change their incorrect understanding of the boiling process. JF 21 is an example of student who consistently used the incorrect category A. Her pre survey explanation about boiling water is seen in the following:

> "The level of boiling water goes down because of heat which sucked by water and then forms bubbles" (JF 21 pre survey)

Eventhough JF 21 did many activities about the boiling process; her understanding did not changed much. Her explanation of the process of water change into gas was found but as seen in pre survey, she consistently believed that the bubbles in boiling water were hot water:

> "The level of boiling water goes down because water absorbs heat and changes its state into water vapor….the bubbles which I saw in boiling water were very hot water."(JF 21 - post survey)

For JF 21, she was able to use a correct explanation concerning the evaporation process as water got heat and changed into water vapor. But she consistently misunderstood the bubbles in boiling water.

Although most students did not change their alternative ideas, 8 students changed their responses from using of category A to category M2 (correct answer). These students could explain that the boiling process was a process in which water changed to water vapor and the bubbles which were water vapor were formed. JF 2 was an example of students who changed his responses regarding boiling. The differences between his pre survey and post survey responses are shown below:

> "Water evaporation causes the level of water to go down….the bubbles in boiling water come from the fire."(JF 2 - pre survey)

> "Water gets heat and boils; the level of water goes down….the bubbles in boiling water are water particles which changed arrangement to form water vapor." (JF 2 - post survey)

JF 2 added more explanations concerning the effect of heat on the change of water into water vapor. He then used a particle model to explain his understanding about water changing into gas to form bubbles.

Similar problems in high numbers of alternative conceptions arose when students explained melting. As Table 6.7 shows the number of category A in melting process increased from 14 students (pre survey) to 16 students (post survey). There was one student who changed from using category M2 (correct answer) into category A. Other students changed from using category M1 to category A. JF 13 was an example of students who changed her explanations from sound scientific conceptions to alternative conceptions. Prior to instruction, she explained in her pre survey about the ice cube in closed bottle instance that:

"Ice dissolves [melt] and changes into water". (JF 13 -pre survey)

Her response corresponded to category M1, but her explanations had changed to category A in post survey as can be seen below:

"Ice gets heat and then melts into water. The water evaporates into gas which can be absorbed through the bottle". (JF 13 -post survey)

JF 13's understanding in melting was quite complicated, she reported to the researcher during an interview that she thought gas which was absorbed from the bottle could be changed back to water when went outside the bottle. She said coldness of ice made the puddles on the outside of the glass. Nine out of fourteen students who used category A in post survey shared the same problem with JF 13. They confused the condensation and melting processes. This confusion seemed to have increased after the instruction.

Although the condensation process was not included in the pre survey, it was included in the instruction unit. Based on the students' work and students' activities, it was found that most students ignored the change of air outside the container. Nine students including JF 13 did not have any ideas about water vapor in air releasing heat and changing into water. The following excerpts are an example of student responses to the activities of condensation:

"The clashing between heat and moisture forms the puddles."
"Water vapor touches the moisture which includes condensed particles and is changed into water."

The first excerpt shows a misleading view of how the puddles had occurred. It was hard for the students who used this explanation to accept that there was water vapor everywhere and that it could change into water. The second excerpt shows the students' attempt to use the terms "condensation" and "particles" in their explanation but still had alternative conceptions. They perceived that particles were something outside the water vapor.

As for the freezing and evaporation processes, the uses of alternative categories decreased. Most students held the correct category (M2) in post survey. Evaporation seems to be an easier concept because there were 22 students who used category M2 to explain the evaporation process in post survey. As well, 11 students used M2 for explaining the freezing process.

The JF students were still confused about the many processes of changes. They had difficulties in relating the observable change which they could see and the reasons why the change did occur.

2.6.2 <u>Solution Process</u>

The scientific conception of the solution process includes three key points. Firstly, the process of dissolving is the homogenous mixing between two substances. There is the same property in all parts of the solution. Secondly, solute breaks down into pieces which are too small to be seen. The particles of solute are spreading out in the particles of solvent. Thirdly, the solute is still conserved in the solution.

<u>Table 6.8</u> Number of The Students' Categories of Responses Concerning Solution Process from Pre-Post Survey

(n= 28)

Solution process		Category							
		P	A	D	M 1*	M 2	T	C	No response
Process of dissolving	Pre	10	3	-	**3**	7	-	-	5
	Post	1	6	-	**13**	5	-	-	3

Solute in solvent	Pre	14	5	-	-	6	-	-	3
	Post	9	1	-	**13**	4	-	-	1

<u>Table 6.8</u> (Cont'd)

Solution process		Category							
		P	A	D	M 1*	M 2	T	C	No response
Conservation of matter	Pre	-	15	-	**1**	-	-	-	12
	Post	-	7	-	**18**	-	-	-	3

* Scientific conception

From Table 6.8, most alternative conceptions about solution process concerned the conservation of matter. Fifteen students used category A to explain the conservation of matter. These students responded that in the sugar solution instance, it was impossible to get the sugar back from solution because the sugar changed into water or liquid, and some of them just said the sugar had dissolved. However, the decreasing of category A used was observed in post survey. Most students changed their ideas to use category M1 for explaining the conservation of sugar in the solution. They accepted that they could get the sugar from the solution because it was still presented in the solution. It had not disappeared or changed into another substance.

About the process of dissolving, dissolving was often described as the process during which sugar disappeared or dissolved. Ten students relied on perceptible indications, so they used a category P to explain the process of dissolving. The following are the students' explanations used in category P:

> "Dissolving occurs when we put something into water and then it disappears." (JF 22-pre survey)

> "Dissolving is when sugar dissolves in water." (JF 5-pre survey)

Seven students in this group said they thought heat was the main factor for dissolving sugar in water. Although these students used a category M2 for explaining, they did not give any explanation about the effect of heat on dissolving sugar.

> "Sugar disappears because sugar touches hot water." (JF 16-pre survey)

Another problem about language confusion was the use of the melting process as a prototype for dissolving. Three students thought sugar changed into water or sweet water.

The students' explanations of the process of dissolving corresponded with the students' explanations about the changes of solute in solvent. The students who thought the process of dissolving corresponded to a change in state explained the change of sugar as the change from solid to liquid. However, all of them said these water or sweet water could not change back into sugar. This explanation shows the students' alternative ideas about the conservation of sugar in water. As Table 6.8 shows fifteen students gave the reason that they could not get the sugar back from solution because the sugar had already dissolved or changed into water.

Most of students' explanations changed after instruction, they used a category M1 (scientific conception) to explain the process of dissolving in all key ideas (process of dissolving, the change of solute in solvent and the conservation of matter). JF 11 was an example of students who changed from using a category P to a category M1 in all key ideas. In the pre survey JF 11 relied on what he saw about sugar in water. His explanation was:

> "Sugar gets smaller and disappears in water…that mean the sugar dissolves in water…we cannot get the sugar back from water because it already disappeared." (JF 11-pre survey)

JF 11' ideas changed after instruction, the picture he drew during the class also showed his understanding of the spreading out of sugar particles in water particles. The following explanation shows his change from category P to category M1:

> "Dissolving is the process during which sugar mixes homogeneously with a solvent, we cannot see the sugar anymore…sugar mixes with water…we can get the sugar back by evaporating the water." (JF 11-post survey)

After instruction, this group of students reported that they could give microscopic explanation at the particular level. Many models from students' drawing showed their understanding that sugar still existed in water but it could not be seen.

This study of JF students found that they switched from their initial category to the correct category (M1). Most of them understood that the solution process was the mixing of two substances with both of them still present in the solution. The particle model helped most of students to clarify how one substance is present in another substance.

2.6.3 Separation of Mixture

The purpose of the survey is to probe that students can explain how to separate substances from water. The scientifically accepted explanation to this concept is that the properties of substances in mixtures are retained whenever some of their properties are changed. A category M1 is a correct category to refer to the retained properties of the substances in the mixture. The students' responses from pre and post survey are presented in Table 6.9:

Table 6.9 Number of the Students' Categories of Responses Concerning Separation Of Mixture from Pre-Post Survey

(n =28)

Separation of mixture		Category							
		P	A	D	M 1*	M 2	T	C	No Reason
Using filter or sieve to separate sand from water	Pre	13	-	-	-	-	-	-	-
	Post	4	-	-	3	-	-	-	1
Using spoon to separate sand from water	Pre	8	-	-	-	-	-	-	-
	Post	1	-	-	1				2
Precipitate sand from water	Pre	-	-	-	-	-	-	-	-
	Post	8	-	-	-	-	-	-	3
Evaporate water from sand	Pre	-	-	-	-	-	-	-	-
	Post	1	-	-	-	-	-	-	1
No response	Pre	7							
	Post	4							

* Scientific conception

All students who responded to the survey accepted that they could separate sand from water. The students could respond to other instances during the lesson namely mixture of water and mud; mixture of different types of coins; mixture of water and oil; mixture of tea and tea leaves; and mixture of orange juice and its pulp. They learnt to choose strategies such as picking, filtration, sedimentation, sublimation, and evaporation to suit substances properties in mixture. From the data, it seems that separation of mixture is the easiest concept because the students could explain that sand and water still exist and that they can be separated. All students' responses were categorized into category M1 which showed that filtration was an appropriate method for separating sand from water.

Although the JF students could choose the appropriate strategy for each mixture, most of them could not give reasonable explanations for the reason why they chose a strategy. As Table 6.9, shows only four students explained in post survey that they selected the strategies (filtration and using spoon) for separating sand from water by considering the properties of sand (a category M1- the properties of sand is continue be the same). Two of them said “sand’s grains are bigger than sieve’s holes”. One student said “sand is not mixes homogenously with water, it was easy to separate it with a filter” and another student said “sand particles are different from water particles”. Other students did not give any ideas about the properties of sand and water. Most of them used a category P to explain how to separate mixtures. Their reasons were “sand can be separated by sieve” or “filtration is an easy method” or “I use a spoon to separate sand from water”. These reasons did not give any ideas about the students’ understanding of the properties of sand and water. They just only described what they observed.

2.6.4 Chemical Reaction

The key ideas for this concept are that it is difficult to reverse the chemical reaction and that new substances are formed in the chemical reaction. For the lesson, many activities were presented to the students with the purpose to encourage them to meet all key ideas of chemical reactions. For example, the reaction between substances e.g. vinegar changes color of flower, and a dark substance is formed after burning sugar; to apply chemical reaction into everyday life by testing and explaining the reaction in Hockey-Pokey were presented. In the survey, the reaction of burning paper, rusty nail and fizzy of Eno were presented to the students. The results of students’ responses are shown in Table 6.10:

Table 6.10 Number of The Students' Categories of Responses Concerning Chemical Reaction from Pre-Post Survey

(n= 28)

Chemical reaction		Category							
		P	A	D	M 1	M 2	T	C*	No response
Burning	Pre	-	1	-	2	20	1	-	4
paper	Post	-	-	-	3	4	3	18	-
Rusty	Pre	6	2	14	-	-	-	4	2
nail	Post	4	14	5	-	-	-	4	1
Eno	Pre	-	-	11	1	-	-	16	-
	Post	-	-	4	6	-	-	17	1

* Scientific conception

In the pre survey, most of the correct answers concerned the situation about Eno in water. Sixteen students could explain that the bubbles in water occurred when Eno interacted with water. The problematic situation for the JF students in pre survey was the burning of white paper. Twenty students used a category M2 for explaining this situation. They said "Paper was burned and changed its color to black"

A different problem arose for the rusty nail situation. Fourteen students said the rust was in the water and moved to the nail. They used category D to explain this situation. For example,

> "The rust already exists in the nail. If it is not in the nail, it will not appear when we put the nail into water"

In the post survey, most students gave up category D to explain the rusty nail but they still did not use the correct category. Fourteen students used category A to explain the rusty nail. An example of this kind of students' conceptual change was showed by the case of JF 13:

> "Rust is in water and then moves to a nail" (JF 13 pre survey)
> "A nail has been in water for a long time so water makes it go rusty" (JF 13 - post survey)

JF 13's explanation of the rusty nail in pre survey was that rust was present in the water and moved to the nail. Her understanding changed and she now believed that water made rust appear because a nail had been in water for a long time. JF 13's explanation relied on time factor instead of emphasizing the reaction which occurred.

The idea of the creation of new substances (rust) was not understood by this group of students through the rusty nail situation. The burning paper and the Eno were more understandable for this group of students than the rusty nail.

2.7 Conclusion for Case Study II: School JF

Most JF students had alternative conceptions regarding melting and boiling before instruction. However, the use of a category M2 (correct concept) increased from 2 students (pre survey) to 9 students (post survey) for boiling process and increased from 14 students (pre survey) to 22 students (post survey) for the evaporation process. Although the number of students using a category M2 increased in the boiling and evaporation processes, the number of students who had alternative conceptions about melting increased after instruction. The students still used a category A to explain the melting process. They confused the condensation and melting processes. They could not give a reasonable explanation for the formation of water in the melting process. They said that the water present outside a container containing melted ice was water that had come through the container itself. For the solution process, the number of students' using a category M1 (correct concept) increased throughout the unit especially in the key area of conservation of matter. Most students showed that they could use a particle model as a tool to explain how the solute existed in solvent. The use of scientific category also increased regarding the concept of chemical reaction. The students using a category C (correct concept) increased most in the rusty nail situation, from 2 students (pre survey) to 14 students (post survey). The students could explain that rust was a new substance which appeared during the chemical reaction. However, about the separation of mixture concept, there were only four students in post test who could use a category M1 (correct concept) to explain this concept. Other 18 students could not explain how to choose a correct separation method suitable to the properties of substances in each mixture.

3. Case Study III: School AB

3.1 School and Classroom Context

3.1.1 School Context

School AB was the most popular and biggest government primary school in a small town of Saraburi, Thailand. Most of the people in this town were farmers and factory workers. There are a factory and a large rice mill in this town. The school is opposite the town government office. Students came from low to high-income families. The school had high levels of parental involvement and parental financial support in school activities and extra curricula activities for example, local communities' festivals. Classes range from Kindergartens to Grade 6 in this school, two classes per level. There were 1,300 students and 200 teachers at the time when teaching intervention was implemented. Each teacher was responsible for their classroom and their specialized area. The school had been implemented the old curriculum, Thai Primary National Curriculum (Ministry of Education, 1978 and ensuring version 1990) in which science was integrated into life experience subjects (social studies, science and health education). However, this school had separated science from social studies into two distinct subjects for grade 5 and grade 6. Science was taught for three periods per week and 48 periods per semester (one period is one hour).

3.1.2 Classroom Context

There was only one laboratory room for the grade 5 and grade 6 students who had science as a separate subject. The laboratory room was very clean and tidy. The teacher's desk was placed in front of the class and the teacher always sat there. There were four cupboards with a number of science instruments at the back of laboratory room. Most equipment sets were incomplete and some had never been used. During study, the students were divided into six groups. They were quiet and discipline was strict.

3.2 Teacher's Background

Ms Pailin was a 54-year-old teacher. Her formal qualification was a Bachelors degree in primary education. She had 31 years experience in primary teaching. She had taught science for 23 years and won a teaching award in science in 2000. She had enrolled in the science teacher evaluation course provided by IPST in 2004. Her responsibilities in the school, besides teaching, were working in the academic division, taking care of the science laboratory room, and taking care and training the students for extra activities.

Ms Pailin wanted to be involved in the research study because she said she did not know much about science and teaching science because she did not have a qualification in teaching science. She wished to know more about how to teach primary science by participating in the study. She said she had little confidence when teaching science experiments and in using science equipment. Some experiments about fire and electricity frightened her when she had to teach these concepts. She said she asked other teachers to teach these concepts.

3.3 Students' Background

Thirty Grade 6 students (15 boys and 15 girls) participated in this study. Most students in this group had high academic competencies based on their average grade points they had before this study. There were only three students who had low academic competencies, especially in reading and writing skills. The students came from low to high income-families. Student competition in this school was high. Each student was expected from their parents to get good grade and could enter to the most popular secondary school in this province. However, there were many kinds of extra activities for the students because AB school used to represent this town at many activities and participated in festivals or ceremonies and sport competitions with other towns. Therefore, the students were expected not only to get good grades, but also to do well at extra activities.

3.4 Teaching and Learning in Case Study III

As presented in the previous section, before this study, most AB students had high average grade points in science when compared with other two schools. However, from the pre survey, the AB students showed they had difficulties with responding to the open-ended questions and applying science into their everyday life. The majority of the students did not complete the pre survey. Some of them respond to the survey less than fifty percentages of the items.

Ms Pailin was an example of a teacher who accepted that she had low confidence in teaching science but whose confidence increased after she participated in this study. She also showed her appreciation of using an instructional unit to help her students to learn and to do science.

This section will present the successes of a conceptual change-based instructional unit in encouraging the AB students to understand that science was not found only in a textbook and involved more than memorization. Ms Pailin’s success in using experiment and discussion teaching strategies to develop student learning is also presented. The AB students’ learning strategies are presented to confirm the students’ development of scientific understanding and some of the factors involved in the students’ learning.

3.4.1 Teacher Teaching

(1) Discussion and Questioning Technique of the Changes of Matter

Discussion and the use of questioning strategies can be used to promote student conceptual change. In this case, when Ms Pailin introduced scientific conceptions to her students she gave them opportunities to talk and respond to her questions about the scientific conceptions. These opportunities helped the students to express their ideas in their own words and to construct their knowledge using language as a tool to interact with teacher and peers. Through the process of discussion and the use of questioning techniques which included the use of, higher level questions open questions Ms Pailin required student higher levels thinking. An example of Ms Pailin using of discussion and questioning techniques to probe student understanding and introduce new scientific conceptions about chemical reaction is presented below.

Ms Pailin:	The time is up. What are differences among these three situations [burning, sugar dissolves and ice melts]?
FS1:	I think I could get the sugar back from water as we used to do in that activity [solution process lesson].
Ms Pailin:	Does anyone remember that activity?
FS1:	Yes.
FS2:	We heated the water and evaporated it, and then we got the sugar back.
Ms Pailin:	How this situation different from others?
FS3:	We also can get the ice back. To do this put it into the refrigerator.
Ms Pailin:	Nice answer, you can get the sugar and the ice back. What do you think about burning paper? How can you get the paper back?
FS3:	We can't get it [paper] back. It is ash.
Ms Pailin:	That's right. There are some changes that we cannot get the

substances back. We call this change as chemical change or chemical reaction. What about ice melting and dissolving of sugar? What's kind of change?

FS 4: We can get them [sugar and ice] back. It is not change like that [burning].

From this excerpt, Ms Pailin tried to present a new idea about chemical reaction to the students. First of all, she confirmed that her students understood the change in state and solution process by asking the students to differentiate the three situations, burning, sugar dissolves and ice melts. She used students' responses to develop the next questions. She probed the students more about why and how to get sugar back to help them realize that the burning paper situation is different. Her questions such as "How this situation different from other?", "What do you think about burning paper? How can you get the paper back?" required students' reasoning skills not just only yes/no responses. These techniques both helped Ms Pailin to make sure that her students understood science and helped the students to express and clarify their ideas.

(2) Students' Research and Presentation

In a last activity of a conceptual change-based instructional unit, the students had a chance to do research about a topic they were interested in and to present what they learned to the class. This strategy aimed to give opportunities to the students to apply their scientific knowledge to different situations and to find way to present the language and ideas of science in their own words.

The AB students were very creative in presenting their research in different ways such as a drama about the dangers of burning (we can not get wood back from burning. After burning, many animals do not have food and finally people die) and a role play about how particles behave during melting and freezing (a student behaves as a water particle, he is weak when stay outside a refrigerator. He becomes stronger when he is put into a refrigerator again). In this activity Ms Pailin adopted the role of a facilitator to help the students to find and prepare resources. She also encouraged other students to ask questions and express ideas during the group presentations of research. An example of a student presentation is shown below.

Figure 6.13 The Student Drama- The Dangers of Burning

3.4.2 Student Learning

The AB students showed development both in their scientific conception and science process skills. They also realized that science related to their lives. For example, AB 26 was one of a number of students who mentioned that science was important and related to his life.

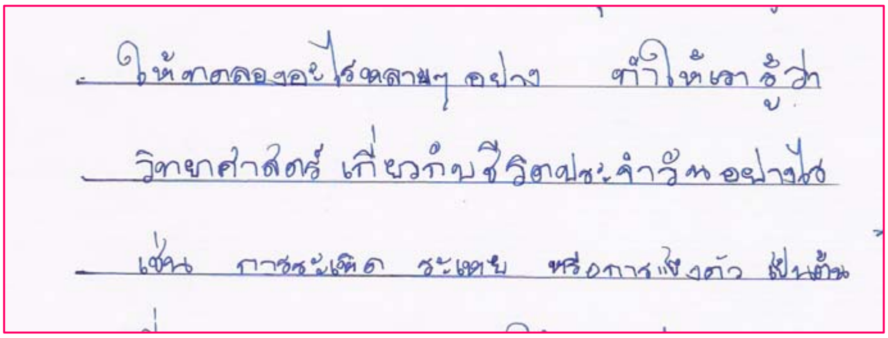


Figure 6.14 Student AB 26's journal

> …I did many experiments which help me to know that science relates to everyday life e.g. Sublimation, evaporation and freezing… (AB 26-Journal)

Although most AB students had high scores in science before grade 6, they rarely had opportunities to practical work and express their ideas. The evidence from the students' presentations of their research showed that all students, even those who had a low score in science, were able to develop their science conceptions, to do science and to present their understanding to others. Most students changed their ways of learning from memorization to expressing what they really understood. The increase in student responses in the post survey was further evidence for this.

Teaching and learning in AB school showed a positive impact of conceptual change teaching strategies on students' development in scientific conceptions. Moreover, the conceptual change-based instructional unit not only encouraged the students who had alternative conceptions to reach for scientific understanding, but also influenced the views of those students who perceived science as a subject for examination alone. The relation of science to everyday life and possibility of learning science by understanding were the new meanings of science developed by most AB students.

3.5 The Teachers' Change during the Unit

Ms Pailin was familiar with lecture methods for teaching science. Although her teaching sequences relied on the instructional unit, she always told the students the answers beforehand, without asking for the students' responses first. She tried hard to follow each part of the instructional unit and to keep to the time allocated. Ms Pailin praised students who were quiet and who listened to her.

Ms Pailin's behavior changed over the course of the instructional unit. Initially, she looked nervous and lacking in confidence when she was observed by the researcher. Later, her confidence increased when she found that she understood more about science. About her relationship with the students; she was interested in the students' everyday life problems as well as their academic problems. She was a good counselor for the students. All the students respected her and were ready to do everything she asked for (such as keeping quiet during class). However, Ms Pailin had a problem with group organization. She could not divide the students into mixed gender and mixed abilities groups. The following sections detail her implementation of the instructional unit.

3.5.1 The Teachers' Confidence in Teaching Science

Ms Pailin had told the researcher from the beginning that she was worried about her content knowledge and science experimental skills. She was a shy teacher during the teacher conferences. She rarely presented her ideas to other teachers and the researcher. Moreover, at the beginning of the teaching unit, Ms Pailin appeared to lack confidence when observed and video taped. She always checked with the researcher and sometimes asked questions. Her confidence in teaching increased over the time of the unit. Her increased confidence was evident in several ways. For instance, she checked less with the lesson plan during teaching. During the teacher conferences it was obvious that her process skills in conducting experiments and using science instruments had improved. She said experiments were easier than she ever had thought:

> …I think science experiments are easier than I ever thought…in the past it scared me because I didn't know how to use some instrument e.g. alcohol burner and I was worried about safety when using fire and chemical substances…

Moreover, her confidence increased in parallel with her curiosity. It was great when Ms Pailin said she would like to learn more about the science experiment packages (e.g. soap making package) the school had brought years ago. She said she now had enough science knowledge and was ready to introduce them to the students.

3.5.2 Ways to Develop Rapport with the Students

Ms Pailin had some good rapport with her students. She took care of her students both in an academic way and for their personal problems. This made most students love her and feel free to talk to her. The students' feelings about Ms Pailin were found in the student journals. For example, a girl said "Ms Pailin is a very kind teacher. I love her because I love science…. I am so sorry when she tells me that I will have a new teacher [the researcher]". She wrote this because she believed that Ms Pailin would be replaced by the researcher. Ms Pailin always gave students a chance to ask for help. Unlike other schools, the AB students asked many questions to the teacher.

3.5.3 The Teacher's Beliefs about Students

Ms Pailin believed that most of her students had high competence in science because they were the clever students from the town. Although Ms Pailin thought hands-on activities would help the students to learn science, her teaching style did not rely on these. She believed in the transfer of knowledge from teacher to students. Her belief was showed especially for the less competent students. Her comment about AB 4, a boy who had low grades and had difficulties in writing and reading illustrates her belief:

> "One boy had problems, he couldn't read or write…I can help him by letting him copy his friends' answers or by asking him to copy the sentences on the blackboard."
> (Ms Pailin's interview)

Her belief in students' learning changed after she realized that the students could learn by themselves. They could search for more data than they could get from the class. Ms Pailin's interview at the last teacher conference showed her idea that:

> …My students did a very good job in the last lesson [research for the changes of matter]. It is really hard to believe that they could find the research topic and search for more data from books and the Internet. My students presented their research in different ways such as role-play, and drama experiment. I have never taught them about these. I am really proud of them… (Ms Pailin's speech from a conference)

3.5.4 Adapting Tasks to Suit the Class

Ms Pailin refused to teach some lessons in the unit, for example the Hockey-Pokey activity (chemical reaction) because it would be too difficult for her students to prepare the materials and she did not want to interrupt other teachers and students. Instead, she used discussion with the students about the advantages from chemical reaction in everyday life. Although she tried to follow the instructional unit step by step, she did not always use it as a way to encourage her students to think. She often asked closed question as the excerpt below shows when she was seeking to summarizes the solution processes:

Ms Pailin:	What did we study about? (Ms Pailin copied a concept map of the solution from the lesson plan onto the blackboard)
Ss:	Solution.
Ms Pailin:	What do we call a substance which makes another substance dissolves?
FS1:	Solvent.
Ms Pailin:	What does the water do in this activity?
SS:	…(no students' response)
Ms Pailin:	Do you know what a solution is?
SS:	…(no students' response)
Ms Pailin:	A solution is a mixing a substance with water. A solution is a homogeneous mixture. Everyone can make his own [concept] map about solution and do it based on his understanding.

In this excerpt, Ms Pailin did not give students a chance to think, answer or reflect on their ideas. Ms Pailin begun by writing everything on the blackboard, and then she asked for the students' ideas. It was impossible for the students not to copy all what the teacher had written. Ms Pailin focused on transferring the information from the unit rather than students' process of developing ideas. So, Ms Pailin could not get the students' actual ideas during this class. Some time after this lesson, at the teacher conference, other teachers talked about how to probe student understanding and the importance of doing this. Ms Pailin did not say anything at the time but later she changed her teaching strategies somewhat. She told the students the objectives of each period and she copied only the main ideas onto the blackboard. She said this strategy was to help the students see the big picture of each lesson. Overall, while Ms Pailin did not change much in the way she presented concepts to the students, she did realize that the students could do many things, even when they were not under her control. For examples, she gave opportunities for the students to search for data from many resources by themselves and she allowed the students for more opportunity to discuss and to debate their ideas. Ms Pailin's role in the introduction to lesson four about chemical reaction showed her increasing to come up with the students' expression of ideas. She encouraged her students to clarify their ideas about the different of the three situation; ice melting, dissolving of sugar and paper burning. The following excerpt demonstrates Ms Pailin's changes in her role.

Ms Pailin:	You had learned many things about changes in state of matter and solution process, so can you explain the different of the three situations in this worksheet?
FS 1:	If I put the water in the refrigerator, the temperature will decrease or not?
Ms Pailin:	What do you think about this? I think we used to talk about this before.

………………………

Ms Pailin:	The time is up. What are different between these three situations?

FS 2:	I think I could get the sugar back from water as we used to do in that activity [solution process lesson].
Ms Pailin:	Does anyone remember that activity?
Students:	Yes.
FS 2:	We heat water and evaporated it, then we got the sugar back.
Ms Pailin:	How this situation different from other?
FS 1:	We also get the ice back. To put it into the refrigerator.
Ms Pailin:	Nice answer, you can get the sugar and the ice back. But there is some change which we cannot get the substances back. We call this change as chemical change or chemical reaction. What do you think about burning paper? Can you get the paper back?
FS 3:	No. It is ash.
Ms Pailin:	That's right. It is a chemical reaction. What about ice melting and dissolving of sugar?
FS 4:	We can get them [sugar and ice] back. It is not change like that [chemical reaction].

Although Ms Pailin did not use many probing questions, she showed her decreasing of telling the answers to the students. She gave more opportunities to the students to answer and reflect their ideas based on what they had learned. These showed Ms Pailin's interesting in the developing of students' understanding rather than focused on a true answer as she used to be.

3.5.5 Student Assessment

As presented above, most of grade 5 AB students had scores in science. However, the low responses' number from pre survey interviews with the students showed that they were not familiar with open-ended questions and they did not want to respond with incorrect answers. The students appeared to worry about their scores. Their answers from worksheet did not tell much about their ideas because most of them copied their friends' answers. Ms Pailin did not rely on the formative assessment; she did not pay attention to the students' worksheet or the students' experiment reports. She paid more attention to the students' final examination scores. Her students' grades were based on their final examination scores only. However, during the unit, Ms Pailin accepted the alternative ways of assessment by following the assessment methods which suggested in the instructional unit. She assessed the students through the hands-on tasks and gave more opportunities for students to ask questions, discuss and reflect their ideas.

3.5.6 Classroom Management

Although Ms Pailin was a very kind teacher she was constrained by the school policy to control her students all the time. Ms Pailin said that she had to be strict about two things; to be on time for each period and to control the students. She explained that she had to be punctual because the laboratory room was used by many classes, so it had to be ready for the next group of students who would use the room. Ms Pailin said if the class was untidy, she would be blamed by the principal who always walked around the school to check what was going on.

During implementing of the instructional unit, the students had more opportunities to do activities and walk around the class. All students told Ms Pailin that they liked this way of learning which let them do many activities and search for more data by themselves.

3.5.7 Group Organization Strategies

Ms Pailin had problems with dividing the students into groups. She let the students manage the group by themselves. Ms Pailin's solution for giving students an opportunity for high competence students to help the low competence students was to put a high competence student into a group of low competence students. Ms Pailin's objective to mix high and low competence students in the same group was a good idea but she needed to manage the ratio of students more. A problem arose when a girl who paid attention in learning was put in a group of five students who did not pay attention. This girl suffered because she was only one student in the group who had to do work while others did not. The girl asked Ms Pailin to change group but Ms Pailin ignored her request and just changed the student's position in the group. This problem was a serious problem for Ms Pailin until the last period and she could not solve it.

Ms Pailin seemed to be a good example of a typical decent Thai teacher. She was kind and had a good rapport with students. She was concerned about all students as if they were her kids. The students trusted Ms Pailin and showed their respect to her all the time, so she had no problem about controlling and managing the class. Ms Pailin believed in her students' competence in science. She said the students in this school were the smartest students in town. However, the teaching style of Ms Pailin was based on the traditional way of teaching based on lecture. She felt happy when the students were in order and kept quiet. Her belieft in the transferable nature of knowledge from teacher to the students was also noticed. She usually told the content to the students. Moreover, her lack of confidence in teaching and learning science was observed. During the first lesson, she usually held the lesson plans during teaching and read from them. She accepted that she did not know much about science and doing science. Her confidence in teaching and doing science increased after learning more about science content and practiced to do science after the teacher conferences. Another problem was her inability to organize students' groups. She did not have a clear agreement with the students to divide them into groups, so some students said they were not happy with their groups and some students felt sad when nobody wanted them to the groups. The change in Ms Pailin's teaching occurred during the unit. She accepted and realized the ideas of the students' construction of their own knowledge. But she said that although she believed in her students' abilities, she did not expect that they could do many activities and search for data by themselves without her help. Her role gradually changed from a person who told knowledge to that of a facilitator during the unit.

3.6 The Changing of AB Students' Understanding about Substance and Its Properties

The change in AB students' conceptions is described in this section. The number of student using of scientific conceptions increased for every concept. The students' responses were categorized into groups which adapted from the concepts' categorizations of Andersson (1990), Tytler and Peterson (2000) and Tytler (2003) as following:

Table 6.11 Students' categories of responses

Categories	Descriptions	Examples
Perceptual (P)	Responses that included the explanation on what is happening only.	Water disappears
Association (A)	Responses that included the misleading associative thinking or incorrect use of terms.	Ice evaporates into water, or wind causes ice change into water
Displacement (D)	Responses that included the substances have been displaced.	Sun sucks the water into the cloud.
Modification 1 (M 1)	Responses that included the substances continue to be the same substances but the appearances have been changed. (scientific conception for solution process and separation of mixtures)	Small pieces of sugar spreading out in water. Filter is used to separate sand from water.
Modification 2 (M 2)	Responses that included referring the effect of heat differences in modification. (scientific conception for changes of state)	Water absorbs heat and change into gas, water particles get move quickly.
Transmutation (T)	Responses that included the substances change into others.	Heat changes into bubbles.
Chemical reaction (C)	Responses that included the new substances were form from the irreversible reaction. (scientific conception for chemical reaction)	Rust is formed because water reacts with oxygen, and iron nail.

The concept of change in state, solution process, separation of mixtures and chemical of students were showed below.

3.6.1 Change in State of Matter

Table 6.12 Number of The Students' Categories of Responses Concerning Change in State from Pre-Post Survey

(n=29)

The changes in state		Category							
		P	A	D	M 1	M 2*	T	C	No response
Melting	Pre	-	7	-	10	-	-	-	12
	Post	-	10	-	12	**7**	-	-	-
Freezing	Pre	-	-	-	2	**6**	1	-	20
	Post	-	4	-	1	**18**	4	-	2
Evaporation	Pre	3	2	-	1	**10**	-	-	13
	Post	2	3	1	-	**22**	-	-	1
Condensation	Pre	-	-	-	-	-	-	-	-
	Post	6	15	-	-	**3**	-	-	5
Boiling	Pre	-	15	-	-	**1**	-	-	13
	Post	-	8	-	-	**20**	-	-	1
Sublimation	Pre	-	-	-	-	-	-	-	-
	Post	-	10	-	5	**10**	-	-	4

* Scientific conception

Regarding the changes in sate of matter, the students needed to understand that when a substance got heat or release heat, the form of the substance would change, but not its other properties nor its mass. This explanation corresponds to a category M2 which refers to the effect of heat differences in modification.

From Table 6.12, 15 students used category A for explaining the boiling process in the pre survey. Their problem was that they were confused about the forming of bubbles in boiling water. Eventhough most students explained the process that water became invisible gas during the boiling process; they did not accept that the bubbles were a forming of invisible gas. The students thought that bubbles were made of boiling water, heat or occurred because of air pressure:

> “When water boils, the level of water goes down because water vapor is created and goes to the air…bubbles in boiling water are made of hot water itself.” (AB 21 –pre survey)

> “Water evaporates into gas…the bubbles are made of fire from the oven.”(AB 10–pre survey)

After instruction, the number of students who used a category M2 (correct answer) increased from 1 to 20 students. Most students who used a category A to explain the boiling process (pre survey) changed to a category M2 (post survey). For example, AB 10’s explanation is more reasonable than their pre survey response.

However, some students consistently used their incorrect category. For example, students AB 10 always explained that bubbles were made of hot water.

> “Water gets heat and then boils. After that water evaporates into water vapor….the bubbles in water is water vapor which evaporates inside water. (AB 10- post survey)

A high number of alternative conceptions were also found in the condensation process for which 15 students used a category A to explain the process. The students showed their confusion between the evaporation and condensation processes. For examples:

"Water gets heat, so it evaporates into puddles."

"The ice cube in the glass touches cold air, it changes into puddles and goes outside through the glass."

The examples above show consistent explanations from the same student. The first explanation is about hot water evaporating and water vapor touching an ice container. The second explanation is about water vapor in air in contact with cold ice cube in a glass that changes into puddles outside the glass. The students tried to explain what they saw (condensed water in water vapor) and related it to the condensation idea. In another situation, he tried to use a definition of condensation to explain what was happening about puddles on the glass but it did not make any sense.

The melting process seemed to be an easier concept for AB students. In the pre survey, 10 students used category M1 (the change of state without referring to the change of heat) to explain how the ice melts and changes into water. The use of category M1 also increased to 12 students in the post survey. Contrastingly, although there were 7 students in post test who used a category M2 (correct answer) to explain melting, the use of a category A also increased. The student understanding between melting and condensation to explain the melting process was evident:

"Ice touches heat outside a container and then melts and goes through the container."

However, the students increased their scientific knowledge regarding the concepts of evaporation and freezing. The students increased their use of a category M2 from 10 students (pre survey) to 22 students (post survey) and from 6 (pre survey) students to 18 students (post survey), respectively. Most changes from other categories to a category M2 were found when analyzing the evaporation process. The sublimation process was another interesting process for AB students.

Ten of them could use the M2 category to explain the situation of sublimated camphor. For example,

> "Camphor gets heat and changes into vapor. It does not change into liquid."

3.6.2 Solution Process

The three key points of solution process were explored. Firstly, the process of dissolving is a homogenous mixing between two substances. All parts of the solution have the same property in. Secondly, solute breaks up into pieces which are too small to be seen. The particles of solute are spreading out among particles of solvent. Thirdly, the solute is still conserved in the solution. The AB students use of categories of responses concerning the solution process is shown in the Table 6.13 below. A category M1 was accepted as the correct response which explained that the solute in solution continued to be the same substance but the appearances have been changed.

Table 6.13 Number of the students' categories of responses concerning solution process from pre-post survey.

(n= 29)

Solution process		Category							
		P	A	D	M 1*	M 2	T	C	No response
Process of dissolving	Pre	5	3	-	-	-	-	-	21
	Post	4	3	-	**10**	9	-	-	3
Solute in solvent	Pre	5	3	-	-	-	-	-	21
	Post	7	3	-	**15**	2	-	-	2

Table 6.13 (Cont'd)

Solution process		Category							
		P	A	D	M 1*	M 2	T	C	No response
Conservation of matter	Pre	-	4	-		-		-	25
	Post	-	9	-	**14**	-		-	6

* Scientific conception

As for other concepts for AB students, the problem of a low response rate in the pre survey was found. For the solution process, there were less than ten students who responded to the survey. The students used categories P and A. Most of them relied on the observable elements that they perceived with their own eyes only. For example, five students consistently used category P to explain the process of dissolving and the change of solute in solvent and used category A to explain conservation of matter. For example, AB 5 is one from five students who used category P and A in pre survey. His response in the pre survey was the following:

> "[Process of dissolving is] sugar dissolves.....the sugar has already dissolved so it one can not get it back." (AB 5- pre survey)

After instruction, AB 5 and other two students changed from using category P and A to category M1 (correct answer). AB 5's response was:

> "[Process of dissolving is] sugar mixes with water.....the sugar is still present in the solution but we don't see it, because it [sugar] mixes homogeneously with water ...we can get the sugar from the solution by evaporating the water." (AB 5- post survey)

Out of the students who used the category A (alternative conception-misleading associative thinking) to explain the process of dissolving, three of them said sugar was digested or was bit by water. Two out of three students changed to category M1 during the instruction. AB 16 was a student who still held her category A during post survey. Her answer in post survey about the process of dissolving as the sugar dissolved and mixed in the hot water seemed to be correct but it was contradicted by her explanation that solute was bit by water. The information gathered from interviews showed AB 16 elaborating:

> "Sugar dissolves in water…sugar was bit by water." (AB 16-interview)

Although the low responses of AB students in pre survey did not refer to the students' changes of their ideas, the students' responses during the instructions showed their high use of scientific conceptions. From Table 6.13, more than ten students used category M1 (correct answer) to explain the solution process. They all developed their ideas to accept the notion of sugar existing in the solution and some of them could use a particle model to explain the solution process.

3.6.3 <u>Separation of Mixture</u>

The scientific category for this concept is a category M1 which relates to the explanation that physical properties of substances are retained whenever some of their properties are changed. The students' responses from pre and post survey are presented in Table 6.14:

Table 6.14 Number of The Students' Categories of Responses Concerning Separation of Mixture from Pre-Post Survey

(n =29)

Separation of mixture		Category							
		P	A	D	M 1*	M 2	T	C	No Reason
Using filter or sieve to separate sand from water.	Pre	1	-	-	-	-	-	-	-
	Post	7	-	-	7	-	-	-	-
Using spoon to separate sand from water.	Pre	-	-	-	-	-	-	-	-
	Post	1	-	-	-	-	-	-	-
Precipitate sand from water.	Pre	-	-	-	-	-	-	-	-
	Post	5	-	-	-	-	-	-	2
Evaporate water from sand.	Pre	-	-	-	-	-	-	-	-
	Post	-	-	-	1	-	-	-	-
No response	Pre	28							
	Post	8							

* Scientific conception

Prior to instruction, only one student responded to the survey. She said filtration was a good method to separate sand from water. Her response fell into category P because she did not elaborate about the properties of the substances in the mixture.

During the activities, the students learnt many types of separation methods such picking, filtration, sedimentation, sublimation, and evaporation and the ways to choose these methods to suit substances properties in a mixture. The students were provided with many activities to challenge their abilities to find out appropriate separation methods.

After instructions, most students regarded filtration as an appropriate method to separate sand and water. Seven of them still used a category P to explain filtration as “efficient method to separate sand and water” or “I [the student] have tried to do it [using sieve] before”. Seven students could use a category M1 to explain filtration. They considered the different properties of sand and water and realized that their properties did not change even they were mixed together. For example, “sand is solid, has weight, and can be separated from liquid” or “filtration is a method to separate a mixture of sand and water in order to get two separate substances”. One student who chose evaporation as a method for separation said “sand could not be evaporated but water could”. From these results, the students’ realization about the properties of substances in mixture increased after instruction. The students could give reasonable explanations to support their thinking rather than just describing what they saw.

3.6.4 Chemical Reaction

Three instances were presented in the pre survey for preliminary probes. They involved the reaction of burning paper, rusty nail and fizzy Eno. A category C was used as a correct category for explaining the chemical reaction. The key ideas of this concept are the difficulty to reverse the chemical reaction and that new substances are formed in the chemical reaction. The results of students’ responses are shown in Table 6.15:

Table 6.15 Number of the Students' Categories of Responses Concerning Chemical Reaction from Pre-Post Survey

(n= 29)

Chemical reaction		Category							
		P	A	D	M 1	M 2	T	C*	No response
Burning paper	Pre	-	-	-	1	4	1	-	23
	Post	-	-	-	1	5	3	20	-
Rusty nail	Pre	-	2	1	-	-	-	1	25
	Post	2	14	1	-	-	-	12	-
Eno	Pre	-	-	1	1	-	-	1	26
	Post	-	-	3	3	-	-	21	2

* Scientific conception

The main problem with AB students was the low quality of responses. In the pre survey, only one student used a category C to explain the rusty nail situation.

In the post survey, category C was mostly used in the Eno and burning paper situations respectively. Interestingly, 14 students used category A to explain the rusty nail. Most of them (12 students) said rust was situated in the nail or in water and that it appeared when water met the nail. Two other students said moistness or other thing such as a germ in air made the nail go rusty.

The AB students could use the category C to explain the chemical reaction in different situations. However, they had a problem to explain the forming of a new substance, for example a forming of rust on an iron nail. On the other hand, they did not have this problem with the forming of ash from burning paper and the forming of bubbles of Eno in water.

3.7 Conclusion for Case Study III: School AB

In summary, there was a problem with the low response rate from AB students in the pre survey. The students said in their interview that they were worried that their answer would be wrong and they were not familiar with open-ended questions. Regarding the changes in state of matter concept in the pre survey, most students did not pay attention to the effect of heat on the changes in state of matter. For example, most students used a category M1 to explain the melting process. They said ice changed into water. Although the response rate of AB students was low in the pre survey, the students response rate in the post test was high and they used a category M2 (correct response) to explain the changes in sate of matter in all processes. Similarly, the students' scientific conceptions for solution process increased in all key areas especially for conservation of matter. Most students used a particle model to explain their ideas about the change of solute and solvent in solution. For the concept of chemical reaction, most students could use a category C (correct response) to explain the formation of new substances and the chemical reaction as an irreversible process during the unit. However, the findings from post survey found that most students had problems with explaining the rusty nail situation. A number of students used a category A to explain the forming of rust on a nail. The students said the nail had been in water for long time so rust was formed. Some students used a category D, they said rust changed place from the water to the nail or from inside the nail to outside the nail. For the concept of separation of mixture, there were only seven students out of 29 who could use a category M1 (correct response) to explain how they chose a separation method to suitable for the properties of the substances in each mixture.

Cross Case Summary and Discussion of Changes in the Teaching And Learning Of Matter Deriving From the Use of A Conceptual Change-Based Instructional Unit

This section presents the cross-case analysis from three schools namely School AB, School JF and School TK. There are two parts in this section. The first part is the teachers' change in teaching and the second part is the students' change in learning. The results from this cross-case analysis answer the research question 3 about how to find out the effectiveness of a conceptual change-based instructional unit into teaching and learning in matter.

1. Teachers' Change in Teaching

Corresponding to the finding of Tobin et al. (1990: 222-223) which highlighted the importance of teacher as a facilitator of students' learning to promote and to maintain the students' cognitive process, their idea of "Teacher Makes a Difference" showed the important roles of teachers in the students' learning process. Hence, the three teachers in this study played an important role in the students' conceptual change.

The data from teacher interviews and classroom observations showed how the three teachers' change of their roles of teaching inclined toward the conceptual change approach using the conceptual change-based instructional unit. Although all three teachers used the same instructional unit, each of them had a different way to adapt the lesson in the unit to his or her class. Based on each teacher's background, each had different pathways of changes in their teaching.

Before the three teachers enrolled in the study, they did not appear to perceive their roles as constructivist teachers. All of them focused on the correct answer which was given by the students rather than the progression of students' understanding.

After they had participated in the study and had been involved in the teacher's conferences, their abilities to understand the role of teachers as facilitators to promote students' learning through the conceptual change approach were indicated. However, similar to the change of students' conceptions, the teachers' changes in their teaching were based on each teacher's prior belief and his or her teaching background. The teachers' motivation and self-confidence was also found as the factors for teachers' changes in their teaching. The table 6.16 summarized the highlights of teachers' changes from three case studies.

Table 6.16: Summary of the Highlights of Teachers' Changes from Three Case Studies.

Teachers / Teacher changes	Ms Chujai (School TK)	Mr. Mana (School JF)	Ms Pailin (School AB)
1. Confidence in Teaching	A willingness /ability to develop herself	Confidence in content knowledge / increase confidence in teaching	Her confidence increases / A willingness to develop herself
2. Belief about students	Respect to students' idea and abilities	Give the students an opportunities to develop themselves	Realize in students' abilities
3. Important of student prior knowledge	Eliciting of student prior knowledge to promote students' learning	The way he used to encourage each student to learn	To develop student's learning base on each student' prior knowledge
4. Using probing questions	Develop her own questions to probe students' ideas	Help the students when get stuck	Her decreasing of telling the answers
5. Motivational technique	Relating tasks to everyday life	Rarely	Follow the sequences in the unit

Table 6.16 (Cont'd)

Teachers / Teacher changes	Ms Chujai (School TK)	Mr. Mana (School JF)	Ms Pailin (School AB)
6. Adapting tasks	- Study objectives - Discuss with others - Change some tasks	- Concentrated on content knowledge the first	- Follow exactly sequences - Refuse to do some activities
7. Student assessment	- Alternative assessment - Assessment during teaching process - Students' reflection	- Follow students' development - Assessment during teaching process - Participate with students	- Students answer and reflect their ideas based on what they had learned. - Alternative assessment
8. Classroom management	- Warm atmosphere - Students' expectation	- Effects from Grade 6 classroom teacher	- Give the students more opportunities -School policy effects
9. Group organization	- Important of working in group	- Make an agreement since the 1st period	- Try to solve problem for mix ability group

Ms. Chujai was the most enthusiastic teacher when compared with the other two teachers. Realizing that she did not know much about science and teaching science, Ms. Chujai tried hard to develop herself both in her teaching strategies and in her content knowledge. Her curiosity and readiness to meet the challenges of teaching science using a conceptual change-based instructional unit increased over the time. Ms. Pailin was another teacher who said she had no confidence in teaching science. She had troubles in making a decision and in expressing her opinions to other teachers and to the researcher. This might be because she had no confidence in talking about science, doing science and her teaching. Moreover, she was constrained by the school's policy and the expectation from the school principal to control the class to be in order, to keep quiet and to push the students to enter famous secondary schools. Ms. Pailin's teaching style was based on the textbooks and the teacher-centered style. However, her confidence in teaching and doing science increased after she had learned more about the content of science and practiced to do science from the teacher conferences. Although some facets of the teacher-centered style could be found in Ms. Pailin' class, the interaction between Ms. Pailin and her students increased more.

Ms. Chujai and Ms. Pailin shared some common relationship with the students. Both of them had good rapport with their students and showed their beliefs in their students' abilities. Most students from these schools were easy to encourage and motivate to learn because they believed in their own abilities.

Another teacher from this study was Mr. Mana. He was different from the other two teachers because he had strong content knowledge in science and teaching experiments. However, his direct teaching which emphasized only on the content knowledge was shown. The belief in his students began at the minus point at the beginning of the unit. He ignored to motivate his students to learn. He also showed his stress which might come from his status as a new teacher and the interruption from the Grade 6 teacher in teaching. However, his development in the teaching style towards the conceptual-change approach and his motivation to teach increased during the unit. His belief in the students was more positive and he could make rapport with the students. Mr. Mana's changes affected the students' learning by making most students to have more self confidence and more motivation to learn.

The three teachers gave the interesting ideas about teaching and learning in real classrooms. Each of them helped each other during the teacher conferences. Their reflections of their teaching helped the teachers to consider about what they did. Their share of problems helped the teachers to share their ideas to solve each problem. The common changes in teaching for three teachers are described below to show the ideas which involved teaching science by using the conceptual change approach.

1.1 The Teacher's Confidence in Teaching Science

The teachers gained confidence in teaching science as they felt that they had more understanding of content knowledge and mastery of science process skills. This might be because the teachers had a chance to develop their understanding about key ideas of matter and its properties and practiced to do science with the teacher conferences. This related to the finding of Harlen (1999) who explained a way to promote teachers' confidence that the teachers should have opportunities to discuss with experts or with other teachers and to develop their understanding of science and science teaching.

1.2 The teacher's Beliefs in Students

The teacher's belief in students was found as an important factor to promote the students to learn. All the three teachers in this study showed their suspicion about their students' learning. Although Ms. Chujai believed in her students' responsibilities to learn, she perceived that the contents and activities in the unit might be too difficult for her students. She thought her students did not know much about science. On the other hand, Ms. Pailin's belief in her students' science content was high but she never knew that her students were also good at doing science. Mr. Mana's belief about the students at the beginning was not good. He perceived this group of students was hopeless in their learning and lacked responsibilities.

The increase in teachers' beliefs in their students' abilities to learn and to do science was found in all three classes. Teachers considered that the students' abilities could be assessed in many ways not just only by the examination. Each of them could do many things if they were given the opportunities. This increase encouraged the students to believe in their own abilities and their motivation to learn.

1.3 Teachers' Realization of the Importance of Students' Prior Knowledge

The teacher's recognition of the importance of exploring students' prior knowledge increased while they implemented the instructional unit. The teachers found that the increase in their interaction with the students and in using probing questions to the students helped them to know that each student developed his or her ideas from what they knew. Each student had different interests and abilities. When the teachers accepted the advantages of probing students' prior knowledge from using the instructional unit, they had abilities to develop their probing understanding techniques by themselves. For example, Ms. Chujai found that the students would be interested in their everyday situations; therefore, she used the situations which related to the lessons as the tools to probe students' prior knowledge about what they would learn.

1.4 Classroom Management and Group Organization

The findings from the three teachers showed that good classroom management and group organization occurred by making an acceptable agreement between teachers and students since the beginning of the unit. For example, Ms. Chujai showed that she was good at classroom management. She did not give orders to the students; on the contrary, she always made discussions and agreement with the students in everything. Ms. Pailin, who received great respect from the students, changed her role from asking the students to be in order to asking them what they would expect to do in class. She learnt to make an agreement and to give the opportunities so that the students could plan what they would like to do by themselves. Mr. Mana also found that a good way of group organization was to make an agreement with the students to set mixed abilities and mixed gender groups since the very first period. Therefore, he was the only teacher who did not have any problems in group organization. This might be because those two female teachers were not aware of the importance of group organization since the first period in the semester when they met the students. It was difficult for them to organize the group into mixed abilities and mixed gender groups.

1.5 Student Assessment

The teachers started to understand the role and potential of formative assessment as a way to assess students in many ongoing ways. The interaction between teachers and students increased throughout the unit. The teachers' feedbacks and the students' self reflections also increased in all three schools. An unexpected, but perhaps not surprising, finding was that the teachers came to realize that some of their students who were less proficient in reading and writing could achieve with hands-on tasks better than some of those whom they had generally considered competent. Therefore, they gained wider appreciation of individual student knowledge and skills.

2. Changes in Students' Learning

Conceptual change was found for each of the target conceptions by most students in all three classes. The change of students' ideas showed the effectiveness of the instructional unit which promoted students' understanding. However, in each school, certain students still had difficulties with some concepts.

According to the change in the state of matter concept, the results of pre-survey from three schools showed similar findings. Most students used Category A to explain the process of change in state such as the boiling process. Their explanations were about the understanding that bubbles were made of heat or pressure. This finding corresponded with the study of Cosgrove and Osborne (1981); Osborne and Cosgrove (1983) and Johnson (1998(a)) of which the main explanations of the students were that bubbles were made of heat, or air, or water or steam. Another alternative conception from these three schools was about the melting process. Some students paid attention to the water outside the melting ice's container. They said water went through the container. This explanation also showed that these students did not have any idea about the condensation process. This information was similar to the study of Osborne and Cosgrove (1983) which found that the students had a question about water on the outside surface of a cold container. Some students from three schools used Category M1 to explain the change of state such as the melting process. They said ice changed to water. These students ignored to mention the effect of heat in the change in state of matter.

However, after the instruction, the number of students who used Category M2 (the correct answer) increased for the boiling process while the number of students who used Category A decreased in all three schools. All students from three schools accepted that bubbles in the boiling water were water vapor as they saw in the experiment of boiling water in the beaker. The conceptual change that occurred in the students' conceptions about boiling could be described as the change which "started from students' conceptions" (Duit, 1999: 275). Most students had prior conceptions that bubbles in boiling water were made of water. During the activities, the students were not told that their conceptions were wrong. They were encouraged to consider that they had a reasonable idea about the evaporation process, the change from water to water vapor when absorbing heat before. Consequently, a similar explanation could be used for the boiling process. The boiling water should be changed to be water vapor when the water met 100 Celsius degree. The observation of boiling water in a beaker supported the students' explanations of the formation of water vapor' bubbles. This showed the process that the students' conception about evaporation was reconciled with a new conception about boiling conceptions that water was suddenly changed into water vapor at 100 Celsius degree. Hewson (1992), Posner et al. (1982) and Strike and Posner (1992) called this process conceptual capture or assimilation.

Although most students in post-survey could use Category M2 to explain the process of change namely boiling, evaporation, freezing, some students had difficulties in the melting process. The number of students who had alternative conceptions in melting increased after the instruction. The students still used Category A to explain the melting process. They were confused between the condensation and the melting process. They could not give a reasonable explanation for the formation of water in the melting process. This might result from their confusion between the activities of ice melting and the situation from the worksheet of condensation of water outside the melting ice’s container. They said water outside the melting ice’s container was the water in the container which went outside. Another alternative conception in post-survey from School TK was sublimation. Data from classroom observation and students’ interviews found out that the students understood that a solid changed into gas but their problem was language confusion. Ms. Chujai (TK teacher) was one of the sources of students' alternative conceptions. Ms. Chujai and her students had confusion between the terms “sublimation” and “evaporation” which had similar pronunciation in the Thai language. They usually used the term “evaporation” instead of “sublimation” because it was more familiar to them. This finding related to Wellington and Osborne (2001) who explained that the scientific terms were completely strange to the students. Some students just felt that the scientific term resembled their everyday life's term but they might not be quite sure what they really were.

The comparison of number of students’ correct responses about the change in state of matter in each school is shown in Figure 6.15.

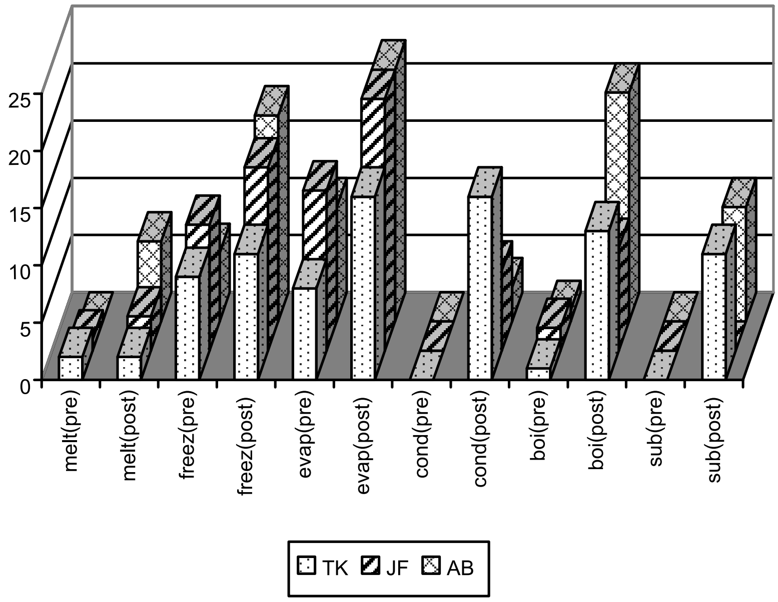


Figure 6.15 The Comparison of Pre-Post Students' Number of Scientific Conceptions iin Each School about the Change in State of Matter.

Due to the concept of the solution process, most students from three schools held the scientific conception to explain the process of dissolution, the change of solute in a solvent and the conservation of matter. Most students held Category P and Category T to explain the process of dissolution and the change of solute in a solvent. They believed that the solute disappeared because it was invisible in water. Some students explained that the dissolution of a solute means it melted (changing state from solid to liquid), or decomposed. Other students who used Category T said that a new substance was formed during dissolution (Longden et al., 1991; Selley, 2000). Most students in three schools had an unclear explanation about the conservation of matter in the solution process. They said the solute was gone and could not get back (Cosgrove and Osborne, 1981; Prieto et al., 1989; Stavy, 1990,). The use of a particle model for students was found as an unknown strategy for the students (Ebenezer and Erickson, 1996; Blanco and Prieto, 1997).

The successful results were found in post-survey in which the number of students who used Category M1 (the correct answer) to explain that the solution process increased in all key ideas, especially for the number of conservation of matter. Most students showed that they could use a particle model as a tool to explain how the solute existed in solvent. This showed the most successful use of a particle model in developing Grade 6 students' understanding for this instructional unit. This finding was similar to many findings which showed that primary students could use the particle model to explain their understanding of dissolution (Rosen and Rozin, 1993; Lee et al., 1993 and Selley, 2000). This finding also answered the question from a study of Skamp (1999) who posed the question, "Are atoms and molecules too difficult for primary children?" The successful results from three schools about the increase of students using scientific conception in each key idea of solution process are shown below.

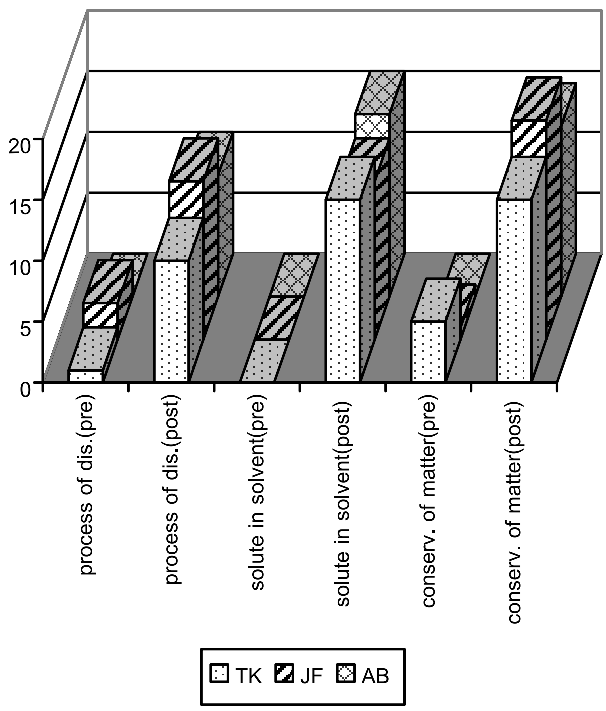


Figure 6.16 The Comparison of the Number of Pre- Post Students' Scientific Conceptions in Each School about the Solution Process.

The concept of chemical reaction seemed to be the hardest concept for all students because there were three different contexts in the survey to explore students' understanding in chemical reaction pre and post instruction. The students' alternative conceptions in pre-survey related to the use of Category M2 and Category D. The students who used Category M2 to explain the chemical reaction said the original substances had changed their form during reaction (Johnson, 2000(a, b);Schollum, 1981; Meheut, 1985; Pireto et al., 1992; Nieswandt, 2001).

However, after the instruction, most students could divide the chemical change into two keys ideas: a new substance was formed and the chemical reaction was an irreversible process. They could use a category C (the correct response) to explain what happened when the reaction occurred and accepted the formation of a new substance.

Some students, especially TK and AB students, could not accept that rust was a new substance resulting from the chemical reaction. That a number of students used Category A to explain the formation of rust on a nail was still high in post-survey. For example, some students believed that rust just happened when a nail was in water, that impurity in the nail cause rust to occur, and that nail was in water for such a long time that rust was formed. Some students, who used Category D, said that rust changed its place from water to nail or from inside the nail to outside. This finding matched with the study of Hessess and Anderson (1992) and Schollum (1981) which described that most students failed to identify some of the components in chemical reaction. The students were confused or had no ideas about the roles of the different reactants. The large number of alternative conceptions in rusty nail might be because the students were familiar with the chemical reaction activities which showed clear reaction and rapid changes such as burning paper, and a reaction between vinegar and baking powder. For rusty nail, however, the students could not see the reaction among water, oxygen and iron nail. An increased number of students who used scientific conception from pre survey to post survey are presented as follows:

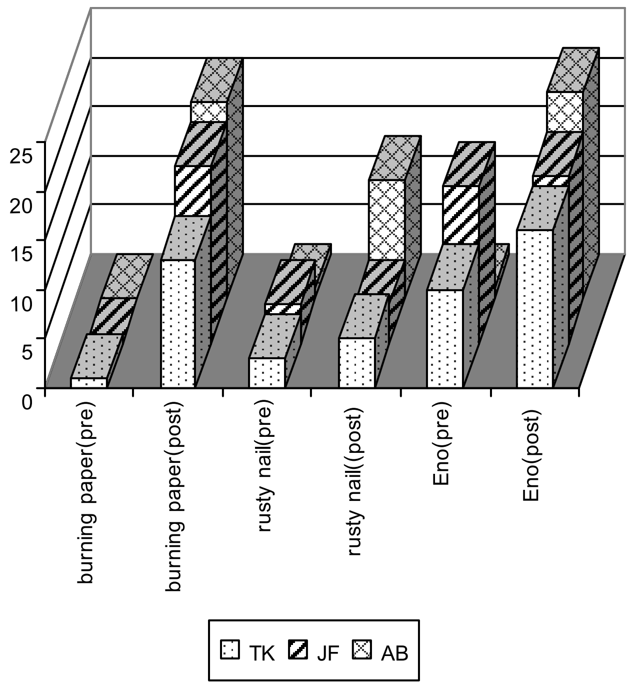


Figure 6.17 The Comparison of the Number of Pre-Post Students' Scientific Conceptions in Each School about the Chemical Reaction.

The last concept about the separation of mixture showed that most students could select an appropriate method for separation mixture. However, they could not give a reasonable reason based on the properties of substances in the mixture. Reasons like "The instrument is efficient" or "This method is easy" are found. The small number of students' use of scientific conception was also found in the concept of separation of the mixture. A small number of students from three schools in post-survey could use Category M1 (the correct concept) to explain this concept. Others had similar responses as those in the pre-survey in which they could not explain how to choose the separation method to correspond to the properties of substances in each mixture. The comparison between number of students who used scientific conceptions in pre and post surveys are presented in diagram below:

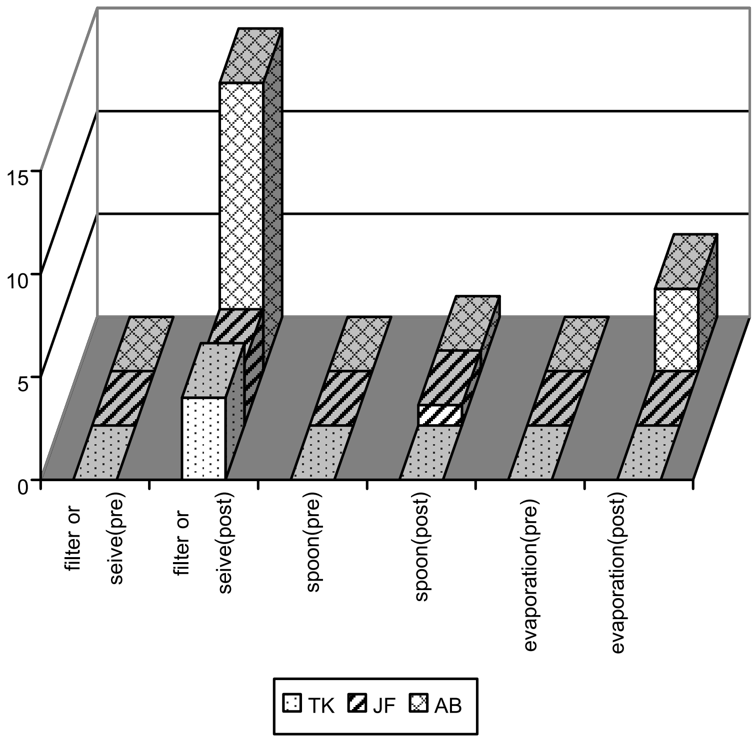


Figure 6.18 The Comparison of The Number of Pre-Post Students' Scientific Conceptions in Each School about the Separation of the Mixture.

Summary

The findings from this study demonstrate the impact of a conceptual change-based instructional unit on teaching and learning about matter. The activities encouraged the students to consider their own ideas and compare their alternative conceptions with scientific conceptions. Students were encouraged not only to accept the scientific conception but also to apply it to new situations. They were challenged to use scientific conceptions to explain everyday phenomena. The students' ability to apply their scientific knowledge to other concepts illustrated the use of metacognition as a tool for encouraging the transferability and durability of scientific conceptions (Georghiades, 2000).

An important finding arising from the use of the conceptual change-based instructional unit was its success in prompting the students to use a particle model to explain changes in matter. They could use a particle model to explain the changes of matter in all concepts, especially in the solution process in which they intentionally used the particle model to represent their mental model about a solution. This finding lends support to the explanation provided by Franco and Colinvaux (2001) about students who could create their own mental models via materials such as notebooks, diagrams or speech from interviews. Moreover, the particle model helped the students to be clearly aware of the limitation of their prior model and of extending their model towards a scientific conception viewpoint (Vosniadou and Ioannides, 1998; Vosniadou, 2003).

Another powerful point of this instructional unit is that it not only emphasizes students' cognitive development but also focuses on affective factors such students' motivational beliefs that are also involved the student conceptual change (Pintrich et al., 1993). A learning experience which interesting helped the students to enjoy themselves learning, it helped them expand their curiosity and prompted them to develop their understanding in scientific conceptions (Hodson, 1993).

According to the teachers' responses, the findings from this study show the positive effects of the instructional unit in preparing and encouraging the teachers to teach matter. The teachers accepted that the instructional unit helped them to understand more about teaching and learning for conceptual change and raised their confidence in teaching science.