THESIS

A CASE STUDY OF THE DEVELOPMENT OF CURRICULUM TO TEACH MATTER AT THE LOWER ELEMENTARY LEVEL USING CULTURALLY RELEVANT, INQUIRY-BASED APPROACH

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This educational ethnographic study aims to examine the use of students' funds of knowledge about toys and utensils as a basis for co-constructing an instructional unit about material concepts with science educators, scientist and experienced elementary science teachers. This study had four phases which included a) exploring students' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers, and d) evaluating the factors influencing the unit implementation. The grade 1-3 instructional unit drew on student informal experiences with toys and utensils, followed by negotiating the design of curriculum with the research team, and then ran pilot study was implemented by three elementary science teachers in academic year 2007. The data on how the unit was implemented by the three teachers were collected using data sources such as participant observations, teacher journals, teacher interviews, student interviews, and field notes.

The findings indicate that the development of inquiry based curriculum that drew on students' funds of knowledge about toys and utensils promoted students' understanding and application of concepts about materials, fostered students' self confidence and enhanced students' attention and involvement in learning activities. However, the success of the design and implementation of the inquiry/culturally relevant curriculum by each teacher was based on teachers' beliefs and understanding about inquiry and culturally relevant practice, level of content knowledge, ability in conducting scientific inquiry, teacher preparation, teachers' perception of students' ability, and students' abilities. It was found that teachers who believed and held understanding about these teaching approaches, had ability to conduct inquiry, strong content background, perceived on all ability students and showed good preparation in teaching tended to implement the curriculum effectively. Additionally, students' ability in conducting inquiry and using vocabulary affected implementation of the curriculum.

Akarat Sreethunyoo — Student's signature

Naruemon Yutakom — Thesis Advisor's signature

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CHAPTER I

INTRODUCTION

This chapter discusses key main topics, including the background, significance of the study, purposes of the study and research questions, methodology of the study, subjectivities/biases, and definition of salient terms. It started with wave of educational reform in Thailand. The significance of the study is then provided. This section includes the need for culturally relevant curriculum, the need for Inquiry-based teaching and the need for developing students' understanding of concepts related to matter. Next, the purposes of the study and research questions are displayed. The methodology framework and brief description of procedure of the study are also discussed. Finally, the subjectivities/ biases and the definition of salient terms are displayed.

Background of the Study

Education in Thailand has a long tradition leading up to current modern education for national development in accordance with the National Scheme of Education and the National Education Development Plan. During the traditional period, 1220-1868, education was offered in the temple at the King's palace and through the family unit. Performance and culture were taught by monks, non-formal learning experiences involving the development of agricultural and social skills occurred primarily in the context of family life, and princes and their relatives were taught by scholars in the palace (Ministry of Education [MOE], 2002; Office of the National Education Commission [ONEC], 1999). In order for Thai education to take into account social and economic changes, three educational reforms were implemented.

1. The First Wave of Educational Reform

The first wave of educational reform in Thailand, systematic schooling was initiated in the period of King Rama V in late 1887. The first school within the palace for young princes and nobles was constructed during this time period. Later, during the reign of King Rama VI, a compulsory primary education law was issued requiring every seven-year old child to receive free primary education until the age of 14 (ONEC, 1999). In 1960, the First National Education Development Plan (1961-1966) was promulgated to extend compulsory education from four to seven years. This plan strongly emphasized the development of vocational education, and the preparation of teachers (MOE, 2002). Economic and social development was still strongly emphasized under the second National Education Development Plan; however the number of youth entering education could not keep up with the market need. Subsequently, a new National Education Development Plan was created to place even stronger emphasis on economic and social development. This third National Education Development plan focused primarily on science and technology education (MOE, 2002)

An assessment of progress after the first wave of education reform revealed that organization was centralized by the government (Ketthat, 2002). Subsequently, students in rural areas, who were not adequately served by the centralized organization, experienced little change in their educational status (Ketthat, 2002). Many elementary students in rural areas were unable to read (Ketthat, 2002). Additionally, curriculum and content standards were not relevant with respect to changes in society, economics and politics. Therefore, a second wave of educational reform was implemented in the middle of 1974. The Thai education system following the second wave of reform is described below.

2. The Second Wave of Educational Reform

During the second wave of educational reform from the 1977-1998, the education development policies, with their emphasis on economy and society were changed by the Ministry of Education. Reforms which strongly emphasized on Thai context and culture were initiated to re-organize the national education system. The 1977 National Scheme of Education consisted of three new five-year educational development plans: the Fourth, the Fifth and the Sixth National Education Development Plans.

In the Fourth National Education Development Plan (1977-1982), educational policies were introduced to strengthen curricula and the learning process, (ONEC, 1999, MOE, 2002). Primary curriculum in Basic Education B.E. 2521 was implemented in 1978. The curriculum strongly centered on the learning of basic living skills. Primary school children were offered work–oriented education as a vehicle for gaining experience that would provide them with basic knowledge for career preparation. Moreover, there was also a focus on human development, particularly with respect to critical thinking, virtue and social responsibility.

During the implementation of the 5th National Education Development Plan (1982-1986), a period of rapid economic and social change, the organization of education strongly shifted to a focus on learning for the sake of earning a living, occupational practices and extended education (MOE, 2002). However, subject matter still focused primarily on cultural experiences. As part of the 6th National Education Development Plan (1987-1991), the primary curriculum in Basic Education B.E. 2521, was first implemented in primary school grade 1 in 1991, and went into full effect in all grades in 1996 (MOE, 2002). It was comprised of five learning experience groupings: basic skill group, life experiences, character development, work-oriented experiences, and special experience as shown below.

1) Basic Skills Group, comprising Thai language and mathematics as the subject learning tools.

2) Life Experiences, dealing with the process of solving social and daily life problems with an emphasis on scientific process skills for better living.

3) Character Development, dealing with activities necessary for developing desirable habits, values, attitudes and behavior, which will lead to a desirable character.

4) Work-Oriented Experiences, dealing with general practical work experiences and basic knowledge for career preparation.

5) Special Experience, dealing with activities based on learners' interests and provided for students in grades 5-6 only. The learning activities in the area of special experiences could be organized by each school according to learners' needs and interests and could include knowledge and skills selected from the other four groups, such as English for everyday life.

In this curriculum the integration of science and technology education was strongly encouraged. The concepts of science, healthy and society were integrated into the life experience subject. The life experience subject aimed at enabling learners to understand status and problems of humans and the environment through a focus on issues related to health, population, politics, administration, religion, and culture, as well as science and technology. The life experience subject was designed, for example, to help students understand and develop good health practices, recognize the relationship between humans and their environment, and develop an understanding of scientific concepts and science process skills. Moreover, problem-solving skills and the application of knowledge were also emphasized in the life experience subject. The foundational framework of the life experience subject in the primary curriculum covered five concepts including: 1) living things, including plants, animals, and relationship among humans, animals and plants, 2) family, 3) surrounding environment, including school, community, natural environment, and human environment, 4) Thai nation, including nationality, religion and King, and 5) news and current situations.

Later, the National Scheme of Education was implemented in 1992, followed by the introduction of the Seventh National Education Development Plan (1992-

1996). The education system, still in the second period of reform, was expected to move forward in its response to emerging needs and rapid changes in Thai society (ONEC, 1999). As part of this development plan, education was viewed as a process of enabling human beings to develop their quality of life, lead a peaceful social life, and make a proper contribution to national development in accordance with contextual changes of the nation. As such, the goals of education emphasized balanced and harmonious development of the individual in four aspects: wisdom, spiritual, physical and social. Moreover, science and technology continued to be strongly encouraged in education. The aim of science was to enable learners to understand basic scientific knowledge and invent and apply such knowledge appropriately. However, educational development after the implementation of the 7th National Education Development Plan changed slowly. One of the reasons for this was that educational management was still centralized with the government. The local and private areas had less responsibility in educational management and teachers and administers did not have opportunities to participate in such management; Thai education subsequently did not progress as much as desired (ONEC, 1997).

Furthermore, with the rapid changes of advanced technologies, especially information technology, education in Thailand was now required to play a more challenging and developmental role in preparing Thai people to cope with globalization movements (ONEC, 1999). The development of education under the Eighth National Education Development Plan (1997-2001) aimed to prepare the Thai people to cope with a rapidly changing world in the 21st century. This plan strongly emphasized the idea that the education system should facilitate the country's development process, with a focus on self-reliance, sustainability and enhanced global competitiveness. Changing the teaching–learning process was considered central to enabling students to develop their capacities for independent thinking and problem–solving.

3. The Third Wave of Educational Reform

The third wave of Educational Reform, which began in 1999, was implemented as a direct effect of the economic crisis in Thailand since 1997. The crisis exposed serious weaknesses in the nation's economy, including declining export competitiveness and the quality of the human resources required to advance the process of economic transformation. Education also experienced the effects of this crisis. The government, therefore, took several measures to mitigate the impact of the crisis on educational development. The National Education Act implemented in August 1999 is expected to bring about changes and new initiatives in the management of education. It will be used as the framework and guideline for educational development in Thailand, replacing the 1992 National Scheme of Education (ONEC, 1999). Thus, the first National Education Act was implemented in August 1999 to serve as the fundamental law for the administration and provision of education and training in accordance with provisions in the Constitution. The new initiatives and reforms outlined in the National Education Act 1999 and the implementation plan of the Act support a vision which states:

According to the National Education Act 1999, education aims at the full development of the Thai people in all aspects: physical and mental health, intellect, knowledge, morality, integrity, and a way of life in harmony with other people (p.5). All individuals will have equal rights and opportunities to receive basic education of quality and free of charge for at least 12 years; however, education will be compulsory for nine years from grade one to nine. Children aged seven are required to enroll in basic education institutions until the age of 16, except those who have already completed grade nine (p.10).

3.1 National Education Guidelines

The educational belief that all learners are capable of learning and self-development is regarded as the most fundamental principle of the National Education Act 1999. Therefore, the teaching-learning process should aim at enabling learners to develop themselves at their own pace and to the best of their potential. The educational emphasis is on developing knowledge about oneself and the relationship between oneself and society, religion, art, culture, sports, and Thai wisdom. It also focuses on the application of wisdom as well as knowledge and skills in pursuing one's career and the knowledge needed to lead a happy life. Finally, education centers on morality, the learning process and integration of such knowledge.

To organize the learning process to facilitate these goals, educational institutions are urged to develop effective processes which provide substance, and develop activities which draw from actual experience, in line with the learners' interest and aptitudes. They are also urged to strive for a balanced integration of subject matter, integrity, and values, enable instructors to create positive learning environments which draw on research to inform the learning process, and facilitate learning to occur at all times and in all places. In addition, educational institutions are urged to assess learners' performance through observation of their development, personal conduct, learning behavior, participation in activities and through results of tests. Instructors will also be encouraged to carry out research needed to inform the development of suitable learning environments and strategies.

3.2 Current Status of Curriculum in Science Education

The science curriculum was revised in 1999 because of some perceived limitations and weaknesses in the Curriculum B.E. 2521 (revised B.E. 2533). The formulation of curriculum by central authorities did not reflect or respond to the needs of educational institutions and provincial society (MOE, 2001). Curriculum and learning development in science and technology failed to build up leaders in these fields. Moreover, the application of curriculum failed to foster the foundations of critical thinking, create learning procedures in life skills and management, or enable learners to effectively tackle rapid changes in the social and economic areas (MOE, 2001). Therefore, a new school curriculum for 12–year basic education was designed by the Department of Curriculum and Instruction Development of the Ministry of Education (MOE). The new curriculum, which has been implemented since the year

2001, emphasizes student–centered learning and new teaching techniques designed to bring about major reforms in classrooms.

The foundational framework for the 12-year core curriculum covers these subjects: art, music and dance, foreign languages, mathematics, physical education, science, social studies, Thai language and literature, and vocational skills. Eight components were included as part of the science subject: living beings and life existence processes, life and environment, properties of matter, energy, evolution of earth, astronomy and space and nature of science and technology.

The curriculum framework for basic education was developed in accordance with the guidelines set forth in the National Education Act 1999. The central curriculum office in Bangkok was charged with setting the core curriculum for each subject. That core curriculum is flexible, and provides substance and learning standards for each group of subjects and for each grade level band covering three years (1–3, 4–6, 7–9 and 10–12). The provincial offices are responsible for preparing supplementary lessons reflecting issues important to each province.

Content standards, teaching time, teaching-learning activities, and assessment have been changed in accordance with the new science curriculum standards (The Institute for the Promotion of Teaching Science and Technology [IPST], 2002). The leader school project was developed as a model for teaching-learning organizations, especially at the primary level, where the quality of science education suffers from the fact that only 7.7 percent of teachers have graduated with a background in science (ONEC, 2001a). Teachers at the primary level lack a specialty in science and quality science learning materials (ONEC, 1999). Many teachers (estimated at nearly 20 percent), do not like teaching mathematics and science (ONEC, 2000a) and lack the ability to foster scientific thinking and skills (ONEC, 1999). They also lack subject matter knowledge and teaching strategies. In addition, research indicates that lecture is relied on as the primary means to teach science. Primary teachers rarely prepare science lesson plans. Additionally, assessment and follow up monitoring in the former professional development program rarely took place and contributed to the crisis in elementary education preparation. Accordingly, many professional development models, namely the National Teacher Project, Master Teacher Project, and Thai Wisdom Teachers, have been implemented by ONEC to enhance the quality of teachers and the teaching–learning process. The National Teacher Project and Master Teacher Project were implemented in 1998, while the Thai Wisdom Teachers project was developed in 2001 (ONEC, 1999, 2001b). Additionally, scholarships for studies at bachelor and master's degree level are now provided for in-service teachers (ONEC, 2003, 2004). However, as studies of the six-year curriculum implementation in Thailand indicate, teachers do not use locally constructed curricular resources. A report of a study conducted by the Office of the National Education Commission revealed that fifty percent of teachers were not ready to implement their own constructed curricula (ONEC, 2000a, 2003). The curricula typically used by teachers still originate from private publishing venues and is not relevant to communities or lifeworlds of teachers.

Significance for the Study

The significance for this study is based on three assumptions: the need for culturally relevant curriculum, the need for inquiry-based teaching, and the need for developing students' understanding of concepts related to matter.

1. The Need for Culturally Relevant Curriculum

Thai students' low achievement in science is no surprise. The educational quality assessment of 1997 and 1999 revealed that the average science score of Thai students was about 45.35 and 44.30 percent respectively. Moreover, the performance of Thai students in the Third International Mathematics and Science Study (TIMSS) was lower than those of many countries including Hong Kong, Singapore, and New Zealand (Pascal and Forgione, 2001). The average science score of Thailand's grade 3 students was ranked at 21 out of 24 countries and the achievement of grade 4 students was ranked 24 out of 26 countries; this was attributed to students' lack of application and problem solving skills (MOE, 2001; ONEC, 2001a).

One of the reasons attributed to the low achievement in application and problem solving skills was the perceived limitations and weaknesses of the formal curriculum, the Basic Education: B.E. 2521 (revised B.E. 2533). Foremost, the formulation of curriculum by central authorities did not respond to the needs of education institutions and provincial society (MOE, 2001). Moreover, students frequently reported that what they learned in school was not related to everyday life (ONEC, 1997). Thai wisdom and community knowledge are strongly emphasized in the current curriculum. Basic education institutions have responsibility for constructing their own curriculum in accordance with local community problems and wisdom (MOE, 2001; IPST, 2002). The local available materials are to be utilized as learning media (MOE, 2001). Moreover, parents, guardians and all parties in the community are encouraged to participate in the learning process to develop students to their fullest potential (ONEC, 2000c).

Similar to the Thai context, teacher education in other countries also focuses on the importance of drawing on several funds of knowledge, including the students' own knowledge, as well as parents' and community members' expert knowledge of agriculture, mining, economics, household management, materials, medicine, and religion (Moll, 1992; Gonzalez, *et al.*, 1995; Ladson-Billings, 1995a; Barton, 1998; Osborne and Barton, 1998; Fusco, 2001). However, curriculum implementation studies indicate that Thai teachers still have difficulties in constructing relevant curriculum (ONEC, 2000a). They are not ready to implement their own constructed curricula (ONEC, 2000a, 2003). The curricula typically used by teachers still originate from private publishing venues and is not relevant to communities. The development of curricula and teaching-learning processes with student-centered approaches and flexible central curricula that apply individually to school contexts and communities has been mentioned; however, challenges in constructing curricula based on student and local wisdom and knowledge still prevails. This study aims to develop a culturally relevant instructional unit that takes into account the school/community context and students' funds of knowledge.

2. The Need for Developing Students' Understanding of Concepts Related to Matter

Matter and its properties is one of the new science content standards in the current curriculum, organized in accordance with the emphasis on students, local knowledge, and nature of science and technology. In the former curriculum, elementary science concepts that were included in the life experience subject- the integration among science, health, and society-did not foster students' development of science conceptual understandings and process skills. Moreover, only concepts associated with energy and chemicals were included in the curriculum for grade five and six students. Basic chemical concepts, including matter, were not taught at the lower elementary level (grade1-3). In this former curriculum, matter was initially introduced at the higher elementary level (grade 5 and 6). Research conducted by Savakunanon (1992) found that grade one and three students, with no formal instruction about matter hold several misconceptions about related concepts. Students explained matter in terms of objects and their functions, findings similar to those of Stavy (1991). Students demonstrated little awareness of the properties of matter. Additionally, they did not consider gas as a form of matter. Similar research also suggests that elementary students have alternative conceptions about matter (Stavy and Stachel, 1995; Nakhleh and Samarapungavan, 1999; Johnson, 2000). Information of Education Department data indicates that students' achievement in science decreases as they continue from elementary to secondary schooling. These findings were the impetus for including matter and other fundamental chemical concepts in the elementary curriculum as part of new reforms.

To make rapid changes in science and technology as articulated in the National Education Development Plan, and to improve understanding and process skills in early education, science was emphasized and separated from life experience in the new curriculum (B.E. 2001). Matter and its properties, one science content standard, was considered to be the basic chemistry concept that should be initially taught in grade one (IPST, 2002). The standard aims for grade one to three learners to develop an understanding of material concepts, including the types, properties and changes in materials used to make toys and utensils. The concept of “materials” is now taught in grade one to three as a fundamental building block to further learning about matter, substance and chemical change (Johnson, 2000; IPST, 2002).

Many studies have been devoted to understanding elementary students’ alternative conceptions of materials, a concept of major importance in teaching and learning chemistry (Smith, Carey and Wiser, 1985; Dickinson, 1987; Jones and Lynch, 1989; Russell, Longden and McGuigan, 1991; Solomonidou and Stavridou, 1991; Johnson, 1996; Johnson, 2000; Schibeci and Hickey, 2000; Krnel and Glazar, 2003). In many of these studies, elementary students were rarely concerned about property and type when they were asked to classify materials. They normally used color, object identification, and prototype to group materials (Dickinson, 1987; Krnel and Glazar, 2003). Elementary students were able to explain which materials an airplane, plastic knife and nail were made of at the 70%, 50% and 30% levels, respectively. In addition to students’ alternative conceptions about materials, Kruger and Summers (1989) and Schibeci and Hickey (2000) found that elementary teachers held alternative conceptions about materials. In both of these studies, most primary teachers explained the concept as “material as raw materials that have been processed or used to make something. Primary teachers conveyed a sense of materials being used for a purpose, (e.g. wood and plastic are materials to build things) without discussing changes to materials in molecular terms.

To study the current situation in Thailand regarding the teaching and learning about matter, including the concept of materials (types, properties and changes when pressed, twisted, hammered, bent, pulled, heated and cooled, composition, configuration, states and properties, bonding, and separation of substances, A questionnaire for grade 1-3 science teachers was developed and administered by the researcher during the first semester of the academic year 2004 (Sreethunyoo, 2007). It was given to elementary science teachers in all schools of Education Area 1, Nonthaburi province the suburban area of Bangkok. The questionnaire asked about teachers' perceptions concerning their understanding of matter and related concepts and general problems in teaching science. The survey indicated that most teachers thought that they had moderate level of understanding of science concepts. The concept of "materials", one concept in this survey, was one which teachers perceived to be difficult for them. Moreover, the survey shed light on some general problems of science teaching and learning, including lack of upgraded equipment and media and the need for a better understanding of science content, teaching strategies and skills. Thus, the concept of materials, and particularly materials used in making toys and utensils, is a primary consideration in this study.

3. The Need for Inquiry-Based Science Teaching

Passive teaching is still a problem of science teaching in Thailand. Research suggests that students are passively listening to their respective teachers, and taking down notes from the board almost six hours a day in order to obtain information or messages conveyed by teachers with little engagement (Nomnian, 2002). In Thailand, the use of lecture and textbooks were traditional common means for teaching science because this type of instruction was orderly, well controlled, and easy to access (Pearce, 1999). However, research shows that listening to a teacher rather than participating in activities does not work for the majority of students. They are not able to gain knowledge through the processes as scientists do (ONEC, 1997). As an alternative to lecture and textbooks in teaching science, teacher demonstration is another common approach found in science classrooms. However, demonstration by teachers does not necessarily permit students to use their own styles of learning (Pearce, 1999). When demonstration is the predominant mode of instruction it is the teachers doing the science, not students (Lindberg, 1990).

In contrast to more traditional ways of teaching science, hands-on teaching, where students are provided opportunities to personally construct understandings by posing their own questions, designing and conducting investigations, and analyzing and communicating findings has been promoted; however, a hands-on approach is still different from the way children learn. Hands-on science is often “cookbook” in nature, with children following directions and using teacher selected materials for a particular activity (Pearce, 1999). Instead, students need active, hands on and minds-on experiences from which they can construct their own knowledge (Hiebert, *et al.*, 1996; Hebrank, 2000). Inquiry-based methods are advocated as an approach which provides concrete, active learning experiences and give students the opportunity to engage in problem-posing, problem solving, decision-making, and research skills needed to become life-long learners (Hebrank, 2000).

To move away from teaching science by lecture, textbook and teacher demonstration, the inquiry approach is being promoted in Thailand and in many countries such as the United States, United Kingdom, and Japan (ONEC, 2001a). The National Science Education Standards (National Research Council [NRC], 1996) suggest that science as inquiry can help students develop an understanding of scientific concepts, how we know and what we know in science, the nature of science, and skills such as problem solving, thinking and reasoning. In Thailand, the inquiry approach was promoted in science curriculum (B.E. 2533) as a form of student-centered activity that allows elementary students to create experiments, construct their own understandings and learn how to apply scientific processes in the construction of knowledge. However, research highlights several difficulties, similar to those found in Thailand involving the actual implementation of inquiry in the classroom (Hackett, 1998; Pearce, 1999). First, some studies note the difficulty in creating materials that in fact provide inquiry experiences for each student, too much time must be devoted to developing good inquiry materials (Edward, 1997). Second, studies suggest several factors that constrain the implementation of inquiry, including the difficulty in shifting teacher habits away from long time teaching styles, the discomfort of teacher and students, and the expense of materials needed to maintain an inquiry approach (Costenson and Lawson, 1986). Research also indicates that there are some misconceptions about inquiry, including the idea that inquiry simply means asking students a lot of questions, inquiry mean the teacher should know all of the answers, and inquiry is for high-achieving students and does not work with students who have learning disabilities (Hinsrichsen, Jarrett and Peixotto, 1999; Reed, Crocker and

Shaw, 2004). These researchers maintain that teachers should allow student thinking to drive lessons, encourage and accept student autonomy, and ask students to elaborate on their responses; however, in spite of many years of reform, classroom inquiry still holds a back seat to traditional teaching approaches (Hinsrichsen *et al*., 1999).

A number of studies indicate that inquiry-based instruction can be a highly effective instructional approach for fostering students' achievement in terms of thinking skills, reasoning ability and problem solving (Teeranurak, 2001; Toh-Tid, 2001), and understanding of scientific processes (Lindberg, 1990) which are currently challenging for Thai students . Additionally, research indicates that inquiry approaches can increase student involvement in the learning process (Bermstein, 2003). Particularly, several studies reveal effective inquiry-based teaching practices for elementary students (Fradd and Lee, 1999; Key and Kennedy, 1999; Crawford, 2000; Key and Bryan, 2001). Allowing students' questions to drive the lesson, fostering collaboration between students and teachers in inquiry classrooms (Key and Kennedy, 1999; Hill, Stremmel and Fu, 2005) is example of student learning through their own inquiry (Saul *et al*., 2005). Accordingly, an inquiry-teaching approach served as a conceptual framework in the design and implementation of an instructional unit focused on the concept of materials.

Purpose of the Study and Research Questions

The purpose of this study was to examine grade one to three students' funds of knowledge about toys and utensils as a basis for co-constructing with science educators, and experienced elementary science teachers an instructional unit about material concepts. The instructional unit built on and integrated Thai wisdom and students' and parents' funds of knowledge with respect to toys and utensils. In addition to studying the process of designing this unit, the study examined teacher implementation and students' experience. The study can serve as an example for science teachers and curriculum developers of how students' and parents' knowledge and local wisdom can be used in constructing relevant curriculum. What is learned about the process of developing curriculum from this culturally relevant approach may help science teachers better understand how to construct or develop other curriculum based on funds of knowledge and inquiry approaches. More specifically, the research questions for the study include the followings:

1. What informal learning experiences do elementary level 1 students have with toys and utensils and what science concepts have students developed by interacting with toys and utensils in informal learning contexts?

2. How can we draw on students' and parents' funds of knowledge to design an instructional unit on material concepts for elementary level 1 students?

- How can toys and utensils serve as an "Organizer" for students' explorations of material concepts?

- How can culturally relevant experiences be incorporated into the unit?
- How can inquiry be used to develop students' knowledge of science content and process skills with respect to material concepts?

3. What happens when teachers implement a unit on material concepts designed around students' funds of knowledge?

- What do students learn by participating in an instructional unit using toys and utensils?

- What constrains or facilitates the teaching of a unit that incorporates students' funds of knowledge and inquiry?

These research questions and the data that were collected to learn about them are depicted in the matrix that follows.

Table 1.1 Research Questions and Data Sources

Research Questions	Data Sources								
	Interview of students	**Interview of teachers**	**Interview of parents**	**Students ' drawing/ writing**	**Week-long parent logbook**	**Team planning meeting**	**Classroom observation**	**Teachers' journal**	**Researcher' journal/ field note**
1. What informal learning experiences do elementary level 1 students have with toys and utensils and what science concepts have students developed by interacting with toys and utensils in informal learning contexts?	X		X	X	X				X
2. How can we draw on students' and parents' funds of knowledge to design an instructional unit on material concepts for elementary level 1 students?						X			X
- How can toys and utensils serve as an "organizer" for students' explorations of matter?				X		X			X
- How can culturally relevant experiences be incorporated into the unit?	X		X		X	X			X
- How can inquiry be used to develop students' knowledge of science content and process skills?						X			X
3. What happens when teachers implement a unit on materials concepts designed around students' funds of knowledge?	X	X					X	X	X
- What do students learn by participating in an instructional unit on material concepts?	X	X					X		X
- What constrains or facilitates the teaching of a unit that incorporates students' funds of knowledge and inquiry?	X	X						X	X

Methodology of the Study

The methodology used to investigate the process of designing this unit, teacher implementation and students' experience was educational ethnography, an approach where the researcher is an instrument of data collection who gathers words or pictures, analyzes them inductively, and focuses on the meaning of participants, a process that is expressive and persuasive in language (Bogdan and Biklen, 1998; Cresswell, 1998). A qualitative methodology was selected for this study because of the nature of the research questions which often start with *how* and *what* in order to describe what is going on (Cresswell, 1998). In addition, Spradley (1980) emphasizes that ethnographic studies also ask "What is happening here?" This study aims to describe what happens when a culturally relevant/inquiry based instructional unit is designed, implemented and experienced by students. Similar to the aims of other qualitative methodologies, the presentation of a detailed view of individuals in natural settings is emphasized (Cresswell, 1998). Finally, the researchers' roles as active learners in a qualitative study can foster description from the participants' view rather than from the perspective of an expert who passes judgment on participants (Cresswell, 1998.).

Ethnography is a type of naturalistic inquiry, that makes use of non-interfering data collection techniques to describe the natural flow of events and actions (McMillan, 1989). Ethnographers' understanding is acquired by analyzing the many contexts of the participants and by narrating the stories of the participants. Ethnographers become immersed in the situation and the phenomenon studied. Ethnographic researchers assume interactive social roles in which they record observations and interactions with participants in a range of contexts. To obtain rich and descriptive information of what happens when a culturally relevant/ inquiry based instructional unit is designed, implemented, and experienced, common techniques of data gathering including interviewing, documentary analysis, life history, investigator diaries, and participant observation (Merriam, 1988; McMillan, 1989) were used.

This study has four phases which include a) exploring students' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers who were members of the research team, and d) evaluating the factors that constrain or facilitate the teaching of the unit that incorporates students' funds of knowledge and inquiry. After grade one, two and three students' informal learning experiences with toys and utensils are studied and analyzed, an instructional unit about types, properties, and change of materials used in making toys and utensils were initially designed by one of the science educators and then negotiated with the research team. The objectives, contents, learning activities and assessment approach were negotiated with other science educators, experienced elementary teachers, and three participant teachers who served as members of the research team. A scientist served as a de-briefer to provide feedback on the accuracy of the content. The preliminary instructional unit was modified by the key researcher and ran pilot study by the three participant teachers serving on the research team. The factors which constrain or facilitate the implementation of the unit emerged from two follow up meetings of research team members were served as a basis for unit modification. Teaching-learning activities during implementation were conducted for four weeks. Teachers' teaching and students' learning were observed during every regularly scheduled science time, two periods a week. Grade one to three teachers were interviewed about what and how students learn during the course of the unit. Additionally, nine students taught by these teachers were examined about their understanding of scientific concepts about materials. Throughout the implementation phase of the study the key researcher and three participant teachers kept journals to investigate the factors that facilitate or constrain unit instruction.

The primary sources were analyzed in this study. The primary data sources that were employed in this study included students' drawing activity, parent logbooks, student interviews, parent interviews, teacher interviews, classroom observations, research team planning meetings, and teachers and key researcher journals. Information from these sources were coded into patterns relative to the theoretical framework of curriculum development, constructivist learning theory and theories of culturally relevance. As recommenced by Miles and Huberman (1994), the data analysis for this study used these three steps: 1) data reduction, 2) data display, and 3) conclusion drawing and verification. Data reduction involves coding of data and the elucidation of themes present within the data. The related data were then displayed in an organized way which facilitates the formation of conclusions. The last step, conclusion drawing and verification, is the process of constructing meaning by making note of patterns present from the data.

Subjectivities/ Biases

Three main reasons contribute to my interest in developing, implementing, and studying the experience of inquiry/cultural relevant- based instruction related to materials, specifically toys and utensils. I am interested in this research topic because of my personal life experiences. One of my personal subjectivities stems from personal science learning experiences throughout my life. I am a student who learned science under Curriculum B.E. 2533 (1990), the former curriculum prior to the reform of 1999. The emphasis in teaching-learning organization in the curriculum at that time was inquiry. The textbook developed by the Institute for the Promotion of Teaching Science and Technology (IPST), was comprised of many inquiry activities and experiments. However, I had never experienced inquiry because my teachers used textbooks as cookbooks. The steps, necessary instruments and experimental results were presented through the book. I learned science concepts by reading and memorizing, in order to pass examinations until grade 12, the last school year. At that time, I never really understood the nature of science or scientific skills until I had my first experience in doing science at university level. I learned many scientific skills at that time; however, learning how to solve problems and apply knowledge to everyday life was still difficult for me. I studied for a Bachelors' degree in the field of chemistry. Although I had a deep understanding of how atoms interact with each other and form molecules, I had no idea how these concepts related to me. Therefore, my belief that it is important to construct curriculum that can relate to everyday life is one of my personal subjectivities in this study.

Another personal subjectivity I hold stems from my classroom observations. In academic year 2003, I had a chance to observe grade three students learning science at a famous private school which strongly emphasized inquiry based teaching. Throughout the three months of classroom observation, I found that the elementary science teacher in this school had an inaccurate understanding about inquiry. When I talked with her about the teaching style that she usually used, she described the inquiry teaching approach as a way of teaching whereby students figure out scientific concepts by themselves. However, the way she taught science only relied on students' reading and presentation. Students had no chance to pose questions, create activities or do experiments based on their interests. For example, in her unforgettable lesson about simple machines and how they relate to everyday life, she started the lesson by dividing the class into groups. She then distributed documents illustrating characteristics of lever, inclined plane, wheel and axle, screw, wedge, and pulley to each group, followed by students' reading and presenting in front of the classroom. No demonstration or examples of simple tools were introduced this time. I wondered how grade three students could imagine the force of those machines. It was difficult for students to explain how well the wheels on their bicycles work. This kind of teaching does not respond to students' needs, interests, and curiosity. It makes science appear to be difficult for young children. After I encountered this situation in this famous school, I began to wonder about other visions of what science teaching might be/like. Hence, I bring a bias toward inquiry approaches to this study.

Considering these subjectivities, I intended to develop a curriculum that model what inquiry and culturally relevant based teaching might be like. I hope to provide an example for science teachers and curriculum developers of how students' knowledge and local wisdom can be used in constructing relevant curriculum.

Definition of Salient Terms

In this section, I provide definitions of six terms that are integral to this study and used repeatedly throughout this dissertation.

Matter

In this study, the term matter referred specifically on the concepts of objects, kinds properties and changes in materials used in making toys and utensils that aligned with the 3rd strand: Matter and Properties of Matter for level one students.

Toy

In this study, the definition of toy that were used corresponds with Goldberg (1981) and Caney (1972)'s definition of playthings of children aimed at providing fun and developing and expanding a child's potential. Every day objects or household items that can become toys, for example, the cardboard cores from paper towels, straws, toothpicks, paper plates, string, sticks, clothespins, paper tubes, cups, shirt cardboard, and old magazines were included in this definition.

Utensil

In this study, the concept of "utensil" was defined in a way that contrasted with the definition of toy. Utensil is an instrument or tool that is use in a specific place such as office, kitchen, and school for a specific purpose such as cooking, cleaning, or wearing.

Inquiry Based Teaching

Based on the National Research Council's (2000) definition, inquiry based teaching in this study means a form of hands-on activity intended to get students involved in process such as observing, comparing, contrasting, and hypothesizing to develop scientific knowledge and understanding as well as skills. Children are provided in an environment that facilitates their experimentation, is purposefully designed to spark their curiosity, supports their question-asking and contains many resources to fuel their problem solving that facilitates theory building. Students have opportunities to ask simple questions about the natural world, plan investigations and collect relevant data, organize and analyze collected data, think critically and logically about relationships between evidence and explanation, use observational evidence and current scientific knowledge to construct and evaluate alternative explanations, and communicate investigations and explanations to others. Particular instructional method employed in this study is the 5-E Model of inquiry developed by the BSCS group (Biological Science Curriculum Study [BSCS], 1989), which includes five phases: a) Engagement, b) Exploration, c) Explanation, d) Elaboration, and e) Evaluation.

Culturally Relevant Teaching

According to Ladson-Billings (1995a) and Aikenhead (1996), cultural relevant teaching is a pedagogical practice of teachers who create classrooms that empower students to accept and affirm their cultural identity. Culturally relevant teachers incorporate aspects of students' cultural background into their instruction as a basis for helping them examine and critique social inequality and work for social change. In this study, drawing on Ladson-Billings' and Aikenhead's perspective, culturally relevant pedagogy meant the teaching that incorporates students' funds of knowledge into the science classroom and curriculum.

Curriculum

According to Joseph Schwab (1978), curriculum is described in terms of three aspects: the planned curriculum, translated curriculum and experienced curriculum. This conception of curriculum is important and relevant to the four phases of this study, including a) exploring students' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers who are members of the research team, and d) evaluating the factors that constrain or facilitate the teaching of a unit that incorporates students' funds of knowledge and inquiry. The planned curriculum in this study corresponds with the development of a culturally relevant/ inquiry-based instructional unit. The translated curriculum corresponds with the implementation phase, and centers on the way in which teachers actually enact the curriculum. Finally, the experienced curriculum was used to describe students' learning in the last phase of the study.

Instructional Unit

Instructional unit means a plan of teaching consisting of objectives, participant learning outcomes, concepts, learning activities, assessment and materials.

Preview of the Study

This chapter I present an overview of the study. It initially provides an overview of historical perspectives on waves of educational reform in Thailand. The need for culturally relevant curriculum, the need for developing students' understanding of concepts related to materials, and need for inquiry-based science teaching are described in the rationale of the study. The purpose and specific research questions guiding the study are introduced. The theoretical framework and methodological framework which ground the study are briefly described. The set of personal biases are also presented and discussed. Moreover, the salient terms for this educational ethnographic study are defined.

Chapter II highlights the literature relevant to the theoretical framework of the study. Four important theories, including curriculum theory, culturally relevant practice, constructivist learning theory and inquiry-based teaching are reviewed in this chapter. The basic tenets of different curriculum theories are reviewed with an emphasis on explicating a view of curriculum most appropriate to this study. The historical context, definitions and research on culturally relevant curriculum served as an important theoretical referent for this study. The basic tenets of constructivist learning theory are reviewed, along with studies that focus on the application of this theory to practice in science education. Finally, the key elements of inquiry based teaching that draw specially on 5-E model of learning were reviewed to serve as a basis for this study.

Chapter III presents the research methodology of the study through an in-depth discussion of the methodological framework, method of the study, context of the study, participants, procedures, and data collection and analysis. Ethnographic case study used as the methodological basis for this study was described. Two groups of participants, including the research team and nine students and their parents were described. The four phases of this study which include a) exploring students' and parents' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers who were members of the research team, and d) evaluating the factors that constrain or facilitate the teaching of a unit that incorporates students' funds of knowledge and inquiry were also provided. Moreover, the common techniques of data gathering including students' drawings, parent logbooks, interviews of parents, interviews of students, research team planning meetings, participant observation, interviews of teachers, researcher and participant journals were described. The three steps of the data analysis process, including data reduction, display, and conclusion described by Miles and Huberman (1994) were provided.

Chapter IV provide the description of the development of curriculum which draws upon the funds of knowledge found in grade 1-3 students' households. This chapter consists of two major sections: a) the description of students' informal experiences with toys and utensils identified as important funds of knowledge and b) the connection and integration of students' experiences into science curriculum. The first section starts with a description of students' and parents' background, followed by experiences in kinds and materials used in making toys and utensils, and then students' and parents' funds of knowledge, including students' science concepts and alternative concepts. Community funds of knowledge in terms of local products and religious rite are also discussed. The process in the developing of inquiry-based science curriculum about material concepts draw upon students' funds of knowledge and pilot study are reviewed. Finally, the contents and activities of each lesson are displayed.

Chapter V discusses the implementation of an inquiry based curriculum on matter for grade one to three which drew on students' funds of knowledge. A description of how the three teachers implemented the unit, how students participated in the learning activities and factors that constrained or facilitated the teaching of the unit is provided. The curriculum implementation is discussed separately with respect to each teacher. After individual implementation is presented, a cross case analysis of factors that constrained and facilitated the implementation of curriculum incorporating culturally relevant and inquiry-based approaches is provided.

Chapter VI leads to a summary and discussion of how inquiry based curriculum draw on students' funds of knowledge for grade one, two and three students about matter was designed and implemented. The chapter starts with the descriptions of the purpose of the study, research questions and methodology. The conclusion about the development of the inquiry based curriculum which drew on students' funds of knowledge is described. The discussion about the development of inquiry based curriculum which drew on students' funds of knowledge and the implementation of curriculum by three teachers was also provided. Moreover, the challenges in the effective implementation of the curriculum and the recommendation of this study are then discussed.

CHAPTER II

REVIEW OF LITERATURE

The purpose of the study is to examine grade one to three students' funds of knowledge about toys and utensils as a basis for co-constructing with science educators, and experienced elementary science teachers an instructional unit about material concepts. The review of literature in this study consists of four major sections: a) a critique of different curriculum theories, b) a review of studies related to culturally relevant curriculum, c) an explanation of constructivist learning theory and relevant studies in science education, and d) inquiry based teaching The historical context, definitions and research on culturally relevant curriculum served as an important theoretical referent for this study. The basic tenets of constructivist learning theory and inquiry based teaching are reviewed, along with studies that focus on the application of this theory to practice in science education. Finally, the basic tenets of different curriculum theories are reviewed with an emphasis on explicating a view of curriculum most appropriate to this study.

Curriculum Theory

1. Ways of Defining the Term Curriculum

A number of definitions of curriculum have been used by various people at different times over the past 60 years. Initially, the term curriculum was widely used by specialists in two ways to mean: 1) body of subjects, or 2) experiences. During the early years of the twentieth century, the term curriculum was used to mean the body of subjects or subject matters set out by teachers for students to learn. In 1936, the idea that curriculum should include grammar, reading, rhetoric, logic, mathematics, and the study of the western world was set forth by Robert M. Hutchins (1936). On the other hand, since 1940, researchers have termed curriculum as all learning experiences that are fundamental for all learners placed under the direction of the school (Giles, McCurchen and Zechiel, 1942). As described by Tyler (1949), learning takes place through the experiences the learner has; the "learning experience" is not the same as the content with which a course deals. In short, according to Tyler (1949), the curriculum consists of all of the learning of students which is planned by and directed by the school to attain its educational goals.

During the range from the late 1950's to the decade of the 1980s, the definition of curriculum changed from one of content of courses of study and lists of subjects and courses to one consisting of all the experiences which are offered to learners under direction of the school, and eventually to the notion that curriculum was a mode of reflective thinking experience, guided learning experience, guided living, instructional plan, and technological system of production (Tanner and Tanner, 1980; Smith and Lovat, 1991; Longstreet and Shane, 1993). In 1950, Krug *et al.*, for instance, used the term curriculum to describe all learning experiences set up in school for the purpose of disciplining children and youth in group ways of thinking and acting. Frankin Bobbitt (1918) in "The Curriculum" defined curriculum as a series of experiences which children and youth must have. Similarly, the five bodies of experiences necessary to consider for curriculum were described by Schwab (1973) as follows:

1. Subject matter refers to knowledge of curriculum materials, the discipline of study and its underlying system of thought.

2. Knowledge of learners involves familiarity with the children who will be learning the subject matter. Such knowledge includes awareness of their developmental abilities, what aspirations and anxieties may affect learning, the unique qualities of the children, and understanding about their probable "future economic status and function" (p.503).

3. The milieus refer to the school and classroom- for example, the social structure in those environments. Schwab also wants to know what the influences upon the classroom and school are; he asks, what are the conditions, dominant

preoccupations, and cultural climate of the whole polity and its social classes, insofar as they may affect the careers, the probable fate, and ego identify of the children whom we want to teach.

4. Knowledge about teachers means what "these teachers are likely to know and how flexible and ready they are likely to be to learn new materials and new ways of teaching as well as their possible biases, political stances, personalities, and prevailing moods.

5. Body of experiences is knowledge of the curriculum-making process.

Eisner and Valance (1974) developed a typology involving five different ways of conceptualizing curricula. In the first way, a cognitive-developmental perspective, the focus of the curriculum is on the use of educational practices that lead to greater cognitive activity such as making inferences or problem solving-content. Second, in a technological perspective, curriculum as technology is concerned with processes in education; however, instead of focusing on cognitive development, this curriculum type is oriented around developing instructional practices that lead to successful knowledge transfer. In the third way, self-actualization perspective, curriculum is focused on the holistic development of individuals and their relations with the world. According to Eisner and Valance, proponents of this type of curriculum hope curricular experiences provide an opportunity for students to become autonomous, aware of themselves, and to continually grow. A social reconstruction view of curriculum, the fourth perspective, focuses on the relation of education as a way of maintaining, or changing, the existing society. Finally, the fifth type of curriculum that Eisner and Valance described is known as academic rationalism. Participants in this variety of curriculum value the important products of thinking that the disciplines have produced. The goal of academic rationalism is to give students what they need to know about great thinking that has taken place in different fields.

In the early 1990s, conceptions of the term curriculum were widely used in three different ways: 1) curriculum as a plan, 2) curriculum system, and 3) field of study. First, curriculum as a plan was intended to be used by teachers as a point of departure for developing teaching strategies to be used with specific classroom groups of pupils, including objectives, activities, instructional materials, and time schedules (Beauchamp, 1981). Similarly, Cohen and Harrison (1982) used the term curriculum to explain the planned areas of learning and growth for an individual or a group of learners focused upon an educational centre, incorporating a set of objectives, a set of learning experiences, suggestions for their organization and techniques for evaluation of learning outcomes. The second use of the word curriculum refers to the idea of a curriculum system. A curriculum system is that part of the organized framework of a school or a school system within which all curriculum decisions are made (Beauchamp, 1981). Moreover, Beauchamp further explained that curriculum systems consist of the personnel organization and the organized procedures needed to produce a curriculum, to implement it, to appraise it, and to modify it in light of experience. Finally, the most popular use of the word curriculum is a synonym for a field of study or a course of professional study for colleges and universities students in planning, teaching and learning in an educational institution (Beauchamp, 1981; Giroux, Penna, and Pinar, 1981; Tyler, 1981; Zais, 1981). For example, Giroux *et al.* (1981) utilized the term curriculum as the course of study designed for student instruction under the direction of the school. Content and skills may be included in the course of study.

However, some researchers in this era still employed the term curriculum to refer to all the experiences that students actually have under the auspices of the school (Zais, 1981; Longstreet and Shane, 1993). In this sense, curriculum included all the means employed by the school to provide students with opportunities for desirable learning experiences (Longstreet and Shane, 1993). Furthermore, Longstreet and Shane (1993) described curriculum as the results of instruction, and did not take into account the means, that is, the activities, materials, or even the instructional content to be used in achieving the results. However, Macdonald posited a conception of curriculum that was broader than Johnson containing, in addition to intended learning outcomes, other ingredients, such as content and learning activities.

2. Rethinking of Curriculum in Education Research

In the last two decades, conceptions of curriculum stand in stark contrast with the prior ideas that referred to product conceptions of curriculum or viewed curriculum as document, plan or course of study. More recently, conceptions of curriculum have concentrated on social processes. In Grundy's account of "curriculum as praxis" (1987), the curriculum is not just a collection of materials that students work through; rather, it can be thought of as a cultural product that arises through social interactions. The curriculum of a society's schools is an integral part of the culture of that society. To understand the meaning of any set of curriculum practices, they must be seen as arising both out of a set of historical circumstances and as being a reflection of a particular social milieu. This means that it is not the teacher's shelf where ones look for the curriculum, but in the actions of people engaged in education. In a similar approach to conceptualizing curriculum, Cornbleth (1990) conceived the term to be what actually occurs in the school classroom, that is, an ongoing social process comprised of the interactions of students, teachers, knowledge, and milieu; however, Cornbleth's conception differs from Grundy because Cornbleth concentrated more on contextual and sociocultural aspects of education. Cornbleth suggests that curriculum is best conceptualized as a social activity that takes place within a particular structural and sociocultural context. The failure of curriculum-as-managerial-product to enhance learning provided her impetus for thinking about other ways curriculum might be conceived.

In addition, Beyer and Apple's (1998) conception of curriculum has centered on process. They address the definition of curriculum in their book "The curriculum: Problems, politics, and possibilities. (2^{nd} ed.), noting that,

We are referring here to the transformation of curriculum theory and practice from a concern about what should be taught and why we should teach it to those problems associated with how to organize, build and above all now, evaluate curriculum and teaching. The difficult ethical and political questions of content, of what knowledge is of most worth, have been pushed to the background in our attempts to define oriented methods that will "solve" our problems once and for all (Beyer and Apple, 1998.)

In recent years, curriculum has been depicted as various discourses (Pinar *et al.*, 1995; Joseph, 2000). As proposed by Pinar *et al.*, (1995), curriculum consists of a multitude of discourses including historical, political, radical, gender, poststructuralist /deconstructed/ postmodern, autobiographical-biographical, aesthetic, theological, and institutional ways of thinking. Each discourse has its own premises and foci; each creates a particular "reality" of phenomena. Each discourse contains particular language, patterns of thoughts, and norms about what is appropriate and valuable. Curriculum as text illustrates the continual dialogue of culture-the conversations and themes that are important to people who "live" in the culture or who portray it. Similarly, Joseph (2000) defined curriculum as enveloping patterns of norms, endeavors, and values which are particularly lacking in these times, both within public discourse and in schools. Conceiving curriculum as text or discourse compels us to listen to and make sense of the words, phrases, and patterns of language that characterize curriculum and to be aware of how this language itself shapes the construct. Moreover, Joseph conceptualized curriculum as the way that culture educates us to pay attention to belief systems, values, behaviors, language, artistic expression, the environment in which education takes place, power relationships, and most importantly, the norms that affect our sense about what is right or appropriate.

Finally, Wardekker (2004) stated that the curriculum is something to do with the planning of learning and its results, on different levels of society, including state, school, teacher and student level. Curriculum is often expressed as laws and rules at a state level; however, as the general plan of lesson at school level. However, there are common notions of goals, of means of reaching those goals, and qualities of the situation in which learning is going to take place, among which are probably most important the properties in the various definitions addressed.

3. Conceptions of Curriculum in Thailand

Not surprisingly, there have been different ways of viewing the notion of curriculum in Thailand over the past two decades. The major conception of curriculum in the 1990s referred to the idea of a written document and set of experiences. Phetchuen (1987) used the term curriculum to describe a written document depicting the philosophy, principles, goals, contents and practice in organizing learning activities, assessment and evaluation, as well as directions for using guidelines. Additionally, Prididilok (1989) referred to curriculum as a document consisting of proposed objectives, contents, experiences for school pupils and learning and assessment processes. In contrast, Chaichirachayakun (1986) used curriculum to describe all inside and outside experiences which are offered to learners under the auspices or direction of the school. Other authors in the late 1980's and early 1990's described curriculum as a program, plan and course of study. Sathon (1980) described curriculum as a program to prepare children and youth to reach their potential in social activities appropriate for the society. In addition, Bausri (1989) used the term curriculum to describe a plan depicting objectives, subject matter, activities and series of experiences in an educational program designed to develop students in all aspects in order to accomplish intended outcomes. Uthanan (1989) referred to the term curriculum as a course of study consisting of ordered subject matter, and planned learning experiences constructed by society in order to provide students opportunities to participate in, perceive and respond to school direction.

Since the last decade, conceptions of curriculum as a written document are still used in the Thai context. Curriculum is often viewed as an elaborate document designed to guide education at different levels, including inside and outside school experiences and activities which assist students in developing knowledge, skills and attitudes needed to live in harmony with other people (Lekroengsin, 1997). However, the conception of curriculum has moved forward to include descriptions of the educational system, and learning outcomes. Kitpridaborisut (1990) employed the term curriculum to describe the important parts of educational system that strongly effect the quality of students' learning (Kijpridaborisut, 1990). Similarly, Wonganutrot

(1992) referred to curriculum as an educational system concerned with input (e.g. teacher, student, materials, place), process (e.g. organizing teaching activities), and output (e.g. achievement and academic success). Wonganutrot (1992) also referred to curriculum in terms of subject matter and plans aimed at helping students to accomplish intended outcomes. Additionally, Suwannachot (2001) implied a different meaning of curriculum to include: all experiences provided to students, a course of study or subject matter, all activities which are offered to learners, the reactions among teacher, students and classroom environment, and the intended learning outcomes as guidelines for human development.

In conclusion, the term curriculum has been used in several different ways in educational literature. The conception of curriculum was initially utilized to mean the content of courses and experiences provided for learners in the classroom. Basically, the three different perspectives of curriculum, a plan, curriculum system and field of study were used in the early 1990s. In recent times, the conception of curriculum has concentrated on social processes, rather than product. Joseph Schwab (1978) described curriculum in terms of three aspects: the planned curriculum, translated curriculum and experienced curriculum. This conception of curriculum is important and relevant to four phases of this study, including a) exploring students' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers who are members of the research team, and d) evaluating the factors that constrain or facilitate the teaching of a unit that incorporates students' funds of knowledge and inquiry. The planned curriculum in this study corresponds with the development of a culturally relevant/ inquiry-based instructional unit. The translated curriculum corresponds with the implementation phase, and centers on the way in which teachers actually enact the curriculum. Finally, the experienced curriculum was used to describe students' learning in the last phase of the study.

Culturally Relevant Curriculum

1. History and Definition of Culturally Relevance

Since the last two decades, a variety of terms have been developed to describe the kind of teaching that incorporates students' culture into instruction in order to promote academic success of diverse student populations. Terms such as culturally appropriate, culturally congruent, culturally responsive, culturally compatible, cultural synchronis and culturally relevant have been commonly used to characterize pedagogies which aim to connect students' lifeworlds outside the classroom with their educational experiences. Au and Jordan (1981) coined the term "**culturally appropriate"** to describe the pedagogy of teachers in Hawaiian schools who incorporated aspects of students' cultural background into their reading instruction. Mohatt and Erickson (1981) use the term "**culturally congruent**", whereas Cazden and Leggett (1981) and Erickson and Mohatt (1982) used the term "**culturally responsive** to describe the instruction of teachers who used language interaction patterns that approximated the students' home culture. Moreover, Gay (2000) employed the term culturally responsive to describe teaching that uses the cultural knowledge, prior experiences, and performance styles of diverse students to make learning more appropriate and effective for them. Vogt, Jordan and Tharp (1987) coined the term "**culturally compatible**" for their work at the Kamehameha Elementary Education Program (KEEP) to explain that successful educational practices must be compatible with the culture of children being education. In this work, the idea of cultural compatibility is used as a guide in the selection of elements for educational programs that foster academically desirable behaviors and avoid undesirable behaviors (Jordan, 1985). Moreover, Irvine (1990) developed the concept of "**cultural synchronization**" to describe teachers' acceptance of students communication patterns, along with a constellation of African-American cultural mores such as mutuality, reciprocity, spirituality deference, and responsibility. In the early 1990s, Ladson-Billings (1990a,b, 1991, 1992a,b) used the term " **culturally relevan**t" to describe the kind of teaching that uses culture as the basis for helping students understand themselves and others, structure social interactions and conceptualize knowledge. She defined this type of instruction as a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes (Ladson-Billing, 1994). Ladson-Billings (1995a) further explained that cultural relevance as a theoretical model not only addresses achievement but also helps students to accept and affirm their cultural identify while developing critical perspectives that challenge inequities of schooling. Instruction that incorporates interactional patterns, instructional methods, and social contexts for learning that are culturally compatible with students' primary cultures is also viewed as culturally relevant (Jone, Pang and Rodriguez, 2001).

2. Culturally Relevant Pedagogy/ Curriculum in Education

The theory of culturally relevant pedagogy is originally described in the work of Ladson-Billings (1990a). Ladson-Billings, in 1998, investigated eight teachers in a small predominantly African-American, low income elementary school district in North California. Nine outstanding teachers who demonstrated excellence in teaching, including being accorded respect by others teachers, demonstrating enthusiasm toward school and academic tasks, fostering positive student attitudes, exhibiting excellence in classroom management skills, and facilitating student achievement were selected by parents and principals. Eight of them were interviewed about background, philosophy of teaching, and ideas about curriculum. Moreover, their teaching was observed and video-recorded. Analysis and interpretation of their own teaching, and one another's video tapes was conducted.

Three common aspects of culturally relevant pedagogy used by these teachers were identified: conceptions of self and others, conceptions of classroom social relations, and conceptions of knowledge. In the category of conceptions of self and others, the teachers believed that all students were capable of academic success, saw their pedagogy as unpredictable and always in the process of becoming, saw themselves as members of a community, saw teaching as a way to give back to the community and believed in a Freirean notion of "teaching as mining" or pulling knowledge out. These culturally relevant teachers managed social relations by maintaining student-teacher relationships, demonstrating a connectedness with all of the students, developing a community of learners, and encouraging students to learn collaboratively and be responsible for one another. Finally, the conceptions of knowledge held by these teachers was one in which knowledge was viewed as dynamic, shared, recycled and constructed. Knowledge was also viewed critically with teachers being passionate about knowledge and learning, emphasizing scaffolding or building bridges, and using multifaceted assessments. Additionally, these teachers demonstrated culturally relevant teaching by ensuring that students whose educational, economic, social, political and cultural futures were most tenuous were selected to become the leaders of the classroom, apprenticing students into a learning community rather than teaching isolated and unrelated skills, and creating opportunities for students to participate in a broad conception of literacy that emphasized experiences where, teachers and students together were engaged in a collective struggle against the status quo. Many of the characteristics of these culturally relevant teachers were ones emphasized in later research of Ladson-Billings (1991) as well.

Based on assumptions of culturally relevant pedagogy developed by Ladson-Billings, there have been many efforts to develop culturally relevant curriculum focusing on students' cultural background, learning styles, interactional and social patterns, common knowledge, and the community needs (Scherer, 1991-1992; Haukoos, 1992; Marines and Ortiz de Montellano, 1993; Banks, 1994; Barba, 1995; Ismat, 1995; Davison and Miller, 1998; Callanan, Alba-Speyer and Tenenbaum, 2000; Jone *et al.*, 2001; Menchaca, 2001; Lutz, 2002). Many of these studies emphasize the idea that students' experiences can be used for bridging the gap between home and school (Erickson and Mohatt, 1982). Marines and Ortiz de Montellano (1993), Banks (1994), Barba (1995), and Menchaca (2001) suggest that when the curriculum is culturally relevant in terms of real life experiences, students can connect new knowledge with prior experience, thus empowering them to build on their personal background knowledge. Ladson-Billings (1995) studied three examples of culturally relevant teachers who utilized songs, artists or craftspersons-in-residence and students' home language as a vehicle for learning. The first teacher, Patricia Hiliard, had her second grade students bring in samples of lyrics to learn about literal and figurative meanings as well as technical aspects of poetry such as rhyme scheme, alliteration and onomatopoeiam. Gertrude Winston, the second teacher in this study, invited students' parents into her classroom to be experts in art in order to have students learn from each other's parents and affirm cultural knowledge. Such knowledge included carpentry, professional basketball, nursing, and music. A third teacher, Ann Lewis, encouraged six grade students to use both their home language and English in the classroom in order to develop proficiency in both.

Some of these studies highlighted characteristics of culturally relevant curriculum based on the assumption that children learn best in a culturally relevant context. Churchman (1975) suggests that culturally relevant curriculum should rely specifically on materials and activities related to the cultures, lifestyle and symbols of students. Moreover, there are several common characteristics of effective culturally responsive/relevant curricula that cut across numerous studies (Ismat, 1995). Culturally responsive/relevant curriculum is integrated and interdisciplinary (Spears, Oliver and Maes, 1990; Chisholm *et al.*, 1991; Scherer, 1991-1992). Culturally responsive/relevant curriculum is authentic, child-centered, and connected to the child's real life (Ismat, 1995). It employs materials from the child's culture and history to illustrate principles and concepts (Martinez and Ortiz de Montellano, 1988; Chisholm *et al.*, 1991; Dickerson, 1993; Chion-Kenney, 1994). Culturally responsive/relevant curriculum develops critical thinking skills (Ismat, 1995), often incorporates strategies that utilize cooperative learning and whole language instruction, and recognizes multiple intelligences and diverse learning styles (Association for the Advancement of Health Education, 1994). Finally, effective culturally responsive/relevant curriculum is supported by appropriate staff development and pre-service preparation. In this regard, culturally responsive/relevant curriculum should be a part of a coordinated, building-wide strategy. Successful implementation of culturally responsive/relevant curriculum requires a receptive school climate and recognition that the hidden curriculum in any school can be a powerful ally or a powerful enemy.

Additionally, Craviotto and Heras (1999) suggest the following characteristics as important in making the curriculum and the classroom culturally relevant to students:

- Families are actively sought as resources for knowledge
- Multicultural literature is used as a resource for understanding perspectives.
- Students are regarded as active knowledge generators.
- Classroom dialogue is a fundamental aspect of classroom discourse.
- Classrooms are framed as an inviting space for exploration, learning, and dialogue among peers, students, and adults.
- Several languages are used in the classroom as resources for communication and learning (p. 27).

3. Culturally Relevant Curriculum and Research in Education

Studies in a variety of fields, including language and art (Scherer, 1991-1992), social studies (Jone *et al.*, 2001; Hanley, 2002) and mathematics (Moll, 1992; Gonzalez *et al.*, 1995; Tate, 1995; Gutstein, 1997; Barta *et al.*, 2001; Matthews, 2003), have employed culturally relevant curriculum as a framework to enhance educational success. In a study conducted by Scherer (1991-1992), African- American content was used to develop integrated curriculum for teaching elementary students in reading. Similarly, social studies teachers used students' cultural and historical examples as a starting point for children to be able to gain a deeper understanding of the context of history (Jone *et al.*, 2001). Another example from social studies addressed the parallel struggles of South Africa and the United States, with the content and instructional methods placing the African Diaspora experience at the center of learning. To tap into the thinking of students, a poem by Langston Hughes was read and his poetry was used as a basis for discussing his contributions to U.S. culture (Hanley, 2002). In the mathematics field, Moll (1992) developed a learning unit based on community funds of knowledge about construction. To expand such knowledge, she invited parents and other members who worked for the school district, to describe their use of construction instruments and tools, and how they used mathematics in their work to estimate or measure the area or perimeter of a location.

4. Culturally Relevant Curriculum and Research in Science Education

Research on developing culturally relevant curriculum has been found not only in the fields of language arts, social studies, and mathematics but also in science (Martinez and Ortiz, 1988; Marines, 1993; Banks, 1994; Barba, 1995; Nelson-Barber, 1995; Aikenhead, 1996; Zwick and Miller, 1996; Davison and Miller, 1998; Callanan *et al.*, 2000; Fusco, 2001; Hammond, 2001; Menchaca, 2001; Kimmerer, 2002; Chinn, 2003). The majority of these studies use students' familiar culture as a starting point and tool for helping students develop a deeper understanding of the history of science and related concepts. In many of these studies, the emphasis was on helping students connect new knowledge to their own personal background knowledge (Banks, 1994; Barba, 1995). As Ovando (1992) has pointed out "All children bring with them to school a base for scientific knowledge, skills, and experiences and this base can be related to the school's curriculum" (p. 223).

In a study conducted by Zwick and Miller (1996), for instance, teachers, administrators, community resource people and college personnel with various sources of knowledge, worked together to develop a science curriculum that was activity-based, integrated with other disciplines in science, educationally sound, and centered on process and critical thinking skills culturally acceptable to American Indian students. The activities were developed particularly to teach science using students' direct experience with the natural surroundings and/or hands-on approaches that incorporated American Indian culture. The district teachers and administrators represented the various disciplines of sciences, mathematics, language arts, art and the social sciences. The community resource people' background included a range of careers such as electricians, soil scientists, engineers, and agricultural experts. The college personnel represented the areas of hard sciences, science education, educational psychology and educational research. The two classes selected for the study were divided into experimental and control groups. The experimental class utilized the new activity-based program, while the control class utilized the textbook based program that had been in place for several years.

The results indicated that the experimental curriculum composed of the outdoor,"hands-on", group oriented activities contributed more toward development of student cognition than did the more traditional textbook-based curriculum with few or no activities. The students in the experimental class had greater gains in the CAT 85 science scores than did the students in the control class. Moreover, using ethnomathematics and ethnoscience activities from students' communities, teachers were able to help students see common conceptual underpinnings between everyday life and school mathematics-or to see where the mathematics and the science of school diverge from their own everyday conceptions. Similarly, other authors concluded that culturally relevant materials in science should be based on the culture and history of students to illustrate scientific principles and the methodology of science in the school's science curriculum (Martinez and Ortiz de Montellano, 1988).

5. Culturally Relevant Curriculum and Research in Elementary Science Education

Particular at the elementary level, there are several studies in science education that have focused on the development of culturally relevant curriculum. The majority of these studies are descriptive in nature, providing narrative accounts of attempts to develop culturally relevant curriculum. For example, in a study conducted by Haukoos *et al.* (1995), the integration of science with culturally relevant materials and activities from American Indian culture at the elementary level was investigated. In their study, training activities emphasized relevant cultural problems and materials of local interest in educating children about problem solving and inquiry processes of science. The science training portion was followed by a curriculum development phase where cooperative groups of participants constructed conceptual thematic unit plans which brought science and native culture together for students. The findings of this study revealed that institute activities were successful in persuading participants to change their understanding of how science and native culture could be integrated through relevant hands-on activities. Participants were persuaded to move away from teaching science using lecture-discussion and memorization strategies, and move toward students' inquiry and exploration activities using hands-on materials.

In another study, Callanan *et al*. (2000) conducted research aimed to assess the benefits of students' questions as a basis for designing a curriculum to fit the needs of particular children. The development of the curriculum was informed by four components of 1) observation of parents, children, and teachers engaging in Family Science workshops focused on garden-based activities, 2) telephone conversations with parents, asking them to report any questions, comments or activities that their children had initiated at home after the workshop, 3) brainstorming" sessions with the teachers, reporting to them about the children's questions and discussing ways that the children's ideas could be incorporated into the next workshop, and 4) observing the activities of the children, teachers, and parents in the teachers' second workshop. The findings revealed that students' spontaneous questions could be used as a source of information about how children develop scientific concepts. Moreover, the authors suggested that links between home conversation and classroom practices could be beneficial to children. Additionally, the findings suggested that home-school activities such as Family Science Workshop could be extremely positive experiences for parents, teachers, and children alike.

6. Discourses of Relevance in Science Education: A Focus on Students' Funds of Knowledge

Some of the various discourses that have been used to promote "culturally relevant" pedagogies in science education include: crossing culture borders (Aikenhead, 1996), drawing on funds of knowledge (Hammond, 2001; Chinn, 2003), creating a practicing culture of science teaching (Fusco, 2001), and thinking critically about knowledge and the world. This study draws primarily on the community funds of knowledge as a theoretical referent. Funds of knowledge refers to those historically developed and accumulated strategies (skills, abilities, ideas, practices) or bodies of knowledge and information that households use to survive, to get ahead, or to thrive (Moll, 1992; Gonzalez *et al*., 1995). The emphasis is on various sources of funds of knowledge, including students' own knowledge, as well as parents' and community members' expert knowledge of agriculture, mining, economics, household management, materials, medicine, religion and other familiar topics (Moll, 1992; Gonzalez, *et al*., 1995; Ladson-Billings, 1995a; Barton, 1998; Osborne and Barton, 1998; Fusco, 2001).

Many studies have focused on or tapped into students' households as the basis for developing classroom activities that are more comprehensive, realistic and contextualized (Moll, 1992; Garcia, 1993; Gonzalez *et al*, 1995, Gonzalez, 1996; Gonzalez and Moll, 2002). The case study of Moll (1992) and Gonzalez *et al.* (1995), for example, focused on studying the implications of students' funds of knowledge for the classroom.

In the first component of their study, teachers conducted household visits to identify and document knowledge that existed in students' home. Using interviews and fieldnotes, household information was gained from 30 families about different soils, cultivation of plants, seeding, and water distribution and management. Moll found that many families in this study knew about carpentry, masonry, electrical wiring, fencing, and building codes. Some families employed folk remedies, herbal cures, midwifery, and intricate first aid procedures. And family members with more formal schooling had knowledge about archaeology, biology and mathematics. Moll argues that these families and their funds of knowledge represent a potential major social and intellectual resource for schools.

The second component of their study was the use of after-school settings created to enhance the collaboration between teachers and researchers, to discuss research findings, and to plan, develop and support innovations in instruction. Finally, a third component of the study featured classroom observation to examine existing methods of instruction and implement innovations based on the household of funds of knowledge identified and conceptualized at the after school sites. There were many positive outcomes of this study. The emergence of teachers as qualitative researchers was clearly one by-product. A second involved increased access to the school felt by parents.

A third was the changed relationships between teachers and the students whose households were visited. A fourth, and for the purpose of this study, a significant goal, was the emergence of curriculum units based on the household funds of knowledge. Teachers were able to sift through the household resources and found multiple elements that could be used as the basis for math, science, language arts or integrated units. For example, teachers formed mathematical units based on construction knowledge, ecology units based on ethnobotanical knowledge of the home, a unit on sound and properties based on music, and a comparative history of clothing, including topics such as inquiry into absorbency of fabrics.

The findings of this study were similar to other studies conducted by Bett (2000) and Gonzalez *et al.* (1995). In addition to documenting households' funds of knowledge, Gonzalez and Moll (2002) further studied how household members used their funds of knowledge in dealing with changing, and often difficult, social and economic circumstances. Their study emphasized how families develop networks that interconnect them with their social environments and how these social relationships facilitate the development and exchange of resources, including knowledge, skills, labor and basic cultural values.

Additionally, students' funds of knowledge have been employed as a source for developing culturally relevant science curriculum in studies conducted by Hammond (2001), Chinn (2003) and Upadhyay (2006). The development of culturally relevant science curriculum drew on community funds of knowledge in a study conducted by Chinn (2003). Chin emphasized that cultural dialogue and knowledge of students' lifeworlds were important precursors to using Native Hawaiian knowledge as a centerpiece for creating a relevant curriculum. In another example, Hammond's (2001) school community garden project and field house was designed to empower Iu Mienh immigrant families with respect to science education by bridging their "funds of knowledge" into the science curriculum. Likewise, Calabrese Barton (1998) and Osborn and Barton (1998) used students' experience with pollution in their drinking water as a starting point for science teaching.

In another key study of culturally relevant curriculum focused on students' funds of knowledge, Upadhyay (2006) conducted a case study to examine how a fourth grade teacher (Jane) who participated in the Linking Food and the Environment (LiFE) program used students' experiences to create authentic learning in the classroom. The research questions included in this study were a) What does Jane's life story tell us about her views on teaching, her experiences, and science teaching that is relevant to students and their lived experiences?, b) What student experiences does Jane identify as important funds of knowledge in teaching the LiFE curriculum?, and c) How does Jane connect student experiences to her own and integrate them into her science teaching? The LiFE curriculum was designed to facilitate science learning by providing: (a) active hands-on activities, (b) critical thinking and conceptual learning opportunities, (c) opportunities for students to share personal experiences as a part of the science-learning process through questioning and discussions, and (d) parents as partners in science learning. Students' experiences with the kinds of food they ate at home, the harvesting of crops in their backyard, or at their grandparents' home in foreign countries were integrated into the LiFE lessons during the curriculum development process. The implementation of the LiFE curriculum was co-conducted by researchers (curriculum developers), teachers, parents, and school administrators. Parents were involved in the LiFE curriculum during the implementation and participated in six workshops to learn and engage in all the activities of the LiFE curriculum. Some of the parents who participated in the workshops also volunteered to help teachers in the science classrooms. Most parents participated in the group discussions by sharing their lived experiences and the knowledge that they gained from the LiFE workshops. In addition, school curriculum specialists were also invited to participate in the workshops. The results of this case study are consistent with the finding of Gonzalez and Moll (2002) and Moll *et al.* (1992) who maintain that students can retain conceptual understandings of science, when their funds of knowledge and everyday life experiences are included in the curriculum.

In summary, this study drew specifically on funds of knowledge, including students' own knowledge, well as parents' knowledge as a theoretical referent to design learning activities in the early childhood science curriculum in response to the emphasis on relevancy in the Thai National Education Act. In addition emphasizing students' understanding of scientific and technological knowledge and skills, the National Education Act emphasizes the development of knowledge about oneself and the relationship between oneself and society, namely; family, community, nation, and world community. Basic education institutions in Thailand have responsibility for constructing their own curriculum in accordance with local community problems and wisdom (MOE, 2001; IPST, 2002) in order to promote connections between what students learn in school to everyday life. The local available materials are to be utilized as learning media (MOE, 2001). Moreover, parents, guardians and all parties in the community are encouraged to participate in the learning process to develop students to their fullest potential (ONEC, 2000c). Thus, the school/community context and students' funds of knowledge are going to be important in developing a culturally relevant instructional unit in this study. According to Davison and Miller (1998), culturally relevant curriculum is supported by the theory of constructivism, which stresses the importance of prior experiences in learning. Constructivism is premised on the belief that learners actively create, interpret, and reorganize knowledge in individual ways that reflect the cultural and social contexts in which ideas occur (Windschitl, 1999). The notion of culturally relevant science curriculum is integrally connected to constructivist learning theory, which also served as a theoretical referent for this study.

Constructivist Leaning Theory

1. Defining the Term Constructivism

The term constructivism has been discussed and debated by researchers in different ways. Lorsbach and Tobin (1992) and Brooks and Brooks (1993) view constructivism as an epistemology, a theory of knowledge used to explain how people construct knowledge or understand the world through experiencing things and reflecting on those experiences. von Glaserfeld (1993) refers to constructivism as a theory of knowing. Some researchers argue that constructivism is a philosophy of learning founded on the premise that we construct our own understanding of the world we live in (Saunders, 1992; Brooks and Brooks, 1993). Other researchers such as Fosnot (1996) consider constructivism to represent a method of teaching whereby the teacher frames what happens on beliefs that are consistent with constructivism. Tobin and Tippins (1993) suggest that constructivism is a set of beliefs about knowing and knowledge that can be used as both a referent to analyze the learning potential of any situation and method of teaching. Moreover, a large number of researchers define constructivism as a theory of learning that has roots in both philosophy and psychology (Fostner,1996).

There are several varieties of constructivism proposed by educators or philosophers (see for instance Good, Wandersee and Julien, 1993; Solomon, 1994; Geelan, 1997; Nola, 1997). Fifteen adjectives such as contextual, dialectical, empirical, humanistic, information-processing, methodological, moderate, Piagetian, postepistemological, pragmatic, radical, rational, realist, social, and socio-historical have been used to describe the range of implied meanings for constructivism in education (Good *et al.*, 1993). For example, the word contextual refers to part of a written or spoken statement that surrounds a word or passage and that often specifies its meaning or the circumstances in which a particular event occurs. In contrast, the word dialectical refers to the art or practice of arriving at the truth by disclosing the contradictions in an opponent's argument and overwhelming them (Good *et al.*, 1993). Solomon (1994) summarized three different aspects of constructivism. First, Solomon discussed constructivism as a "theory of personal constructs". Second, Solomon (1994) discussed constructivism as an attempt to examine and respond to the particular phenomenon of children's ideas in science. Finally, Driver *et al.* (1994) and Solomon (1993) emphasized the "Social" aspect of constructivism in describing a constructivist framework for science education. Adding to the complexity of the discussion, Geeland (1997) summarized six different types of constructivism as personal constructivism (Kelly, 1995), radical constructivism (von Glasersfeld, 1993) social constructivism (Solomon, 1987), social constructivism (Gergan, 1995), critical constructivism (Taylor, 1994) and contextual constructivism (Cobern, 1993).

Matthews (1998) conceptualized constructivism in terms of three varieties: educational constructivism, philosophical constructivism, and sociological constructivism. He divided educational constructivism into personal and social constructivism. Educational constructivism of the personal variety stresses the individual creation of knowledge and construction of concepts. This stream has its origins in Piaget's Kantian –inspired theories of cognitive development, of which Ernst von Glassersfeld's work is perhaps the best known representative (Matthews, 1998). Educational constructivism of the social variety stresses the importance of the group for the development and validation of ideas. This has its origins in Vygotsky's work in linguistics and language acquisition.

Although many forms of constructivism are described in the literature, there are three forms which are most widely discussed in educational research: radical, social, and contextual constructivism. Radical constructivism originated with George Kelly (1995) with the idea that individuals construct knowledge for themselves through construing the repetition of events, and that knowledge is individual and adaptive rather than objective. Conceptual change pedagogy (Driver and Easley, 1978; Driver and Oldham, 1986; Pines and West, 1986) lies within the personal constructivist paradigm. Moreover, Ernst von Glasersfeld (1989, 1993) describes radical constructivism based on two principles. First, knowledge is not passively received but actively built up by the cognizing subject. In other words, knowledge is not transferred directly from the teacher into the learner, but has to be actively constructed within the individual mind. The second principle of radical constructivism is that the function of cognition is adaptive and serves to organize the experiential world, not the discovery of ontological reality. According to the radical constructivist perspective of Von Glasersfeld (1993), scientific ideas and theories not only result from the attempts of individuals but also through communication and interaction similar to the ways scientists construct scientific knowledge. Social constructivism, the second form of constructivism, is based on the idea that knowledge does not arise or reside solely within cognizing individuals or within the natural world, but within societies-that the consensus processes of language-use and meaning-making are social in character. Gergan (1995) suggests that meaning is achieved through social interdependence, and that meaning in language is context dependent, and primarily serves communal functions. Finally, contextual constructivism, conceptualized by Solomon (1987) and Cobern (1993) implies that the construction of new knowledge takes place in a context. Solomon's (1987) particular interest in context is social interaction; however, Cobern (1993) argues that social interactions do not form all of the context of human cognition; culture is a central force in the development and organization of student ideas. The culture that influences the construction of meaning includes race, language, economic and education levels, occupation, geographic location, gender, religion, and philosophy (Cobern, 1993). Similarly, Finkelstein (2001) stated the idea that "context is central to student learning, not as an analytically separate factor, not as the backdrop to student learning, but as an integral part of the learning process" (p.2). In short, based on principles of *contextual constructivism*, students build an understanding of content *in* context and that context mediates student understanding of content. It is not possible to separate student learning from the context in which it occurs; context is not a backdrop for student learning. Rather, context shapes student learning and is in turn shaped by both the content and student (Finkelsten, 2001).

2. Basic Tenets of Constructivism

Over the past decade practitioners in a variety of fields have embraced constructivism as a theoretical framework on which to base some of their ideas. Not surprisingly, different basic tenets of the theory appeal to diverse practitioners such as Wheatly (1991), Brooks and Brooks (1993) and Good *et al.* (1993). These basic tenets provide the foundation for fundamental principles of teaching and learning; however, these tenets may be emphasized differently depending on the type of constructivism. Wheatly (1991) suggests two principles of learning as central to constructivist theory. The first principle emphasizes the idea that learners construct their own understanding rather than passively receiving information from teachers.

The second principle is that the function of cognition is adaptive and serves the organization of the experiential world, not the ontological reality. Brooks and Brooks (1993) elaborate further on the basic principles of constructivism, emphasizing that learning is a search for meaning. Accordingly, they suggest that the starting point of learning should be the issues around which students are actively trying to construct meaning. Secondly, they point out that meaning requires an understanding of the whole as well as parts. Thirdly, they emphasize the importance of understanding the mental models that students use to perceive the world and the assumptions they make to support those models.

In addition, Ernest (1996) and Brooks and Brooks (1999) offer five guiding principles of constructivism that can be applied to the classroom. The first principle emphasizes the importance of posing problems of emerging relevance to students. According to these researchers, a focus on students' interests and their previous knowledge as a departure point helps them engage and become motivated to learn. The relevant questions posed to the students will force them to ponder and question their thoughts and conceptions. Another guiding principle of constructivism put forth by Ernest and Brooks and Brooks centers on the idea that learning should be structured around primary concepts. They emphasize the importance of building lessons around main ideas or concepts, instead of exposing students to segmented and disjointed topics that may or may not relate to each other. "The use of broad concepts invites each student to participate irrespective of individual styles, temperaments, and dispositions" (p.58). Their third principle emphasizes the need to seek and value students' points of view. This principle allows for access to students' reasoning and thinking processes, which in turn allows teachers to further challenge students in order to make learning meaningful.

To accomplish this, however, Ernest and Brooks and Brooks point out that the teacher must be willing to listen to students, and to provide opportunities for this to occur. Adapting curriculum to address students' suppositions is the fourth principle according to Ernest and Brooks and Brooks. "The adaptation of curricular tasks to address student suppositions is a function of the cognitive demands implicit in specific tasks (the curriculum) and the nature of the questions posed by the students engaged in these tasks (the suppositions)" (p.72). Their final principle centers on the assessment of student learning in the context of teaching. This refers to the traditional disconnect between the contexts/settings of learning versus that of assessment. According to Ernest and Brooks and Brooks, authentic assessment is best achieved in the context of teaching through interactions between both teacher and student, student and student, and observations of students engaged in meaningful tasks.

Matthews (1994) describes the five steps or phases of constructivist teaching introduced by Driver and Oldham. The first step involves orientation, where pupils are given the opportunity to develop a sense of purpose and motivation for learning. In the second phase, elicitation, pupils make their current ideas on the topic of the lesson clear. The third step refers to restructuring of ideas; this is the heart of the constructivist lesson sequence. It consists of a number of steps, including: a) clarification and exchange of ideas during which pupils' meanings and language may be sharpened by contrast with other and possibly conflicting, points of view held by students or contributed by the teacher, b) construction of new ideas in light of the above discussions and demonstrations, c) evaluation of the new ideas either experimentally or by thinking through their implications. The final phase is application of ideas, where pupils are given the opportunity to use their developed ideas in a variety of situations, both familiar and novel. Moreover, Saunders (1992) suggests four instructional features which stem directly from this constructivist perspective, including hands-on, investigative labs, active cognitive involvement, group work, and higher-level assessment.

In addition to principles of constructivist learning, general features of constructivist teachers and classroom environment are viewed as important in encouraging students to restructure their ideas. For example, Brooks and Brooks (1993) suggest several important characteristics of constructivist teachers. According to these authors, teachers using constructivist principles encourage and accept student autonomy and initiative, use outside resources and materials such as additional books, videotapes, and computer programs, do not rely solely on a textbook to enhance learning, allow student response to drive lessons, inquire about students' understandings of concepts before sharing their own understanding of those concepts, encourage students to engage in dialogue both with teacher and with each other; encourage inquiry by asking thoughtful, open-ended questions, encourage students to ask questions of each other, seek elaboration of students' initial responses, engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion, allow for wait time after posing questions, provide time for students to construct relationships and create metaphors and nurture students' natural curiosity through frequent use of the learning cycle model.

Although several tenets of constructivist learning theory have been discussed, there are other basic tenets of constructivism that provide a foundation for the principles of teaching, learning, and knowing as described by this epistemology. These tenets may be emphasized differently depending on the type of constructivism. However, in general, these tenets can be summarized. The first major tenet of constructivist theory is "meaning is constructed by the cognitive apparatus of the learner (Resnick, 1983). In this sense, meaning is created in the mind of the student as a result of the student's sensory interaction with her or his world. The second important tenet is schema or mental constructions have been created at great cognitive expense, i.e. the construction of meaning is a psychologically active process which requires the expenditure of mental effort. The third tenet of constructivist theory emphasizes the idea that cognitive structures are sometimes highly resistant to change, even in the face of observational evidence and/or formal classroom instruction to the contrary (Champagne *et al.*, 1980; Linn, 1983; McDermott, 1984).

3. Constructivism and Research on Alternative Conceptions

In the past two decades, the idea of constructivism has become popular in science education to explore what science schemata learners possess. Consequently, researchers have investigated contradictions between students' existing ideas and scientific conceptions. In numerous studies, researchers use various terms, such as misconceptions, preconceptions, alternative conceptions (Viennot, 1979) and alternative frameworks (Driver and Easley, 1978) to indicate how students' ideas differ from those of current scientists. Haidar (1997) use a concept scheme to describe students' level of understanding as appears below.

Complete understanding (CU), the student's response closely approximates the abstract, theoretical explanation found in a science textbook.

Partial understanding (PU), the student's response contains part, but not all, of the information necessary to convey a complete understanding. No incorrect information occurs in the response.

Partial understanding with specific misconception (PS). The student's response contains correct information, but also indicates a misconception concerning some aspect of the concept.

Specific misconception (SM). The student's response indicates a complete misconception of the concept.

No understanding (N). The student's response consists of " I don't know", a request for the question to be repeated, irrelevant remarks, or the page is left blank.

Studies indicate that alternative conceptions are commonly found in elementary, high school and college students, as well as adults among learning various domains in science, especially in physical science. There are many studies which investigate students' misconceptions in physical science, including the concept of energy (Watts, 1983; Solomon, 1985; Goldring and Osborne, 1994), diffusion (Markek, Cowan and Cavallo, 1994), electrical circuits (Shipstone, 1988), and phase changes (Tsai, 1999).

In research conducted in secondary education, Jimoyiannis and Komis (2003), for instance, conducted a survey to investigate secondary students' ideas about forces involved in objects moving under the sole influence of gravity. The results of their study indicated that the majority of the students exhibited the idea that "the original force is continuously exerted to the ball during its motion." Multivariate analysis was used to identify three discernible groups of students which exhibited a persistent and rather consistent approach: (1) an extended group of students having the above misconception, (2) a second group of students which, generally, responded correctly to the tasks, and (3) a third group of students, which ignored the presence of the gravitational force and/or believed that the action-reaction forces were both exerted to the ball during its motion. Moreover, a number of studies were conducted to examine students' understandings about conservation of matter (Andersson, 1984; Driver *et al.*, 1984; Gomez, Pozo and Sanz, 1995; Barker and Millar, 1999; Ozmen and Ayas, 2003), chemical change (Abraham *et al.*, 1992), states of matter (Haidar and Abraham, 1991; Abraham *et al.*, 1992; Lee *et al.*, 1993; Gomez *et al.*, 1995; Nakhleh and Samarapungavan, 1999), molecules (Griffiths and Preston, 1992), and other related concepts. For example, Driver *et al.* (1984) conducted a study to access secondary students' understandings of conservation of matter in a closed system. The majority of students held the alternative idea that the total mass would increase or decrease depending on whether the precipitate produced was solid, liquid or gas. In Driver's study and another study conducted by Anderson (1984), water was placed in a sealed flask and then heated by the sun. Students were told that the phosphorus catches on fire producing a white smoke which dissolves in water. They were asked to state whether the final mass would be the same, greater, or less than the starting mass. Both research studies reported that about one-third of the students gave a conservation type answer, suggesting that the mass would not change "because the flask is sealed". A further 16% thought the mass would decrease, and only 6% thought the mass would increase. The same question was used in a study conducted by Barker and Millar (1999) to probe students' ideas about conservation in a closed system of chemical reactions. It was found that some of the students who participated in the study had misconceptions, suggesting that mass would decrease or that mass would increase. Moreover, Gomez *et al.* (1995) and Ozmen and Ayas (2003) found that secondary students believed that the total mass would increase in a precipitation reaction because the precipitate produced is solid and it is heavier than a liquid.

In another example of secondary students' alternative conceptions about matter, Abraham *et al.* (1992) investigated students' understanding of chemical change based on the idea that chemical change is a transformation resulting in the formation of a new substance. They found that eighth grade students could not differentiate between chemical and physical changes. For example, when they were asked to identify whether a phenomena was a physical or chemical change, they showed understanding of a chemical change but provided an explanation based on physical change (e.g. shape and form). Moreover, some students responded to this same question with the explanation of physical change because no chemicals were involved. In addition, others studies have found that students have misconceptions about all aspects of molecules including structure, composition, size, shape, weight and bonding. The findings of Griffiths and Preston (1992) indicate that grade twelve students thought that water molecules in the solid phase are the smallest, and differ in weight from those in the liquid phase, and that in the gas phase, water molecules were not all composed of the same atoms. Chantanapitan (1997) also found that grade 11 Thai students had misconceptions about the size of molecules.

3.1 Elementary Students' Alternative Conceptions in Matter

Many studies suggest that elementary students have alternative conceptions about matter (Stavy, 1991; Abraham *et al.*, 1992; Au *et al.*, 1993; Lee *et al.*, 1993). For example, Stavy (1991) investigated the development of students' conceptions of matter by asking students (grade1, 3, 5, 7) to explain their understanding of matter and to classify items as matter and nonmatter. The materials for classification includes items such as (a) solid-rigid solids (iron cube, piece of wood, ice cube); non-rigid solids (cotton wools and metal spring); powders (sugar, flour, potassium per manganate, soil) (b) liquids (mercury, milk, water); (c) biological materials (flower, human body, meat); and (d) gas (air). The non-material items were: (a) phenomena directly associated with matter (fire, electricity, wind, smell); and (b) other nonmatter (light, heat, and shadow). The results indicated that grade 1-3 students refer to matter by means of example (such as plasticene, clay, glue, cleaning materials, building materials, sugar, wood, and iron) and function and structure. By contrast, grade 5-7 students explained their understanding of matter by means of properties divided into three subgroups (a) specific properties such as hardness, tangibility, color, etc., (b) state of matter such as solid, powder, and (c) properties of weight and/or volume. In addition to the meaning of matter, the findings regarding classification of matter/nonmatter indicated that students did not consider everyday substances such as soil, ice, water, and biological material as matter.

In another example, Au *et al.* (1993) studied children from 3 to 7 years of age concerning their beliefs about matter. Students in this study indicated that tiny invisible particles exist in an aqueous solution and properties of the solution such as taste or portability may be affected by these particles. Au *et al.* investigated whether the children (ages 3-7) understood that matter continues to exist even after dissolving and becoming essentially invisible. Au *et al.* found that the children believed that sugar was still present after dissolving, even though invisible, and that certain properties of the sugar solution such as taste and heaviness were due to the invisible sugar. Some students thought that sand did not dissolve because it was denser, thicker, harder or rougher. Moreover, when children were directly asked to explain what they thought matter was, they tended to explain by giving typical examples or by describing visual characteristics (color, visible, invisible), shape (pointy, square, round), composition (made of wood), texture (smooth, rough, dry) and function, rather than defining the properties themselves (Stavy and Stachel, 1995; Nakhleh and Samarapungavan, 1999).

Specifically, several studies have been devoted to understanding elementary students' alternative conceptions of materials, a concept of major importance in teaching and learning physical science (Smith, Carey and Wiser, 1985; Dickinson, 1987; Jones and Lynch, 1989; Russell, Longden and McGuigan, 1991; Solomonidou and Stavridou, 1991; Johnson, 1996; Johnson, 2000; Schibeci and Hickey, 2000; Krnel, and Glazar, 2003). In many of these studies, elementary students were rarely concerned about property and type when they were asked to classify materials. Dickinson (1987), for instance, interviewed to assess children's understanding of objects and materials. In this study, Dickinson used two differently colored examples of plastic, wood and metal. The results indicated that the children were unclear about material identities and often focused on color and object identities. Students responded by talking about parts of objects (seat, chain) rather than by mentioning materials. The results also indicated that elementary students were able to explain which materials an airplane, plastic knife and nail were made of at the 70%, 50% and 30% levels, respectively. Similarly, Russell *et al.* (1991) studied primary students' conceptions about materials. The results of their study revealed that children initially learned the names of objects and raw materials based on a material' s function, what can be considered as the material property of common use.

3.2 Teaching Strategies for Alternative Conception

The "misconceptions" often interfere with learning because students resist change unless they are dissatisfied with their current explanations and can find sensible alternatives with supporting evidence (Schulte, 1996). Numerous studies have concluded that students' alternative conceptions are persistent and resistant to change by traditional instructional strategies (e.g. Gunstone, 1987). Therefore, for students to change their alternative conceptions, they should encounter some conceptual revolutions. Posner *et al.* (1982) constructed a model of conceptual change which articulates the process by which people's central, organizing concepts change from one set of concepts to another set that is incompatible with the first. The authors propose the following conditions as necessary for conceptual change: there must be dissatisfaction with existing conceptions; a new conception must be intelligible; a new conception must appear initially plausible; and a new conception should have the potential to be extended. For example, through a quasi-experimental research design, a study was conducted to examine the effects of using a concept map as an instructional tool to facilitate eighth graders' conceptual change about simple series electric circuits (Tsai, 2000). The findings illustrated how the concept maps could help students overcome alternative conceptions about simple series electric circuits and help them construct greater, richer and more integrated ideational networks about electric circuits.

Different strategies have been utilized to explain levels of students' understanding. Perkins (1992) and Chinn and Brewer (1993) are among many authors who suggest that if students ignore or reject the ideas presented by science teachers, their conceptual understanding will be "undisturbed and then retained as naïve knowledge". If learners try to exclude scientific conceptions from their alternative conceptions, they may acquire a set of conceptual frameworks that are only applicable for school science and retain another set of theories to explain real life phenomena. These authors further explain that if students protect their alternative conceptions by reinterpreting or even distorting scientific theories, scientific ideas are used to reinforce their preconceptions. This mixed outcome stems from students' attempt to reconcile two seemingly incompatible theories; therefore, they may make some peripheral changes to the original theories. These strategies could also be related to Vosniadou's (1991) three levels of understanding. At the first level of understanding, pupils simply memorize the scientific concepts. Students at the second level try to resolve two contradictory ideas by incorporating their preconceptions and scientific models. A third level of understanding of the scientific concepts is achieved when these ideas are being used in a generative way.

In order to resolve students' alternative conceptions, a number of studies have incorporated different teaching strategies to encourage the construction of new concepts. The following are some of the strategies that have been used by Driver and Leach (1993): eliciting the extent of students' prior conceptions; differentiating a confusing conception; building experiential bridges to a new conception; unpacking a conceptual problem; importing a different model or analogy; progressively shaping a conception; constructing an alternative conception that acknowledges students' prior ideas and, helping students to see the limitations and problems with their current conceptions.

In teaching physical science for young children, Kammii and DeVries (1993) suggest that instead of teaching scientific concepts, principles, or explanations children should be provided with opportunities to act on objects and see how objects react, as these experiences will build a foundation for physics and chemistry.

Moreover, they also suggest appropriate criteria for developing physics activities for young children; that is, activities should foster students' ability to produce movement by their own action and vary their action through immediate and observable reactions. Such immediate action includes rolling, pushing, blowing, tilting, throwing, balancing and swinging objects such as balls, cubes, beanbags, tubing, dowels, pulleys, hooks, blocks, planks, boxes and containers of all shapes and sizes (Marxen, 1995). Although commercial items such as Hula Hoops, bowling and basketball sets, water wheels, marble games, pendulums and ring toss are appropriate for physics activities, readily available and inexpensive items such as containers, cardboard, tubes and other items can make wonderful materials for children's exploration activities (Marxen, 1995).

3.3 Using Toys in Teaching Physical Science

There are several studies that address the use of toys to promote physical science learning. Williams and Grace (2004) use the Rainbow Shake Stick, a transparent rod that has small bubbles inside, to demonstrate the concept of vision. This toy uses three LEDs flashes – one red, one green and one blue that give the impression of white light in the transparent stick. The LEDs flash one after another with a time interval between each flash. In their study Williams and Grace had students discuss the color patterns created when the light stick is held by its loop, whirled around or waved quickly backward and forwards. In another study, Amir and Subramaniam (2006) used a toy puzzle consisting of two small blocks of wood, identical in all aspects, and interlocked through some free moving cylindrical rods in the interior of the blocks to study students' understanding of centripetal force and foster their creativity. The results of their study also indicated that student has understood the relationship between types of material and friction, realizing that, it is easier to spin this centripetal toy since plastic is smoother in nature and contributes to less friction. Students also demonstrated an understanding of the concept of balance using this toy.

In addition, Featonby (2005) suggests the use of a variety of different toys to foster students' understanding about force and motion, energy, movement, electricity and other concepts. For example, in teaching the concept of force and motion, Featonby notes that a plastic duck can be used because its weight is balanced with several different forces such as when sitting on a bench, floating on water or suspended on a thread or spring. Additionally, a wooden animal on a swing can be used to teach about motion, oscillation, and unbalanced forces. Many toys involve some kind of motion. Battery-powered helicopters (or similar) suspended by a thread from the roof, moving conical pendulums, and a variety of rockets can provide interesting ways for students to learn about force and motion. Furthermore, Featonby suggests some toys which can be used to help students identify primary energy sources, energy forms, energy transformations and transfers, and how and where energy is stored or lost. Spinning tops, dropping marbles one by one into a container, and rotating frogs can be employed to teach the concept of movement. In addition, children can be introduced to the idea of a complete circuit using a 'buzzer game' where a ring is maneuvered over a wire loop and the buzzer sounds if contact is made. In the electric circuit buzzer game, when someone touches both metal contacts on the ball it begins to flash. This can be done with several children joining hands in a circle. The ball flashes once a complete circuit is made, and if anyone breaks the circle it stops. It is a simple matter to build the circuit into any fluffy animal and perform a similar experiment. Additionally, Herald (2001) suggests that using toys to teach physical science can engage students and provide a hands-on experience that stays with students a lot longer than simple paper-pencil exercises. To teach the concept of speed motion, and wavelength and bounce, toy cars, spring toys (slinkly) and bouncing balls (e.g. tennis ball, ping-pong, sponge ball, kickball and racquetball) were used in his activities.

Toys can be used as an organizer in teaching physical science to early childhood students, and can serve as a tool to cross different students' culture and background. According to Swiniarski (1991), a variety of toys, including dolls, animals, musical instruments, seriation games, puzzles, board games, construction toys, movement toys(car, trucks, planes), miniatures (from teacups to space stations) and famous character replicas, serve to build connections between children of various cultures and helps children accept and appreciate one another. Toys, as national symbols, represent political, historical, and social events. For example, dolls are worn as fertility charms in parts of Africa, while masks play a major role in many Asian festivals. Many religious forms are represented by animals. In China, for example, a popular figure is the dragon, often replicated in kites, puppets and chenille-stuffed animal toys (Fawdry, 1977). The dragon may appear in many sizes, shapes and colors. Each culture seems to add its unique features. European dragons have been depicted with or without wings and as serpents or worms. Thus, students' backgrounds with toys can serve as a tool to develop students' understanding of both physical science concepts and different cultures in the classroom.

Moreover, Neuman and Roskos (1994) recommended two teaching activities that particularly encourage cultural responsiveness about toys in early childhood classrooms. One recommended activity is a three-part open-ended question, which includes: a) questions to name and describe something in greater detail (e.g. what is it?), b) questions to convey emotions associated with an object or event (e.g. what do you think about it?), and c) questions to stimulate the speaker to think ahead, using language to plan and anticipate future actions (e.g. what else do you want to know or do?). The second activity, designed to facilitate students' conversations with peers, involves the construction of "me-museums" where students can display their special items. For example, teachers could have students bring their toys into the classroom and then engage them through questioning to expand on their experiences with these items. Additionally, using these favorite toys, a parent or grandparent could visit and tell the class about each item's special qualities in the me-museum activity.

4. Constructivist Learning Theory and Research in Science Education

There are many studies in which students' science conceptions have been investigated in light of constructivist theory. A constructivist framework has been used as a referent in developing science curriculum, instruction, and assessment (Brooks and Brooks, 1993). In 1990, Pfunt and Duit (1991) produced a bibliography at Leeds University, a major center of constructivist research. The bibliography listed over 1000 studies of this kind, with about 20% focusing in the area of biology, 10% in chemistry, and 70% in physics. The majority of research concentrated on using the idea of constructivism as a framework for creating a specific type of learning environment where students are involved in hands-on interaction with scientific materials, and are frequently encouraged to communicate their ideas (Watson and Konicek, 1990, p. 685). In a study conducted by Christianson and Fisher (1999), for instance, the aim was to compare the learning about diffusion and osmosis of university students taught through a small discussion/laboratory approach supported by constructivist theory with a traditional lecture approach. The results of pre- and post-testing indicated that students learned about and understood diffusion and osmosis most deeply in the small discussion/ laboratory course. In another example, Glasson and Lalik (1993) reported on a case study to explore the changing beliefs of a physics teacher as she used the learning cycle-exploration, invention, and discovery in her science classes. The teacher initially expressed the positivistic view that the goal of science instruction was for students to arrive at scientifically acceptable conclusions. In the course of the study, she changed her practice to give students more time to discuss and test ideas through problem solving. However, she experienced tension between her efforts to give her students opportunities to develop their own understandings and her efforts to present scientific information. She did, however, move toward giving students more control of their learning and more time to explore and clarify their understanding through dialogue, writing, and collaborative problem solving.

5. Constructivist Learning Theory and Research in Elementary Science Education

There has been considerable effort to use the findings of research concerning children’s preconceptions in science to inform teaching practice. Attempt to introduce teachers to constructivist ideas asks them to change not only their views about learning, but also the classroom practices which result from them. Some studies have concentrated on teacher development. Several examples of teachers’ journeys as they try to come to grips with constructivism and its implications for teaching have recently been reported (Hollingsworth, 1989; Peterman, 1991; Bell, 1993; Stofflett and Stoddart, 1994; Wildy and Wallace, 1995). For example, in a case study conducted by Appleton and Asoko (1996), the constructivist ideas about teaching and learning implemented by one elementary science teacher who had undertaken an extended in-service program was investigated. The key principles emphasized during the 20 day in-service program focused on eliciting ideas which children brought to learning situations, defining conceptual goals for the learners, developing an understanding of how learners achieve these goals, using teaching strategies involving challenge to, or development of, the initial ideas of the learners and ways of making new ideas accessible to them, providing opportunities for the learners to utilize new ideas in a range of contexts, and providing a classroom atmosphere which encourages children to put forward and discuss ideas. The course aimed to increase teachers' confidence in their own understanding of science and to introduce ways of working with children which take account their existing ideas in the teaching process. The result of the study indicated that the in-service training had raised teacher awareness of some of these issues for consideration in terms of their classroom practice. For example, the teacher was aware of many of the ideas his children already had, and employed several strategies to elicit their ideas during his teaching. The teacher used challenge during discussions to guide the children's thinking.

In another example, Tippins, Tobin and Nichols (1995) created a composite teacher, Mrs. Halfaday, from the teachers they have worked with, and used vignettes and interview data from their research to tell her story. The story is in the form of an engaging narrative that demonstrates the application of constructivism to science teaching. Throughout the story, the change in thinking and teaching practice of Mrs. Halfaday as a result of participating in a partnership project was examined. The results suggest that the teacher changed her view of teaching from objectivism to constructivism. Mrs. Halfaday used constructivism and the belief that students should have control over their learning as key referents in changing her practice.

A number of other studies have focused on constructivist teaching in elementary schools in Thailand. These researchers studied the effect of using a constructivist teaching model for elementary students' learning. These researchers suggest that a model based on a constructivist framework enhances elementary students' achievements. Moreover, a study by Kanjanachatree (1999) suggests that four steps are important in an instructional process aimed at improving knowledge construction in elementary students, as follows: 1) cognitive conflict in which students must create a conflict in their thinking resulting from the contradiction of their prior knowledge and the newly perceived information, 2) searching for responses in which students must organize themselves into groups to look for possible answers to reduce cognitive conflicts that might arise, 3) understanding check-up in which students must construct their own knowledge through a process of social negotiation, and 4) knowledge application where the students must apply the acquired knowledge to some other contexts.

In summary, this study also drew specifically on constructivism as both a referent to analyze the learning potential of any situation and method of teaching (Tobin and Tippins, 1993). According to the National Education Act (1999), Thai educational principles emphasize teaching-learning processes that foster learners' self-development in accordance with the constructivist idea that knowledge cannot be transmitted but must constructed either personally or in a social context. Constructivists believe that learners come to science lessons already holding ideas about natural phenomena which they use to make sense of everyday experiences and their views of “how the world works” (Solomon, 1994:.25). It is important to understand the fundamental, culturally-based beliefs about the world that students bring to class and how these beliefs are supported by students’ cultures.

Inquiry-Based Teaching

1. Definitions of Inquiry

Scientific inquiry refers to ”the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists work" (NRC, 1996: 23).

Numerous definitions can be found in the education literature. Flick (2002) provided a threepart definition that includes the process of how modern science is conducted, an approach for teaching science, and knowledge about the nature of science. Other definitions encompass processes, such as using investigative skills; actively seeking answers to questions about specific science concepts; and developing students' ability to engage, explore, onsolidate, and assess information (Yore, 1984, Barman, 2002; Lederman, 2002). Teaching students, science as inquiry, involves engaging them in the kinds of cognitive processes used by scientists when asking questions, making hypotheses, designing investigations, grappling with data, drawing inferences, redesigning investigations, and building as well as revising theories.

2. Features of Inquiry-Based Teaching

The National Science Council Standards (1996)define five essential features of inquiry-based teaching:

1. Learners are engaged by scientifically oriented questions.

2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

3. Learners formulate explanations from evidence to address scientifically oriented questions.

4. Learners evaluate their explanations in light of alternate explanations, particularly those reflecting scientific understanding.

5. Learners communicate and justify their proposed explanations.

3. Learning Cycle

The learning cycle model of instruction, originally proposed by Robert Karplus, is based on Piagetian theory and involves a constructivist approach to teaching. It is intended to help students progress from concrete to abstract thinking about content (i.e., from concrete to formal operations) Learning cycles teach science in three consecutive phases known as exploration, term introduction, and *concept application that* are based on the way people spontaneously learn about the world (Lawson, Abraham, and Renner, 1989; Musheno and Lawson, 1999). These phases have been described as follows: *Exploration* allows students to investigate new materials and/or ideas so that patterns of regularity can be discovered and questions are raised that students then attempt to answer. *Term introduction* allows the teacher to introduce terms to label the patterns and to explain the newly invented concepts. *Concept application* provokes students to seek the patterns elsewhere and to apply the new concepts to additional examples, often employing abstraction or generalization techniques (Lawson, 1988). Research has supported the effectiveness of the learning cycle in encouraging students to think creatively and critically, as well as in facilitating a better understanding of scientific concepts, developing positive attitudes toward science, improving science process skills, and cultivating advanced reasoning skills (Lawson, 1995).

As an instructional approach, the origin of the learning cycle is generally attributed to the Science Curriculum Improvement Study (SCIS) materials of the 1970s. Many versions of the learning cycle appear in science curricula with phases ranging in number from three to five (5Es). The 5E learning cycle based instruction was developed by the Biological Sciences Curriculum Study (BSCS) in 1989. It consists of 5 phases called as; Engagement, Exploration, Explanation, Elaboration and Evaluation.

1. Engagement

In this phase activities that initiate students' curiosity are made. These activities help students to make connections with the previous knowledge. In this stage teacher creates interest, generates curiosity, raises questions, and elicits responses that uncover what the students know or think about the concept/ topic, while, student asks questions such as: "Why did this happen?", "What do I already know about this?", "What can I find out about this?" and shows interest in the topic (Carin and Bass, 2000: 120-121).

2. Exploration

Once students are engaged in the learning tasks, exploration activities follow. In exploration, students observe properties, form simple relationships, note patterns and raise questions about events to develop fundamental awareness of the nature of materials and ideas. They have the opportunity to get directly involved with phenomena. The teacher's role in the exploration phase is that of guide, coach and facilitator. Teacher encourages students to work without direct instruction from the teacher, observes and listens to students as they interact, asks probing questions to redirect students' investigations when necessary, provides time for students' investigations when necessary, provides time for students to puzzle through problems and acts as a consultant for students (Carin and Bass, 2000: 120-121).

3. Explanation

In this phase, teachers help students make sense of their observations and the questions that arise from their observations. The teacher asks children to describe what they see and give their own explanations of why it happened. Teacher also encourages students to explain concepts and definitions in their own words, asks for justification (evidence) and clarification from students, formally provides definitions, explanations and new labels, uses students' previous experience as the basis for explaining concepts. (Carin and Bass, 2000: 120-121).Student explains possible solutions or answers to the others, listens critically to one another's explanations, questions one another's explanations, listens to and tries to comprehend explanations offered by the teacher, refers to previous activities, and uses recorded observations in explanations. (Carin and Bass, 2000: 120-121)

4. Elaboration

In this phase new experiences are designed to assist children in developing broader understandings of the concepts already introduced. Students expand on the concepts they have learned, make connections to other related concepts, and apply their understanding to the real world around them. Children work in cooperative groups, identify and complete new activities. It often involves experimental inquiry, investigative projects, problem solving and decision making. Lab work is common. Small-group and whole-class discussions provide students opportunities to present their own understandings. By observing the students in this phase the teacher may decide to recycle through the different phases of the 5E learning cycle to improve children's understanding or move on to new science lessons. In this stage teacher expects students to use formal labels, definitions, and explanations provided previously, encourages students to apply or extend the concepts and skills in new situations, reminds students of alternative explanations, refers students to existing data and evidence (Carin and Bass, 2000: 120-121). Students applies new labels, definitions, explanations, and skills in new, but similar, situations, uses previous information to ask questions, propose solutions, and make decisions, design experiments, draw reasonable conclusions from evidence, records reasonable conclusions from evidence, records observations and explanations and checks for understanding among peers (Carin and Bass, 2000: 120-121).

5. Evaluation

Evaluation and assessment occurs at all points along the continuum of the instructional process. Rubrics, teacher observation structured by checklists, student interviews, portfolios designed with specific purposes, Project and problem-based learning products, concept maps and roundhouse diagrams may be used to assess students' understanding of concepts. In this stage teacher observes students as they apply new concepts and skills, assesses students' knowledge and/ or skills, looks for evidence that students have changed their thinking or behaviors, allows students to assess their own learning and group process skills, asks open-ended questions, such as: "Why do you think….?", "What evidence do you have?", "What do you know about x?" How would you explain?" (Carin and Bass, 2000: 120-121). In this stage student answers open-ended questions by using observations, evidence, and previously accepted explanations, demonstrates an understanding or knowledge of the concept or skill.

4. Comparison of the Learning Cycle Approach and Traditional Approaches

Several key studies have compared the learning cycle approach with traditional approaches. Pavelich and Abraham (1979) concluded that the learning cycle approach more accurately reflects scientific inquiry processes than traditional approaches. Students distinguish the learning cycle approach from traditional approaches in the following ways: (a) the learning cycle approach emphasizes the explanation and investigation of phenomena, the use of evidence to back up conclusions, and the designing of experiments. (b) traditional approaches emphasize the development of skills and techniques, and receiving of information, and the knowing of the outcome of an experiment before doing it (Abraham, 1982).

Studies show that 5E Learning Cycle approach is also an effective teaching strategy in enhancing students understanding and achievement. Bevenino, Dengel and Adams (1999) have explored 5E learning Cycle approach in their study. After their study they conclude that 5E Learning Cycle approaches encourage students to develop their own frames of thought and it is effective in the classroom. Colburn and Clough also supports the 5E learning cycle as an effective way to help students enjoy science, understand content, and apply scientific processes and concepts to authentic situations. The 5E learning cycle is a great strategy for middle school and high school science teaching because it works, is flexible, and places realistic demands on teachers and students.

Lord (1999) published a study that compared two classes taught by traditional methods with two classes taught with 5E Learning Cycle method. The traditional classes were teacher-centered and taught in lecture fashion. 5E Learning Cycle method used involved small heterogeneous groups who worked on thought-provoking scenarios and critical thinking questions or constructed concept maps. The study showed that the experimental groups had much greater understanding of the information covered especially on questions that required interpretation. "The students taught with the 5E Learning Cycle method understood the course material in a much deeper, more comprehensive way" (Lord, 1999, 26). There was a significant difference in the feedback from the students. In the experimental group the vast majority of the students wrote positive comments about the course. In the control group only about half of the students wrote any response, and of the comments that were written, few were positive.

Caprio (1994) published a study that compared a class which he taught with traditional (lecture) methodology in 1985 to one in which he taught with 5E Learning Cycle method in 1994. The students in both groups had the same prerequisites, and the same exam was used for comparison. The exam grades were much higher for the class taught with the constructivist methodology. "The control (traditional) group's average grade was 60.8 percent, while the experimental (5E Learning Cycle) group averaged 69.7 percent" (Caprio, 1994, 212). In addition to the test scores, the experimental group had a high energy level and gave positive feedback on the course.

5. Promoting Science Inquiry with Elementary Students from Diverse Backgrounds

In recent years, research has focused on understanding and promoting science inquiry with students from diverse languages and cultures. This research points to the need for teachers to incorporate linguistic and cultural funds of knowledge that students of diverse backgrounds bring to the classroom (Moll, 1992) and the extent to which students' everyday knowledge and language intersect with scientific practices; however, researchers and research programs have differing views of the manner in which these two areas intersect and their implications for instructional approaches. For example, using science standards documents (NRC, 1996, 2000) as the guidelines for science inquiry (Fradd and Lee, 1999). Lee (2002, 2003) examined students' cultural values and practices relative to those of Western modern science. Their research indicates areas where these two sets of values and practices are discontinuous as well as continuous. The areas of discontinuity necessitate transitions, or border crossings, between the students' home culture and the culture of science. As students attempt these transitions, teachers initially provide extensive guidance. As students learn to take initiative and conduct inquiry on their own, teachers gradually withdraw assistance.

Aikenhead (1996) suggest that learning science is a process of "culture acquisition" (p.5). For many students, learning science is like learning another culture. The norms of practice in the sciences may be largely unfamiliar to most students, especially students who come from ethnic or gender groups that are traditionally underrepresented in science (Lemke, 1990). Further, Gerber ***et al.*** (1997) stated that, "Such inquiry classroom environments may be consistent with how children learn naturally in informal learning environments; in essence, the development of [scientific] reasoning abilities is promoted through students' experiences, cognitive conflicts and social interactions" (p. 3). Rosebery *et al*. (1992) and Warren *et al*. (2001) used the model of everyday practices of scientists in their attempts to promote children's sense making in science. This research emphasizes that everyday experiences and ways of knowing and talking with students, including students from nonmainstream backgrounds, are continuous with those of science. Therefore, teachers provide opportunities for students to explore their ideas and investigate questions following the model of science as practiced in the scientific community. Additionally, teachers identify intersections between the students' everyday knowledge and scientific practices, and use these intersections as the basis for instructional practices.

Summary

The research draw on four theoretical frameworks, including curriculum, culturally relevant curriculum, constructivism and inquiry based teaching. In this, the conception of curriculum has concentrated on social processes, rather than product. Joseph Schwab (1978) described curriculum in terms of three aspects: the planned curriculum, translated curriculum and experienced curriculum. The planned curriculum in this study corresponds with the development of a culturally relevant/ inquiry-based instructional unit. The translated curriculum corresponds with the implementation phase, and centers on the way in which teachers actually enact the curriculum. Finally, the experienced curriculum was used to describe students' learning in the last phase of the study. Moreover, this study drew specifically on funds of knowledge, including students' own knowledge, well as parents' knowledge and inquiry based teaching as a theoretical referent to design learning activities in the science curriculum in response to the emphasis on relevancy in the Thai National Education Act. Moreover, this study was also draw specifically on constructivism as both a referent to analyze the learning potential of any situation and method of teaching (Tobin and Tippins,1993).

CHAPTER III

RESEARCH METHODOLOGY

This study was conducted as an ethnographic case study of three elementary science teachers who were co-construct an instructional unit about material concepts with three science educators and a scientist. The unit was developed with an emphasis on incorporating grade one to three students' and parents' funds of knowledge about toys and utensils and were used by the teachers in their classrooms. This chapter presents the research methodology of the study through an in-depth discussion of the methodological framework, method of the study, context of the study, participants, procedures, and data collection and analysis.

Methodological Framework

Ethnography is a research design which aims to provide an in-depth description and interpretation of cultural patterns and meaning within a culture or social group (Merriam, 1988; Gall, Borg, and Gall, 1996; McMillan, 2004). Ethnography was initially developed by anthropologists to explore different cultures (Freebody, 2003). In education, ethnographic methods were first used as a basis for studying classrooms in a microethnography which described the subtleties and complexities of a classroom culture in a low income school for those who were not part of it. In addition to being a product of description, ethnography is also a process, a way of studying human life. Ethnographic study asks research questions about the setting (participants, time, place, events), what happens, why it happens, and how it happens (McMillan, 1997).

The purpose of conducting ethnographic research is to seek understandings of events that occur within the life of a group with special regard to social structures and the behavior of individuals in light of their group membership. Ethnography focuses on interpretation of meaning from participants' perspectives through their participation in the research (McMillan, 1989). It aims to look at what people do, what they say, and the tension between what they really do and what they ought to do as well as what they make and use.

As a study of event, this ethnographic research seeks understandings of the curriculum development process setting. The study was intended to develop thick description of what happens, why it happens, and how it happens when individual members in a research team participate in four phases of a curriculum development process, including; exploration of students' and parents' funds of knowledge about toys and utensils, design of an instructional unit, implementation and evaluation of factors that constrain and facilitate the teaching of the unit that incorporates students' funds of knowledge and inquiry.

To understand the process from participants' perspective, the key researcher, a doctoral student in science education, immersed as one of research team members to co-construct an instructional unit with three experienced science educators, three elementary science teachers and a scientist. Different knowledge/notions from individual research team member perspectives during the curriculum development process were collected, analyzed and described from the perspective of the researcher. Moreover, the classroom culture with an emphasis on implementation of a science unit based on students' funds of knowledge and inquiry, instead of common lecture, were studied. The classroom context, including teacher-student and student-student interaction with the unit content were described. During this phase of the ethnographic study, the researcher studied in depth how three participant teachers implement the instructional unit, and what factors constrain and facilitate the teaching of a science instructional unit which incorporates students' and parents' funds of knowledge and inquiry.

1. Ethnography in Educational Research

Particularly in education, an ethnography provides rich, descriptive data about the contexts, activities, and beliefs of participants in educational settings (Goetz, and

LeCompte, 1984). According to Goetz and LeCompte (1984), ethnographic researchers explore ways of describing and interpreting what is happening in formal and informal educational settings to provide the reader the "shared beliefs, practices, artifacts, folk knowledge, and behaviors" of people involved in an educational activity (p. 2-3). For example, educational ethnographers examine the processes of teaching and learning; the intended and unintended consequences of observed interaction patterns; the relationships among such educational actors as parents, teachers, and learners; and the sociocultural contexts within which nurturing, teaching and learning occur.

Educational ethnography is intended to contribute to improvement in educational and school practice in several ways. First, the ethnographer focuses on the vagaries of everyday life and on the perspectives of those involved, confirming the reality experienced by educators in the attempt to demonstrate concretely the connections among research activity, educational theory, and pragmatic concerns (Brown, 1982). Second, ethnographic methods are used to understand the culture and the interactions between the members in ways that are different from that which can be obtained from conducting a questionnaire survey or an analysis of document. The investigators' involvement in the normal activities of the group may be treated as a case of partial acculturation in which they acquire an insider's knowledge of the group through their direct experience with it. According to McMillan (1989) and Merriam (1988), common techniques of data gathering include interviewing, documentary analysis, life history, investigator diaries, and participant observation.

Educational ethnography has been chosen as the basis for this research because it is one of the most appropriate and effective ways to investigate the educational practice of co-construction among elementary science teachers, science educators and experienced elementary science teachers a curriculum that incorporate students' funds of knowledge and inquiry. According to the policies of the Thai National Education Act (1999), the challenges of teachers to develop curricula and teaching-learning processes with student-centered approaches and apply central curricula to school contexts and communities is very important in today's world. To enhance school teachers’ experiences in the development of a culturally relevant instructional unit that takes into account the school/community context and students’ funds of knowledge, science educators, experienced elementary science teachers, a scientist, students and parents were all contributors to the curriculum development process. Students and their parents were the sources of everyday life knowledge that served as the basis for developing culturally relevant curriculum. The connection among scientific concepts, educational theory and practical concern during the curriculum development process were negotiated within research team members, depending on personal experiences. Instead of the numerical data gained from questionnaire analysis, the in-depth description of the whole curriculum development process from researchers who were involved members of the research team was a strength of conducting an ethnographic study. What research team members say during discussion about students’ funds of knowledge, aspects of inquiry that should be addressed in the instructional unit, modifications appropriate for the school and student context, organization and implementation of the unit and what actually takes place during instruction was the key focus of the main researcher and other team members.

2. Method of the Study

One of the more common research methods in qualitative research, including ethnography, is the case study. Yin (1994) stated that “a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (p.13). Case study design is very effective in producing a rich and holistic account of complicated social phenomena because it is “anchored in real life situations” (Merriam, 1998 p. 41). The main purpose of the case study is to intensively describe and analyze a specific situation, individual, event, or community, by looking in-depth within a relevant context and describing contextual influences on the person, object, or program being studied (Stufflebeam, 2000). Yin (1994) has suggested three features of case study methods, which include (1) triangulating information from multiple sources of evidence; (2) collecting rich and detailed contextual data, and (3) research that takes place within a single or multiple cases. According to Yin (1994) triangulation, includes collecting and converging information and perspectives from multiple sources, including observation, interviews, documents, archival files, and artifacts. Facts and conclusions are built from the consistency of data derived from multiple methods. Based on this regard, seven types of data collection methods, including interviews, parent log books, focus group research team planning meetings, participant observations, journals, students' drawings were used in this study. The data gained from each method were analyzed, and interpreted in terms of consistency presented across the data sources. The consistency of information about students' informal experiences with toys and utensils were obtained through the four methods of student interview, parent interview, parent logbooks, and students' drawings. The consistency of data about three participant teachers' experiences during unit instruction were obtained by methods of participant observation, teacher journal, and focus group research team planning meetings. The second feature of case study method focuses on capturing the contextual influences of the case and demands that researchers collect detailed data from the field. In this study, school policies and vision, classroom culture, teacher and student rapport that may influence the unit instruction were observed and described. Finally, the third feature of case study method described by Yin (1994) includes the single, collective, or multiple nature of case studies. In this study, case studies of three elementary science teachers who were volunteers from Kwanpracha School (Pseudonym), Nonthaburi province and participating in the curriculum development process, were studied in depth. Their science teaching practices and personal beliefs and opinions about what happens before, during and after the unit instruction were obtained through audio-recorded interviews and subsequently analyzed. The patterns and meanings emerging from this cross-case analysis were interpreted.

There are many types of qualitative case studies, which have different characteristics that make them appropriate to the study of different categories of case. Merriam (1998) suggested that, in the case study design, the researcher's main "interest is in process rather than outcomes, in context rather than a specific factor, in discovery rather than confirmation" (p. 19). Similarly, Bromley (1986) suggested that case study is an especially appropriate research design when the researcher is interested in process. According to Bromley (1986), case study researchers "get as close to the subject of interest as they possibly can, partly by means of direct observation in natural settings, partly by their assess to subjective factors(thoughts, feelings, and desires), whereas experiments and surveys often use convenient derivative data, e.g. test result, official records" (p. 23 cited by Merriam, p.32-33). In education, and science education in particular, case studies can be used for a variety of purposes. Case studies can focus on individual students or teachers in the effort to identify and explain certain problems of practice. Moreover, a historical case study can examine a phenomenon over a period of time wherein the author presents a holistic description and analysis of the case. The emphasis of this case study is on the individual description of three elementary science teachers who participate in the curriculum development process. The description of what is going on when individual teachers make modifications to an instructional unit appropriate for the school and student context, how they organize the unit in the classroom, and what takes place during the unit implementation is central interest.

Ethnographic case study, in particular, focuses on the culture of a school, a group of students, or classroom behaviors (Merriam, 1998). A researcher may choose an ethnographic case study design to understand or explain the cultural characteristics of the field, including the ways of feeling, thinking, and behaving among the people in the field. This study seeks to develop an in-depth understanding of grade one, two, and three students' and parents' funds of knowledge to design, implement and evaluate an instructional unit. Ethnographic case study is used as the methodological basis of this study. The thick description of three elementary science teachers, who negotiate with three science educators, and a scientist in designing, implementing, and evaluating an instructional unit focused on material concepts was at heart of this study. Moreover, what students experience and learn by participating in a culturally relevant/ inquiry instructional unit was investigated in order to more fully understand what constrains and facilitates teaching that incorporates students' funds of knowledge and inquiry. In this ethnographic case study, observation serves as a primary data collection method during the implementation phase because it provides a firsthand account of the situation or field under investigation. Observation is usually combined with interviews and document analysis in order to present a holistic interpretation of the phenomena under study. The second data collection method, interviewing, is especially effective in exploring the inner thoughts of participants. Other archival strategies, including document analysis and the examination of different artifacts from the field, are important tools that help researchers understand the context of their observations and interviews in the field, providing additional and objective supporting data.

3. Participants and Context of the Study

Two groups of participants, including the research team and nine students and their parents are at the heart of this study. Three science educators, a scientist and three experienced elementary science teachers were research team members who co-construct and implement the instructional unit. One of the science educators is a doctoral student in the Program to Prepare Research and Development Personnel in Science Education at the Faculty of Education, Kasetsart University, Bangkok, Thailand. She graduated from the Faculty of Science in the chemistry field, and taught chemistry to grade ten students for one semester in a public high school in Nonthaburi province, Thailand. The other two science educators are experienced researchers and instructors in science education. One educator has focused her interest on philosophy of science. The other educator has centered her research on analyzing and comparing science teaching situations within the policies of the National Education Development Plan. Additionally, a scientist who has participated in science curriculum development regarding the concept of matter collaborated in the design of the unit and served as a de-briefer.

In addition, three teachers in Kwanpracha School serving as members of the research team, participated in developing and teaching an instructional unit that incorporated students' funds of knowledge and inquiry. These teachers were selected using "purposeful sampling" (Bogdan and Bicklin, 1992). The three participant teachers were selected based on the following participant selection criteria: 1) participants showed evidence that they did not have a good understanding of science content knowledge and science process skills; 2) limited time and expense in conducting the study; and 3) participants were able and willing to be a part of this study. The first criteria evolved from teachers' responses to a questionnaire about their perceptions concerning students' understanding of matter, related concepts, and general problems of science teaching. These questionnaires were distributed to grade one, two and three science teachers in 47 schools of Education Area 1, Nonthaburi province during the first semester of the academic year 2004. Teachers from nine schools indicated that they had problems in organizing science lessons because they did not have a good understanding of science content knowledge and science process skills. Because of the limited time and the expense in conducting the study, Kwanpracha School, one of the nine schools, located near Kasetsart University was selected as the research site. The Kwanpracha School' administrator granted permission for the study to be conducted and for the researcher to solicit participants. Three volunteer teachers from grade one, two, and three participated in the design, implementation, and evaluation of the instructional unit on material concepts. The administrator selected these three teachers based on their interest and willingness to participate in the study. All of the participant teachers are female. These teachers did not graduate in science. Two of them, the grade one and three teachers, are graduates majoring in social studies teaching and have more than ten years of teaching experience in science. The other teacher graduated in primary education and has four years of science teaching experience with the reformed curriculum of 1999. The three participant teachers from grade one, two and three were asked to participate in this study for two main reasons. The first reason refers to the nature of school system where lower elementary science teachers (grade one to three) have to switch grade levels every year. The second reason is that the scientific concepts taught in these three grade level are the concepts of materials, even though there is a slightly different emphasis each grade level. Finally, it hoped that by participating as research team members in designing an instructional unit the teachers would develop ideas of how to construct lessons in accordance with science content standards and student context at each grade level.

Additionally, nine students and their parents also participated in the study. Nine students representing different gender and economic status at each grade level were selected through a review of students' profiles; their parents were asked to participate in the study. Three students at each grade level (one, two, and three) comprised the group of nine. These nine students were interviewed about the kinds of toys and utensils they interact with in everyday life. Later in the study, these same students were interviewed about the scientific concepts they learned from the unit and asked to reflect on their experiences. Similarly, nine parents of these students were interviewed concerning students' informal learning experiences with toys and utensils and perceptions of how their child has been developing by interacting with toys and utensils. Data gained from both sources served as funds of knowledge in the development of a culturally relevant/ inquiry science curriculum for grade one to three students in Kwanpracha School.

This study was conducted in a public elementary school in Nonthaburi province, located in the central part of Thailand. Schools within six districts in this province are divided into two education areas. Schools in two big districts, the Muang and Bangkrou district, are included in education area one. The rest of the schools are included in education area two. One of the schools in education area one, Kwanpracha School, was selected to participate in this study on the basis of the fact that science teachers in this school had little science content knowledge or up-dated teaching equipment. Teachers in this school also indicated that their students had low science understanding and lacked of family support for learning (Sreethunyoo, 2008). The researcher's limited time and the expense involved in conducting the study were additional criteria in the selection of the particular school. At this school, there are approximately 12 classrooms for lower elementary level. There are about thirty two students enrolled in most classrooms. Grade one through six students are taught in this school; however, only lower elementary level teachers, grade one to three, are participants in this study.

4. Research Context of the Study

A long term problem in science teacher education is that students can not connect what they learn in school with their everyday life. To solve this problem, Thai wisdom and community knowledge are strongly emphasized in the current curriculum. Basic education institutions have the responsibility for constructing their own curriculum in accordance with local community problems and wisdom (MOE, 2001; IPST, 2002). The local available materials are to be utilized as learning media (MOE, 2001). Moreover, parents, guardians and all parties in the community are encouraged to participate in the learning process to develop students to their fullest potential (ONEC, 2000). This study attempts to develop a culturally relevant instructional unit that takes into account the school/community context and students' funds of knowledge.

In addition to an emphasis on funds of knowledge, the 5-E model of inquiry was used to design learning activities to foster students' learning about scientific concepts. Inquiry-based instruction was used in the design of unit activities to foster students' ability to construct their own knowledge (Hiebert *et al.*, 1996; Hebrank, 2000). In Thailand, the inquiry approach was promoted in the science curriculum (B.E. 2533) as a form of student-centered activity that allows elementary students to create experiments, construct their own understandings and learn how to apply scientific processes in the construction of knowledge. Inquiry-based instruction is one of several effective instructional approaches that can foster students' achievement in terms of thinking skills, reasoning ability, problem solving and understanding of scientific processes and skills. However, a number of studies have suggested that the major difficulty of implementing inquiry into Thai science classrooms is that teachers don't know how to organize teaching-learning based on an inquiry model. This study can serve as an example for science teachers and curriculum developers of how students' knowledge and local wisdom can be used in constructing relevant, inquiry-based curriculum. What is learned about the process of developing curriculum from this culturally relevant approach may help science teachers better understand how to construct or develop other curriculum based on funds of knowledge and inquiry approaches.

A 22 period instructional unit based on students' and parents' funds of knowledge and the 5-E model of inquiry was developed by the research team. The concepts of properties, types of materials, and changes in materials subjected to pressing, twisting, hammering, bending, stretching, and heating or cooling were included in the unit. These concepts are divided according to grade levels. The concepts of observation properties (color, shape, size, and weight), and types of materials were taught in grade one. The concepts of physical properties and types of materials in making toys and utensils were taught in grade two. The concepts of physical properties, type and the change of materials in making toys and utensils were taught for grade three. In addition to material concepts, science process skills and technology appearing in science content standards for each grade and nature of science were included in this unit.

The 5-E model of inquiry (BSCS, 1989) was used as the basic framework in designing the unit. This model includes engagement, exploration, explanation, elaboration, and evaluation as key elements of inquiry. Engagement involves creating interest by, for example, raising questions about an object or event in the environment to elicit responses that uncover what the student knows or thinks about the science concept. Exploration, the second step in the 5-E model, involves conducting simple investigations by encouraging students to work together without direct instruction from the teacher on concrete objects and observable events. During the explanation phase, the teacher encourages students to explain concepts and definitions in their own words, asks for justification (evidence) and clarification from students, formally provides definitions, explanations, and new labels, and uses students' previous experiences as the basis for explaining concepts. In the elaboration phase, teachers expect students to use formal labels, definitions, and explanations provided previously, encourages them to apply or extend the concept and skills in new situations, reminds students of alternative explanations, and refers them to existing data and evidence by asking "What do you already know?" "Why do you think this is the case?". In the final step, evaluation, the teacher observes students as they apply new concepts and skills, assesses students' knowledge and/ or skills, looks for evidence that students have changed their thinking or behaviors, and allows students to assess their own learning and group-process skills.

5. Procedures of the Study

This study consisted of four phases which include a) exploring students' and parents' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers who were members of the research team, and d) evaluating the factors that constrain or facilitate the teaching of a unit that incorporates students' funds of knowledge and inquiry.

In the exploration phase of this study, students' drawings, parent log book and interviews of students and parents during home visits were conducted during the first part of academic year 2006 to ascertain students' funds of knowledge about toys and utensils. Funds of knowledge in this study included information about the kinds of toys and utensils currently involved in students' everyday lives, their role and history in the family and students' interactions with these materials, and what they learn by participating with toys and utensils. Additionally, information about the kinds of toys and utensils grade one to three students use in everyday life were collected in April, 2006. Three classes of grade one to three students (one class/ grade) were asked to draw pictures of their favorite toys and utensils. The kinds of toys and utensils most students play with and use commonly were used as an organizer for students' exploration of material concepts. To investigate how students interact with toys, nine parents of grade one, two and three students (three parents per grade) were asked to keep a logbook about the kinds of toys and utensils their child plays/uses, materials these objects made of, how they interact with these materials, and what parents expect students to learn with toys. Each parent recorded students' interaction with toys and utensils for a period of one week. Information about students' informal learning experiences with toys and utensils, science concepts students have been developing by interacting with these objects, including kinds of students' toys and utensils, how they play and use with the objects and what they learn from toys were obtained from follow-up interviews with each parent and their students.

In the second phase of designing an instructional unit for elementary level 1 students that incorporated funds of knowledge, principles of culturally relevant pedagogy/curriculum, inquiry based instruction, and constructivism were reviewed and formulated as the framework of the unit. Thai science curricular material was examined by the research team to ascertain what scientific concepts and skills, cultural knowledge and inquiry aspects currently exist in these elementary classrooms. In addition, scientific concepts regarding material concepts and skills from the third science content standard (IPST, 2002) for grade one, two and three students were examined.

Based on the review of these documents, a preliminary draft of a culturally relevant/ inquiry based instructional unit focusing on the concepts of types, properties, and changes of materials subjected to pressing, twisting, hammering, bending, stretching, and heating or cooling used in making toys and utensils were developed with science educators at the University of Georgia. The learning activities addressed in the unit were centered on the 5-E model of inquiry. After the exploration of students' informal learning experiences with toys and utensils were collected and analyzed in phase one, appropriate cultural experiences related to students' experiences with toys and utensils served as an organizer for students' exploration of materials concepts and incorporated into the unit. The aspects of students' funds of knowledge and inquiry that should be addressed in the instructional unit were negotiated with two science educators and a scientist to make modifications appropriate for Thai students. The specific objectives, content, learning activities and assessment approach of the unit were modified. The science educators were consulted about the suitability of lessons and activities in the unit. The accuracy of materials concepts in the science curriculum were examined by a scientist who serves as a de-briefer in this study. One member of the research team, a doctoral student, modified the culturally relevant/ inquiry based instructional unit based on other research team members' feedback and suggestions. Three participant teachers who served as members of the research team were invited to participate in a small session with other research team members to discuss the relevance of the instructional unit to their school and students' context. The instructional unit was modified again, and the modified instructional unit undertaken a pilot study by the three participant teachers serving on the research team.

A pilot study was run by the three teacher members during the second semester, academic year 2006. The researcher asked permission from school administrators and teachers to observe how the three participant teachers taught follow the unit and how students participated in the learning activities for five weeks during every regularly scheduled science time, two periods a week for each teacher. The factors that constrained or facilitated the teaching of a unit that incorporated students' funds of knowledge and inquiry were investigated through classroom observation, interview of teachers and students, journaling and a follow up focus group meeting.

The unit was modified based on teacher reflections on factors that constrained or facilitated the teaching of a unit that incorporated students' funds of knowledge and inquiry gathered during a pilot study. A focus group meeting of research team members was conducted to center on modified unit in May, 2007. Classroom observation, interview of teachers and students, and journaling were conducted to investigate what happened when teachers implemented a unit on materials concepts designed around students' funds of knowledge during unit implementation in the first semester, academic year, 2007. The three participant teachers were asked about what and how students learned following every science period, during breaks or after school time. These three participant teachers were asked to write semi-structured journal entries about what constrains or facilitates the implementation of the unit that incorporates students' funds of knowledge and inquiry once a week. Three students in each classroom were interviewed about what they learned about specific material concepts and cultural knowledge at the conclusion of each lesson. Moreover, after the implementation time, a follow up focus group meeting was conducted to focus on a) factors that facilitated or constrained the teaching of the unit and b) themes that were emerging from the data analysis.

Table 3.1 The Time Line of the Study

Date	**Event**
December 2005 – February 2006	Review literature
March- April 2006	Design draft instructional unit
May-June 2006	Explore students' funds of knowledge
July 2006	Modify instructional unit
October 2006	Small session with three participant teachers
January-February 2007	Try out of instructional unit
June-July 2007	Implementation of an instructional unit
August 2007	Data analysis and interpretation

6. Data Collection and Analysis

6.1 Data Collections

Nine different types of data were collected in this ethnographic study: students' drawings, parent logbooks, interviews of parents, interviews of students, research team planning meetings, participant observation, interviews of teachers, researcher and participant journals, and artifacts to obtain the rich and descriptive information which is characteristic of qualitative research: 1) students' drawings were utilized to gain information about the kind of toys and utensils students used in their everyday lives; 2) parents kept a daily logbook, recording students' interactions with toys and utensils for a week; 3) two different types of interviews for nine parents and their children contributed to an in-depth understanding of students' experiences with toys and utensils. These information about kinds and experiences with toys and utensils were incorporated in designing the instructional unit.; 4) each of the five team planning sessions were audio-recorded to look at what takes place during the design, implementation and evaluation of the instructional unit. The five research team planning meetings were conducted before, during and after instructional unit implementation; 5) observation, particularly of each class and other sites within the school, provided insight into the classroom situations and the school environment in which teacher-student or student-student interactions take place; 6) grade one to three teachers were interviewed to explore what and how nine students learned in each science period, during break or after school time; 7) those same nine students from grade one, two and three were interviewed about their understanding of scientific concepts at the end of each lesson; 8) a subset of the research team, including the key researcher and three participant teachers, kept journals to reflect on their teaching experiences, factors that constrained and facilitated unit instruction and the incorporation of students' funds of knowledge and inquiry during unit implementation. In addition, the key researcher kept a journal throughout the unit development, implementation and evaluation phases; 9) finally, documents, including IPST science curriculum, textbooks, and teachers' old lesson plans that they used prior to the development of this unit served as secondary data sources of the study. These materials were collected and analyzed to ascertain the extent to which they included an emphasis on cultural relevance or any model of inquiry. The level of emphasis on cultural relevance and inquiry in both textbooks and teachers' prior lesson plans were critiqued and served as the basis for developing the culturally relevant/ inquiry based instructional unit. The detailed uses of each method in this study are described below.

6.1.1 Students' Drawings

During the second semester in academic year 2006, three classes of grade one to three students (one class/ grade) were asked to draw pictures of their favorite toy and utensil. The purpose of the students' drawing was to acquire information about the kinds of toys and utensils currently involved in their everyday lives. There were two item formats in the student drawing activity: open-ended question and illustration (See Appendix B). The open-ended question provided a place for students to describe their toys and utensils, and explain their reasons for selecting them. A space was provided for students to draw pictures of their favorite toy and utensil.

6.1.2 Parent Logbooks

Nine parents of grade one, two and three (three parents per grade) were asked to keep a week-long logbook which includes 11 following questions: a) what kinds of toys does your child play with today?, b) what it made of?, c) is it store bought, homemade or got from other?; if it is a store bought item, please give reason why you buy it, d) how does your child play with those toys, e) what sort of things you believe your child learn when playing with toys f) what are dangers of playing with this toy, g) what kinds of utensils did your child use today, h) what it made of, i) how does your child use these utensils, j) what do you consider when you buy it, and k) what are dangers of using with this utensil.

There are two item formats in this logbook. To gather information about the kinds of toys and utensils each child plays with and uses everyday, a name list of toys and utensils were provided as a checklist for parents. To ascertain information about how each child interacts with toys and utensils, open-ended questions were included. The logbook was organized in Appendix C.

6.1.3 Semi-Structured Interviews

Primary data were obtained through semi-structured interviews. Merriam (1998) stated that interviewing is necessary when it is not possible to observe the participants' behavior, feelings, or "how people interpret the world around them" (Merriam, p. 72). As Patton noted, "We interview people to find out from them those feelings we cannot directly observe. The purpose of interviewing is to gather information regarding an individual's experiences and knowledge; his or her opinions, beliefs, and feelings; and demographic data within a given setting (McMillan, 2004). Since it is not possible in the scope of this study, to observe fully students' interactions with toys, parents and students were interviewed about their knowledge and experiences with these materials.

Merriam (1998) described three categories of interviews including structured, semi-structured and open-ended formats. The highly structured interview consists of predetermined questions in which the wording of the questions as well as the order of items has been pre-selected. This type of interview represents an oral form of survey that allows the participant little or no opportunity for input into the types of questions asked, limited control over the direction the questioning may lead, and few chances to voluntarily offer personal perspectives, thoughts, feelings, or experiences. This type of interview is used mostly for gathering sociodemographic data from participants. The semi-structured interview contains a mixture of questions ranging from structured to unstructured. This type of interview allows the participant to respond to some of the questions in a more free form manner thus allowing for more exploration of the respondent's personal thoughts, feelings, and perspectives. The third type of interview is the unstructured, informal interview in which there is no predetermined set of questions and the interview is an exploration of the respondents' thoughts, feelings, and perspectives (Merriam, 1998).

In this study, a semi-structured interview format was used. In the semi-structured interview format questions were planned and their order was arranged ahead of time, although questions are not necessarily asked in a particular sequence. Additional questions not on the interview protocol are asked for clarification, elaboration and openness to responses to go in a different direction. The major use of this type of interview was to gather parents' and students' funds of knowledge in the exploration phase. In addition, semi-structured interviews with each teacher provided information about what and how students learn science during the unit implementation phase. Moreover, three students in each grade level were interviewed about what they learned about specific material concepts and cultural knowledge at the conclusion of each lesson. Three different interview protocols were used to inform the study. The purposes of the interviews and the protocols used are described below. The interviews were recorded, transcribed, and pseudonyms were assigned. The interviews were recorded using an audio-recorder. Each participant was assigned a pseudonym before each interview was transcribed. The pseudonym was used to refer to the participant throughout the study.

A. Parent Interview

The interviews with parents occurred at the beginning of the 2006 school year immediately following their completion of an observational logbook. The purpose of the interviews was to explore students' informal experiences with toys and utensils at home, as well as background information about the history of these materials within each family. Nine parents were interviewed about their child's favorite toys and utensils, including both homemade and store bought items, and their observations of the child's interaction playing with these materials. They were asked to share stories about how their child played with or used these toys and utensils. The same general semi-structured protocol was used with each parent; however, there were variation in the interviews because of the weekly logbooks kept by each parent.

B. Student Interview

Two interview types with nine grade one, two and three students were conducted over the course of this study. In the first interview, questions focused on determining students' funds of knowledge about toys and utensils. Questions given to each participant depend on the results of their response to a drawing activity, and their parents' observation logbook. A semi-structured interview protocol was employed. This interview aimed to deeply understand what students know about and how they interact with toys and utensils. The interview process also provided students with a chance to reflect on their past experiences with and thoughts about toys and utensils.

In the second interview, individual interviews with nine students were conducted at the conclusion of each unit lesson. The purpose of the interview was to examine what grade one to three students were learning about material concepts.

C. Teacher Interview

At the end of each science period, the participant teachers were interviewed concerning their perceptions of what students learned. A semi-structured interview was conducted.

6.1.4 Research Team Planning Meetings

Focus groups are useful in that they "can yield a great deal of specific information on a selected topic in a relatively short period of time" and "offer new dimensions to data collection because of their emphasis on dynamic group interaction" (Vaughn, Schumm, and Sinagub, 1996, p. 13). The research team planning meetings, a type of focus group, are particularly useful in this study in order to collect data about the process of developing an instructional unit. Four planning meetings were conducted with the research team to modify the culturally relevant/ inquiry instructional unit.

The first group meeting included three science educators, and a scientist. This meeting included a discussion of what aspects of students' funds of knowledge and what aspects of inquiry should be addressed in the instructional unit. In the second planning meeting the research team members considered and discussed the instructional unit modifications stemming from the first meeting. The three participant science teachers were included in this meeting to discuss modifications appropriate for the school and student context. The unit was run as pilot study by the three teacher members during the second semester, academic year 2006. The third focus group planning meeting was conducted during and after a pilot study to discuss observations of what is taking place during the unit instruction. Moreover, factors that constrain or facilitate the teaching of a unit that incorporates students' funds of knowledge and inquiry ascertain through classroom observation, interview of teachers and students, and journaling appeared in a follow up focus group meeting were served as a basis for unit modification. In the fourth focus group planning meeting, the research team members considered and discussed the modified instructional unit stemming from unit try out. This modified unit was implemented in the first semester, academic year 2007. At the conclusion of the unit implementation; a follow up focus group meetings was conducted to focus on a) factors that facilitate or constrain the teaching of the unit and b) themes that are emerging from the analysis of data. Field notes were taken during all of the focus group meetings. According to Bogden and Biklen (1992), field notes are written accounts of information observed during the data collection and analysis process. Field notes that are descriptively taken involve recording dates, what the setting is like, the social interactions that take place during the meeting as well as substantive content of the discussions. In addition, each planning meeting was audio recorded.

6.1.5 Participant Observation

Participant observation is the primary technique that enables the researcher to witness and record data on real events in real time within the lived context (Yin, 1994). During participant observation, the researcher takes part in the daily activities of people, reconstructing their interactions and activities in field notes which usually consist of detailed notation of behaviors, events, and the surrounding contexts. The researcher determines what people do, listens to what people say, and interacts with participants such that they become learners who are socialized into the group under investigation.

To investigate how students participated in an instructional unit that incorporated funds of knowledge and inquiry, all science teaching-learning activities in three classes of grade one, two and three were observed twice both in during a pilot study from January to February 2006 and unit implementation in every regularly scheduled science time, two periods a week for each class during June-July, 2007.

Participant observation was enable the researcher to determine how participants were processing information and reacting to the unit. Field notes and a journal were kept throughout the implementation phase. The form of these notes may vary, but they contained sufficient information to recreate the observations. Field notes were complete and descriptive, and include everything the researcher/ observer feels important. In addition to what is actually observed, the field notes contained the observer's feelings and reactions toward the events observed. Some basic information were also included the field notes: the date, who was present, the place and time of the observation, what activities took place, and other pertinent information.

The researcher role as a participant observer is to be involved primarily as an observer rather than an active participant in various activities in the field. In this study, the researcher is careful not to change the instruction designed by the teacher or the flow of thought or problem-solving processes among students. During observation days, the researcher asked follow-up questions about factors that constrain or facilitate the instructional unit. The researcher kept a reflective journal throughout the entire research process to summarize the most significant aspects of daily observations in the three science classes.

6.1.6 Journal

Another document that served as a data source for this study are journals that were kept by the three teacher members of the team. Journals are an effective way for individuals to reflect on their own experiences (Cortazzi, 1993; Clandinin and Connelly, 1994). Nichols *et al.* (1997) regard journals as a primary tool used in teacher education research. Maas (1991), in a preservice elementary teacher program, used journals to gather personal experiences from students, both about teaching and as a stimulus for class discussions. Volkmann and Anderson (1998) used journaling to explore the development of personal identity in a novice chemistry teacher.

In this study, the three teachers and the key researcher wrote journal entries for five weeks. The journals consisted of both semi-structured and unstructured entries and were used to gather information concerning participants' personal reflections upon their teaching experiences, factors that constrain and facilitate unit instruction and reflections about the incorporation of students' funds of knowledge and inquiry. Each week one or two questions were provided to focus the journal. A summative journal entry consisted of a written response to a question as well as a reflection about the classroom experiences during that week.

6.2 Data Analysis

Data analysis is a way to understand the data (Bogdan and Biklen, 1998). Data analysis is also defined as the process of making sense of the data (Schwandt, 1997). Analytic processes used in ethnography differ from those used in many other research designs. Rather than analysis following data collection, ethnographers analyze data throughout the study. The primary data sources include interviews, logbooks, classroom observations, team planning meetings, students' drawings and journals. Three steps of data analysis described by Miles and Huberman (1994) were utilized in this study. These steps are: 1) data reduction, 2) data display, and 3) conclusion drawing and verification.

Data reduction involves coding of data and the elucidation of themes present within the data. Lecompte and Schensul (1999) have used coding to organize data in terms of a framework to support the results and conclusions they reach at the end of a study. The coding process were accomplished through: 1) identifying data sources in order of chronological files and in terms of text numerical or alphabetic codes; 2) reading journal entries, interview transcripts, and notes; 3) after read repeatedly, tiding up and organizing data; 4) developing a primary list of coding categories. The names or symbols that represent a group of similar items, ideas, or phenomena that have been noticed in a data set were coding categories; 5) defining what is meant by each coding category, what kind of data can be sorted by it, and then providing an example of a unit of data that might be appropriately coded under categories; 6) reading through and reviewing the data; 7) grouping data from each source and placing into categories that relate to the research questions and basic theory of funds of knowledge and inquiry. Interview data were organized according to individual respondents and then grouped together across respondents. Similarly, observations were considered individually or by grouping similar types of occurrences together while also looking for differences among individuals, settings, or times; 8) after grouping data into categories, the patterns emerging from relationships among each category was delineated. The related data were displayed in an organized way which facilitates the formation of conclusions. In the final step, conclusion drawing and verification, the process of constructing meaning occurs by making note of patterns present from the data.

The three steps of the data analysis process, including data reduction, display, and conclusion drawing took place both within the individual case analysis and cross-case analysis of data. A detailed description of each case for each participant were analyzed, and then followed by analyzing and interpreting themes presented across the data sources. The analysis for each participant was completed before constructing a cross-case analysis. The final stage of analysis is the cross-case analysis in which analysis of themes common across the individual cases were examined and interpreted.

Summary

Ethnographic case study is used as the methodological basis of this study. The thick description of three elementary science teachers, who negotiate with three science educators, and a scientist in designing, implementing, and evaluating an instructional unit focused on material concepts was at heart of this study. Two groups of participants, including the research team and nine students and their parents are at the heart of this study. Nine students and their parents representing different gender and economic status at each grade level were interviewed about the kinds of toys and utensils they interact with in everyday life. Three science educators, a scientist and three experienced elementary science teachers were research team members who co-

construct and implement the instructional unit. The procedure of this study consisted of four phases which include a) exploring students' and parents' funds of knowledge about toys and utensils, b) developing a culturally relevant/inquiry-based instructional unit, c) implementing the unit with participant teachers who were members of the research team, and d) evaluating the factors that constrain or facilitate the teaching of a unit that incorporates students' funds of knowledge and inquiry. To obtain rich and descriptive information of what happens when a culturally relevant/ inquiry based instructional unit is designed, implemented, and experienced, common techniques of data gathering including students' drawings, parent logbooks, interviews of parents, interviews of students, research team planning meetings, participant observation, interviews of teachers, researcher and participant journals were used. The three steps of the data analysis process, including data reduction, display, and conclusion described by Miles and Huberman (1994) were utilized in this study.

CHAPTER IV

FUNDS OF KNOWLEDGE BASED CURRICULUM DEVELOPMENT

The chapter discusses the development of curriculum which draws upon the funds of knowledge found in grade 1-3 students' households. This chapter consists of two major sections: a) the description of students' informal experiences with toys and utensils identified as important funds of knowledge and b) the connection and integration of students' experiences into science curriculum. The first section starts with a description of students' and parents' background, followed by experiences in kinds and materials used in making toys and utensils, and then students' and parents' funds of knowledge, including students' science concepts and alternative concepts. Community funds of knowledge in terms of local products and religious rite are also discussed. The process in the developing of inquiry-based science curriculum about material concepts draw upon students' funds of knowledge is then discussed. The three guiding principles of the culturally relevant curriculum focusing on funds of knowledge, inquiry based teaching, and constructivism are described to guide way of teaching and learning about material concepts. The developing process comprises planning sessions with three science educators, a scientist and three experienced elementary science teachers and pilot study are reviewed. Finally, the contents and activities of each lesson are displayed.

Students' Informal Experiences with Toys and Utensils Identified as Important Funds of Knowledge

Moll and Greenberg's (1990) definition of funds of knowledge is used to guide this study. According to these researchers, funds of knowledge refers to knowledge and skills gained through historical and cultural interactions that are essential for individuals to function appropriately in his/her community. Funds of knowledge includes knowledge about any activities or interactions that take place in homes, for example cooking, farming, construction, cultural practices, and finances to name a few. This study emphasized developing an understanding of the students' interaction with toys and utensils at home. The funds of knowledge that students and parents specifically drew from in this study revolved around family life involving with toys and utensils, such as kinds of toys and utensils involving in their lives, everyday interactions with toys and utensils, ways of knowing the contents related to toys and utensils.

1. Students' and Parents' Background

The description of students' and parents' background is divided into two sections. It starts with the description of students' home settings and environments. The economic and educational backgrounds of their parents are then provided.

1.1 Home Settings and Environments

Information provided on 98 grade 1-3 students' profiles and nine students' home visits in second semester, academic year 2006 indicated that students' households were located in the central portion of Nonthaburi Province. There were generally crowded households. The neighborhood was easily accessible by public transportation such as bus, taxi and motorcycle on three main roads. There were many lanes distributed along both side of these main roads. Most of the student homes were located in three lanes placed along each main road. A similar structure of student households was apparent in the first two lanes. They consisted of a lot of apartment complexes and houses. Most of the students lived in 3-5 floor high apartments. Each floor was divided into many rooms. Most of these students went to school by bus and motorcycles. On route to the school from their apartment complexes, they passed furniture stores, construction material stores, restaurants, a shopping mall, market, hospitals and schools. Moreover, there was a big doll production industry in back of a lane, where community members worked to earn money. Community member relationships in these two neighborhoods were not close because most of them moved to the community only for 5-10 years ago in order to improve the opportunities for work.

By contrast, another neighborhood was significantly different. The community members had long and close relationship. There was a temple at the center of this community to express religion faith on Buddhist days. Community members came regularly to offer food to monks, pray or listen to a sermon on important Buddhist Days. Moreover, retired and unemployed members of the community had a small business of artificial flower making to earn money. Most of the students living in the community walked a block to school. On route to the school from the community, students passed restaurants, a laundry, and a barber shop. At the front of the lane, there was a shop, where the children in the study frequently visited before and after school to buy snacks and toys.

On the opposite of the school, there were a small furniture production shop and bendsteel shop. This furniture shop was located behind the bus stop which most students use everyday. The bendsteel shop was located in the adjacent building. Students who traveled to and from school this way were familiar with these two shops and have observed how they work. The wooden furniture was made neatly by an experienced man, the owner of this shop. His products included doors, dressers, tables and chairs. The productions from the bendsteel shop all appeared on the school, including the gate, race, and roof frame. Moreover, there was a big shopping mall. This shopping mall was an important source of food, clothes, toys and utensils the community needs. Many restaurants including Pizza, Sukiyaki, and Fired chicken were also provided for students, parents and others.

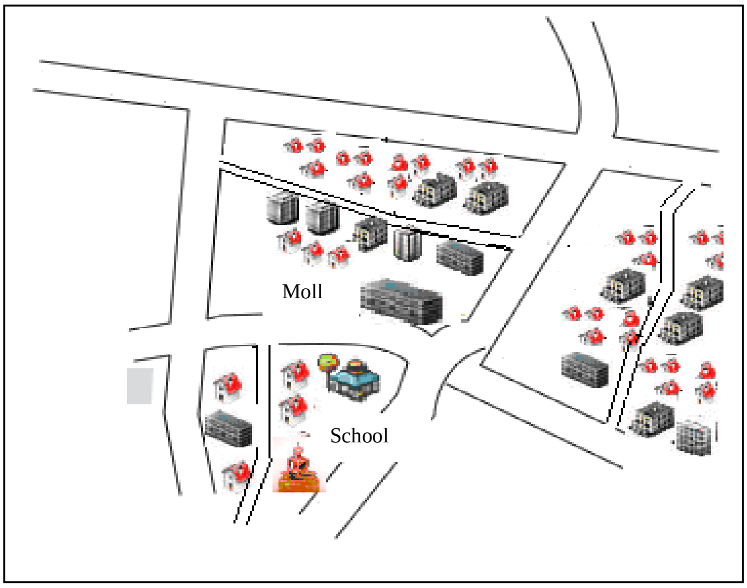

Figure 4.1 Students' Household Setting

1.2 Parents' Economic and Educational Background

In terms of the family economic background, the majority of students came from low economic families according to the National Statistic Institute report. The average income of people living in Bangkok, Nonthaburi, Patumtani and Samutprakan was around 36,096 bahts/month. Ninety nine percent of students' families got low salary than this average income. Most of them came from families with a monthly income of approximately 8,000-12,000 bahts/month. Only 1 percent (1 family) made more than the average monthly income. This family had 40,000 bahts/month. Forty eight percent of parents graduated from primary schools and thirty two percent graduated from high school. Only four percent graduated with a Bachelor's degree. Therefore, more than fifty percent were employees such as construction labor, truck driver, cooker, tailor, laundry job, and waitress. Nineteen percent were merchants. Another nine percent were housekeepers. Only six percent of the parents were government officials, three percent were company officers and one percent were employed in state enterprises that were high income jobs. In some families, the father was the only person who worked to earn money for the family. The mothers played an important role in taking care of the children and home.

The home visits of nine students from these ninety eight students revealed that the majority of households were comprised of small families with four or five members. Six of the students' families lived with parents and their siblings. The rest of students' families lived with grandfather and grandmother only. There was an extensive family. Eight family members lived in one house, including the grandmother, mother, father, sister, an aunt and her two children. The occupations of parents of nine students were truck driver, kitchenware production employee, soldier, dressmaker, publish company worker, car supplies store owner and housekeeper. These student experiences with toys and utensils, and students', parents' and community funds of knowledge are descried below.

2. Students' Experiences with Toys and Utensils

According to week-long logbooks, home visits, parents' interviews, students' interviews, nine students had different experiences with varied toys and utensils in terms of kinds and what they are made of. The description of kinds of toys and utensils of different households' students, and kinds of materials used in making students' toys and utensils are shown below.

2.1 Kinds of Toys and Utensils of Different Households' Students

Students from different households interacted with different kinds of toys and utensils depending on gender, age and their economic backgrounds. According to this study, there was a great difference in kinds of toys between the boys and girls. Boys had more number and a wider variety of toys than girls. Most of the boys played with action figures, electric games, vehicles, military toys, bikes, and toy animals. Most of the girls played with dolls, rump ropes, cooking sets and coloring books.

Comparisons among grade one, two and three students indicated that the higher level students tended to play with electric items that more complicate and concentrate than other levels. Grade one students normally played with fashion toys such as Barbie Dolls and action figures, while grade two and three students played with electronic games, handheld games, and computer games. In terms of utensils, grade one students were expected only to take care themselves and study in school. Therefore, most of their utensils were the clothing and stationeries. The grade two and three students were expected to use electric appliances, including televisions, refrigerators, electric fans, and CD players on their own.

Comparisons among economic status, students who came from higher economic background had more varieties of toys. These students played with electric games that were the expensive toys and had a different color and patterns of toy cars, Barbie Dolls, action figures. By contrast, students who came from low economic status normally played with only one or two kinds of toys. Most of their toys were kitchenware and home items. In terms of utensils, the student who came from a lower socioeconomic status had more experiences with varieties of utensils because they were expected to participate in household chores such as cleaning the house, food preparation, washing dishes, and caring for younger siblings. They then had experiences in using kitchenware and cleaning equipment.

2.2 Kinds of Materials Used in Making Students' Toys and Utensils

As illustrated in table 4.1, there were many kinds of toys and utensils involved in students' lives. These toys and utensils were variety in terms of kinds and number of materials they were made of. It could be summarized into four groups: 1) the majority of students' current toys were made of plastic, followed by rubber and metal. The rest of their toys were made of leather, glass, and wood. Utensils were made of different kinds of materials such as plastic, metal, fabric, glass, rubber, and fabric, 2) most of the students' toys and utensils were made of more than one kind of material. Examples of these are electric games, Barbie Dolls, bicycles, televisions, computers, etc., 3) objects that were made of leather, glass, and fabric were normally made of only one kind of material, and 4) some kinds of toys and utensils could made of different kinds of materials such action figures, Barbie Dolls, jump ropes, and pencils.

Table 4.1 Kinds of Materials Used in Making Students' Toys and Utensils

Objects	Kinds of Materials							
	Plastic	**Rubber**	**Metal**	**Glass**	**Paper**	**Leather**	**Wood**	**Fabric**
Action figure	X							
Action figure		X						
Jump rope		X						
Cooking set	X							
Ball						X		
Puzzle	X							
Balloon		X						
Marble				X				
Doll house					X			
Electric game	X		X					
Barbie Doll	X (hair)	X (whole body)						
Barbie Doll	X (hair and body)	X (face)						
Bicycle	X		X					
Jump rope		X					X	
Robot	X		X					
Toy car	X		X					
Tops	X		X					
Gun	X		X					
Pencil	X							
Ruler	X							
Eraser		X						
Cloth								X
Skirt								X
Short								X
Sock								X
Television	X		X	X				
Computer	X		X	X				
CD player	X		X					
Glass	X							
Spoon			X					
Pencil		X	X				X	
Mop	X		X					X

3. Students' and Parents' Funds of Knowledge

Data showed that students' experiences with varied toys and utensils in terms of kinds and what they are made of influenced the development of students' science concepts and alternative concepts.

3.1 Students' Science Concepts

There were five science concepts arose from their explanations when asked students and parents to provide explanation on how toys and utensils work. These concepts included concepts of physical properties of objects, kinds and properties of materials, change state of matter, force and motion, and electricity. The concept of physical properties of objects covered the concept of color, size, shape and weight of the objects. The properties of material concepts included softness of fabric, elasticity of rubber and fragile of glass.

The following description of students' knowledge is sequenced from concreted concepts that could be seen, touched, heard, or felt, to abstract concepts. Therefore, it starts with the concept of physical properties of objects, kinds and properties of materials, change state of matter, force and motion, and electricity.

3.1.1 Students' Knowledge about Physical Properties of Objects

Students initially developed concept of color, followed by shape and size through participation with the variation in color, size and shape of Barbie Dolls, action figures, balloons, and erasers. The finding indicated the color of objects was first recognized by all grade students. When students were asked to describe their favorite toys and utensils during home visits, most of the students explained by means of color. For example, a grade one boy responded "My favorite toy is a green action figure". One student response also revealed a conception about color. A grade one girl responded "I have two different Barbie Dolls, one comes with blonde curly hair and she is wearing a blue dress and the other comes with dark straight hair and wearing pink dress full with red roses". A grade two girl also showed similar explanation about color of Barbie Dolls. In addition, student's explanation about different color of balloons and erasers was appeared.

Moreover, students developed the concept of size and shape of objects through matching on the variation in color, size, weight and shape of a kind of object such as Barbie Dolls and action figures. Parents' interview responses also supported this assertion. Parents' responses about how students interact with toys and utensils contained some understandings about color, size and shape. A grade one parents whose child has five car toys, 20 action figures of different size, color, and style replied "my child can repair many pieces of these action figures that were taken apart together by looking at the relation of color, shape and size of each action figure". Moreover, one parent reported that his child developed the concept of size by comparing size of cloth used in wearing to different Barbie Dolls. This child described that one Barbie Doll had bigger chest than the other, and could not ware same size of clothes as the other.

In short, the way of knowing in the concept of observable properties of objects started with the recognizing colors, followed by matching on the variation in shapes and sizes of an object. The colorful and varied size and shape of action figures, balloons and erasers served as an organizer for learning this concept.

3.1.2 Students' Knowledge about Materials

The concept of properties of materials was developed by learning to distinguish between objects made of different kinds of materials. However, the number of students' explanations about properties in each kind of material was improved from the easiest concept of softness of fabric to fragile of glass, and then elasticity of rubber. The difference was the influence by the accessible properties of each material.

A. The Softness of Fabric

The concept of fabric and its softness were accessed easily for students who involved with push dolls and one of the grade three student parent. The words “fabric” and “softness” of fabric was used by grade one to three girls. When these students and a parent were asked to describe why they and his child loved their dolls, they responded “they love doll because of its softness”. In addition to the concept of softness, parents described other properties of fabric. A parent responded “The softness, thickness and running out of color are the important things were concerned when I bought clothes”. Moreover, a parent also described specific kinds of fabric, including cotton and silk used in making clothes.

B. The Fragile of Glass

Students developed the concept of fragile of glass before realized about this kind of material. The fragile of glass has been developed when students learned to distinguish between different uses of dishes and glasses made of plastic and glass by students and parents; however, students could not mention word “glass”. Based on students’ interview responses, two students described glasses and dishes were fragile and easily broken. They realized that eating sets they use normally in everyday live differed from what their parents use. They noted that, their dishes were breakable. Parents’ interview responses also supported this assertion. Parents of two students reported that their children had developed concepts of materials naturally according as they grew. As one parent explained, “I provided them with plastic glasses and dishes when they were preschool and shifted to glass and ceramic that was heavier and more fragile”. Additionally, parents showed understanding that raw material used to produce glass is sand. To develop understanding about fragile of glass, the comparison between different properties of glass and plastic of eating sets was an alternative way.

C. The Elasticity of Rubber

The students and parents have been developed concept of rubber in different ways depending on their experiences. Some students developed concept of rubber by distinguishing between different uses of same object made of rubber and plastic. For example, a grade one boy who had a wide variety of action figures showed conceptions about rubber and its properties when asked to describe his favorite toy. He said that “I love my green rubber action figure because it can take apart of hand, head from body and repair again while the rest action figures (made of plastic) would not”. In addition, grade one to three girls could describe the same property of rubber but could not name this kind of material. Their responses were that rubber bands they used in making jump ropes were stretched. Similarly, these explanation patterns were seen from parents’ interview responses. Moreover, concept of rubber and its elasticity was developed by a parent when he explained that “my child Barbie Doll is made of rubber because it can be bent and turn back to same shape and size. A parent was able to give the specific name of “Yang-Pa-Ra” (Hevea Brasiliensis), used in making rubber band. Moreover, a grade two girl had developed the ideas that the shape of materials used in making balloons could be changed by the application of forces. This student showed a flower and sword by twisting balloons, and said “my neighbor can shape of long balloons into any given shape”. However the girl did not realize that the balloon was made of rubber. The common way students and parents used to develop the concept of rubber was the learning to distinguish different properties of rubber and other kinds of materials through providing the same objects made of different kinds of materials, and followed by term of “rubber”.

3.1.3 Students’ Knowledge about Change State of Matter

Students’ understanding the concept of change state of matter was observed. One grade three student described his favorite utensil as the refrigerator, a thing that could cool food and drinks and prevent them from spoiling. Another student in the same grade demonstrated an understanding that liquid can be a solid through the process of freezing. This is the basis for developing the concept that refrigerators make things cold by heat transfer from a higher temperature to a lower temperature. The refrigerator provides a low temperature environment that absorbs the heat from beverages and foodstuffs and carries that heat away.

3.1.4 Students' Knowledge about Force and Motion

The concept of force and motion was developed by participating with toy cars and tops. Students' conception of force and motion improved significantly across grade level. A grade one student stated that he loved his car toy because it could move when force was applied. This illustrated his development of the reaction concept that objects can be moved by the application of force. The concept of friction between floor and point of a tops appeared when a grade two boy and a grade three boy were asked to draw a favorite toy. One parent showed an increasingly complex understanding of force in tops. He responded "tops is science experiment toy, children can develop the concept of force, namely applied force make tops move, and when two tops rubbing together that slow them down or stop". In addition to describing the friction of tops, a grade three student mentioned the term "velocity" in relation to toy cars.

3.1.5 Students' Knowledge about Electricity

The concept of electricity and electric shock appeared in relation to the use of refrigerators. When asked to draw a picture of favorite utensils, one grade two student drew a picture of two people getting an electric shock while using the refrigerator. This notion can serve as the basis for understanding the concept that electricity always follows the path of least resistance. Electricity must have an uninterrupted path, or circuit, to follow. If your body becomes part of that circuit, electricity will pass through it. If your body's resistance to the flow is lowered by wet hands or feet, for example, enough electrical energy can flow through your body to kill you. Moreover, all parents recognized the danger of electric shock when playing with electric games or using electric appliances such as computers, refrigerators, televisions, CD players, electric fans. One parent showed a more developed understanding of good electric conductors of metal. He replied that “I told my child not to hold the metal part of plug when they insert a plug into a socket”. This parent also explained “I protected my daughter from statistic electricity contained in computer by using of circuit breakers and ground wire”. This parent’ explanation is relevant to the concept that a connection to ground was done for safety purposes to protect people from the effects of faulty insulation on electrically powered equipment. It may be used to limit the build-up of static electricity when repairing electronic devices.

3.2 Students’ Alternative Concepts

The similarity of students’ current toys and utensils and everyday language used in naming objects and materials led to students’ alternative conception about materials**.** These students’ alternative conception included confusion between rubber and plastic, rubber and fabric, plastic and fabric, mirror and glass and leather and rubber.

The confusion between plastic and rubber of students and parents was influenced by similarity of students’ current toys and utensils that made of both plastic and rubber. For example, a parent was not sure if the Barbie Dolls were made of plastic or rubber. Another example, a parent of a grade two girl also reported “my child plays regularly with Barbie Dolls but she does not realize what their body made of and think that their hair made of people real hair”. Some students had Barbie Dolls with copyrights that were made of rubber while others had fake Barbie Dolls made of plastic, except for the head. The plastic body Barbie Doll is less durable and flexible; its price is less expensive than the other kind made of rubber. In addition to Barbie Dolls, the stationeries (e.g. pencils, pencil boxes, color pencils) and furniture (e.g. dressers, tables, chairs and cabinets) are things that can make of more than one kind of materials. Pencils can be made of wood and plastic. Pencil boxes can be made of plastic and metal. School bags can be made of leather and plastic. Furniture can be made of wood, metal and plastic depending on its quality. Moreover, most of the students thought that familiar rubber items such as balloons, rubber bands, and action figures were made of plastic. In addition, the confusion between elasticity of rubber and fabric was found.

Student and parent everyday language used in naming kinds of materials was confusing that lead to students' misunderstanding between plastic and fabric, mirror and glass and leather and rubber. They named plastic as "Par Plastic" (Par=fabric). This led to students' misunderstanding between fabric and plastic. Moreover, some parents used word "mirror glass" instead of "glass" to describe kind of material used in making glass of water. These influenced on students' confusion in concept of glass. Not surprisingly, some students then described that glass made of mirror. Additionally, everyday language that parents used in naming rubber band was confusing. They called "Nung Yang" (Nung=leather, Yang=rubber) in stead of Yang (rubber). This led to students' misunderstanding about concept of rubber and leather.

4. Community Funds of Knowledge

Community funds of knowledge were defined as the experiences, knowledge and ways of being community member possess from being members of various figured worlds that matter to them, such as being members in the neighborhood where they live. Two main categories of community funds of knowledge are emphasized. It included local product and religious rite.

4.1 Local Products

Earthenware pottery is the important symbol of Nonthaburi Province. Koa Kret, a tiny island in the Chao Phraya River, accessible by boat from Wat Sanam Nua, not far from the Pak Kret District Office. On it live a community of craftsmen famous for their distinctive style of pottery which dates back many centuries. Koa Kret pots are known for their fine, red-black glazed surface and intricate design. The art of creating functional pieces of pottery in this island first began over 200 years ago by Mon people, and they have managed to retain the skills of their forefathers. Ancient people used pottery for sorts of things, including dinnerware, vases, and other household items.

Community funds of knowledge merged during the process of making pottery. This process included mounting the clay, shaping it by hand, decorating and cooking it in a kiln. During visit, key researcher observed that the clays were first plugged in a pug mill to thoroughly blend them. This machine takes the clay we feed into the hopper and mix it thoroughly, then pushed it through a pipe. The pottery maker described that a good plug mill forces almost all the air out of the clay. The plugged clays were then flatted by throwing it at a wheel thrown pottery, followed by creating the opening, widening the opening, shaping the pot, trimming the excess, and then removing the pottery from the wheel. Later, it was decorated by impressing and incising and fired at 1,100 ^{o}C for 24 hours.

Moreover, the community member also described that there are different pottery types. Each type is distinguished by its clay mixture and the temperature at which it is baked or fired. Earthenware is a pottery clay mixture that is fired at a low temperature. The low baking temperature allows the use of colorful glazes, but also yields a pottery that cracks and chips more easily than other types. The degree of hardness depends on the intensity of heat. After the invention, earthenware was coated with glaze to render them waterproof. Moreover, it was found that, when fired at great heat, the clay body becomes nonporous.

Beside, many local products, including textile, garment and fashion accessories, toys and games and decorative items as well as handicrafts are provided in the Province. The examples are dyed, batik clothes, artificial flowers, bamboo-woven handbag, Java weed box, incensed candle, and round bamboo tray for fish and dimsum, etc.

4.2 Religious Rite

Khao Phansa or Buddhist Lent is one of the important Buddhist Day. This is a time devoted to study and mediation. Buddhist monks remain within the temple grounds and do not venture out for a period of three months. Traditionally, this is done to prevent monks from tramping upon rice paddies when they venture out to receive offerings from the villagers. The celebration of the beginning of Buddhist Lent is marked by a ceremony of presenting larger candles to the monks. The wax candles are large enough to last through the three-month Rains Retreat. School, universities, public and private organizations, and villager living around temples will organize a colorful candle procession leading to a temple to express their religious faith. In addition to the candles, lotus flower, food and other useful items are given during this donation ceremony.

In summary, nine students had experiences with varied toys and utensils. Students had a variety of toys and utensils in term of kinds and what they are made of. Through participating with these toys and utensils, students had developed five key concepts, including physical properties of objects, kinds and properties of materials, change state of matter, force and motion, and electricity. The common way of knowing that students used to develop these concepts was the learning to distinguish between a variation of objects in color, size, shape and what they are made of. Therefore, the opportunities for students to use of a variety of toys and utensils as an organizer in developing material concepts were focused in the curriculum. The colorful, familiar and diverse forms of objects were served as the vehicle for learning because they are attractive, can elicit students' explorations about material concepts, and can serve as a tool to cross different students' culture and background. Moreover, the difference between home and school science were taken into account in the design of curriculum. These difference included perception about the stretching of some fabrics and their ability to return to original shape after they have been stretched of rubber, the similarity of objects that can made of both rubber and plastic and clarification of everyday language used such as "leather rubber", "plastic fabric" "mirror glass".

Connecting and Integrating Students' Funds of Knowledge into Science Curriculum

The goal of this section is to describe the co-construction process of an instructional unit about materials that incorporates funds of knowledge, principles of culturally relevant/curriculum, inquiry based instruction, and constructivism as the conceptual framework for curriculum development. The description of three guiding principles, curriculum development process and the learning activities is provided.

1. Three Guiding Principles of Material Curriculum

The three guiding principles of funds of knowledge, inquiry based teaching, and constructivism are described to guide ways of teaching and learning about material concepts.

1.1 Culturally Relevant Curriculum: Funds of Knowledge

This study drew primarily on notions of cultural relevance stemming from the original work and assumptions of Ladson-Billings (1990a). The term culturally relevant has been commonly used to characterize pedagogies which aim to connect students' lifeworlds outside the classroom with their educational experiences. Culturally relevant instruction should incorporate interactional patterns, instructional methods, and social contexts for learning that are culturally compatible with students' primary cultures. Culturally relevant teaching also integrates cultural elements from the student's everyday experiences into the curriculum and classroom instruction (Tharp and Gallimore, 1988; Pang, 2001). The development of culturally relevant curriculum is focused on students' cultural background, learning styles, interactional and social patterns, common knowledge, and the community needs (Marines and Ortiz de Montellano, 1993; Banks, 1994; Jone *et al*., 2001; Menchaca, 2001).

There are several common characteristics of culturally relevant curricula that cut across numerous studies. Culturally relevant curriculum is authentic, child-centered, and connected to the child's real life (Ismat, 1995). Culturally relevant curriculum should rely specifically on activities related to the cultures, lifestyle and symbols of students. Students' familiar culture can serve as a starting point and tool for helping students develop a deeper understanding of the history of science and related concepts. Culturally relevant curriculum often incorporates strategies that utilize cooperative learning and whole language instruction, and recognizes multiple intelligences and diverse learning styles (Association for the Advancement of Health Education, 1994). It employs materials from the child's culture and history to illustrate principles and concepts (Martinez and Ortiz de Montellano, 1988; Chisholm *et al.*, 1991; Dickerson, 1993; Chion-Kenney, 1994) and materials of local interest in educating children about problem solving and inquiry processes of science.

In particular, this study drew specifically on funds of knowledge, including students' own knowledge as well as parents' knowledge as a theoretical referent to design learning activities in elementary science curriculum in response to the emphasis on relevancy in the Thai National Education Act. Funds of knowledge refers to those historically developed and accumulated strategies (skills, abilities, ideas, practices) or bodies of knowledge and information that households use to survive, to get ahead, or to thrive (Moll, 1992; Gonzalez *et al.*, 1995). The emphasis is on various sources of funds of knowledge, including students' own knowledge, as well as parents' and community members' expert knowledge of agriculture, mining, economics, household management, materials, medicine, religion and other familiar topics (Moll, 1992; Gonzalez, *et al.*, 1995; Ladson-Billings, 1995; Barton, 1998; Osborne and Barton, 1998; Fusco, 2001). This curriculum design takes into account students' and parents' funds of knowledge emerging from their interactions with toys and utensils, and community funds of knowledge in the production of local toys and utensils.

1.2 Inquiry Based Approaches

The 5-E model of inquiry (BSCS, 1989) was a model that used as the basic framework in designing the unit. The 5-E model of inquiry could help students to enhance subject matter knowledge, scientific reasoning, cultivate interest and attitude about science (Bybee, 1993). This model includes engagement, exploration, explanation, elaboration, and evaluation as key elements of inquiry. Engagement involves creating interest by, for example, raising questions about an object or event in the environment to elicit responses that uncover what the student knows or thinks about the science concept. Exploration, the second step in the 5-E model, involves conducting simple investigations by encouraging students to work together without direct instruction from the teacher on concrete objects and observable events. During the explanation phase, the teacher encourages students to explain concepts and definitions in their own words, asks for justification (evidence) and clarification from students, formally provides definitions, explanations, and new labels, and uses students' previous experiences as the basis for explaining concepts. In the elaboration phase, teachers expect students to use formal labels, definitions, and explanations provided previously encourages them to apply or extend the concept and skills in new situations, reminds students of alternative explanations, and refers them to existing data and evidence by asking "What do you already know?" "Why do you think this is the case?". In the final step, evaluation, the teacher observes students as they apply new concepts and skills, assesses students' knowledge and/or skills, looks for evidence that students have changed their thinking or behaviors, and allows students to assess their own learning and group-process skills.

1.3 Constructivism

This study also drew on constructivism as both a referent to analyze the learning potential of any situation and method of teaching (Tobin and Tippins, 1993). Constructivists believe that learners come to science lessons already holding ideas about natural phenomena which they use to make sense of everyday experiences and their views of "how the world works" (Solomon, 1994, p.25). In particular, this study drew specifically on social constructivism. Social constructivism (Vygotsky, 1978; Bruner, 1996; Salomon and Perkins, 1998) purports that learning is a shared experience and accomplished through social interactions and language use within a social context. Vygotsky considered education a socio-cultural activity central to cognitive development (Moll, 1990). This perspective shares some basic tenets of social cognitive theory (Bandura, 1986) in which learning occurs as the result of reciprocal interactions between persons, behaviors and environments. Additionally, social constructivism supports the notion that knowledge is constructed from interactions between persons and their external environments, not solely from individual thinking (Schunk, 2000). Constructivist teaching involves classroom interactions in which the teacher helps the student gain a deeper understanding of reality.

To summarize students', parents' and community funds of knowledge about toys and utensils, the 5-E model of inquiry, and social constructivism were used in designing activities in this culturally relevant curriculum in order to promote connections between what students learn in school and everyday life.

2. Unit Design and Development Process

The development process of this culturally relevant and inquiry based curriculum can be categorized into five basic steps: 1) outline and state expected learning outcomes, 2) develop scope and sequence of concepts that align with science content standards, 3) design preliminary draft of inquiry curriculum which draw on students' funds of knowledge, 4) the planning session with research team, 5) pilot study and revision to develop the completed curriculum package.

2.1 Step 1: Outline and State Expected Learning Outcomes

This step is to prepare an outline that transforms the expected learning outcomes stated in 3rd and 8th strands in the National Science Curriculum Standard into knowledge, skills and attitudes needed for the learner to achieve. The expected learning outcomes were translated into descriptions of intended outcomes that the learner is able to do as a result of participation in planned activities.

The outcomes in terms of knowledge includes ability to a) explain observable properties of objects, kinds and properties of materials and compare types of materials in grade one, b) explain properties and their usefulness and selection of materials in grade two, and c) describe toys and utensils that have many components made from several kinds of materials as well as properties of materials in grade three.

Simple process skills of observation, investigation, classification and gathering data were focused on in grade one, while the ability to experiment and present information were focused in grade two and three. In the 8^{th} strand, nature of science and technology, the common scientific skills were stated across all grade levels. These skills include posing questions on subjects or situations, planning observations, investigations or experiments, using apparatuses and instruments for observation, measuring, investigating and recording data in a simple way, classifying data into groups, posing new questions from results of investigations, expressing opinions, participating in learning and carrying out of group activities, recording results, observations or providing explanations, and communicating and arranging data and findings to present study.

Students' interest, curiosity and carefulness are also included as essential elements in the development of comment scientific attitude.

2.2 Step 2: Scope and Sequence of Concept that Align with Science Content Standard

In this step, science content standards were analyzed to identify the material concepts required in the standard for level 1 students. The content covered four main concepts, including, observable properties of objects, kinds of materials, properties of materials and changes of materials. Grade one standards emphasize three concepts of object, observable properties of object, and materials used in making objects. Grade two standards emphasize two concepts of kinds and properties of materials. Grade three standards emphasize the three concepts of kinds, properties and changes of materials. The details of content and expected learning outcomes for each grade level are summarized in table 4.2

2.3 Step 3: Design Preliminary Draft of Inquiry Curriculum Which Draw on Students' Funds of Knowledge

In this step, the framework of a unit for each grade level was outlined, followed by the design of activities according to the 5-E model of inquiry, and the modifications of the inquiry instructional unit to make it more relevant to students' learning styles and their funds of knowledge.

2.3.1 The Inquiry Activities

The varieties of instructional strategies, including small group activities, whole class discussion, individual work, demonstration, field trips and use of games were applied in each step of 5-E model of inquiry.

Engagement involved creating interest as well as eliciting students' prior knowledge by raising questions about relevant objects, pictures of students' toys and utensils or events, as well as games.

Exploration, the second step of the 5-E model, involved group work activities where students were encouraged to take responsibility within small groups to investigate, share their different experiences and do experiments.

In the next step, students were encouraged to investigate the same concept specifically through their own examples and experiences.

Finally, the variety of assessments included games, students' worksheets, and observation of students' participation in each activity.

Table 4.2 Content, Knowledge, Skills, and Attitude Stated in Science Curriculum Standard (IPST, 2002)

Content	**Expected Learning Outcomes**								
	Grade 1			**Grade 2**			**Grade 3**		
	Knowledge	**Skills**	**Attitude**	**Knowledge**	**Skills**	**Attitude**	**Knowledge**	**Skills**	**Attitude**
Observable properties of objects	- explain the observable properties	-gather information about the observable properties	carefulness interest, curiosity	-	-	-	-	-	-
Kinds of materials	- explain kinds of materials - compare kinds of materials	- observe kinds of materials - classify kinds of materials	carefulness, interest, curiosity	- explain kinds of materials - compare kinds of materials	- observe kinds of materials -compile information of kinds of materials - present kinds of materials	carefulness, interest, curiosity	- analyze and explain toys and utensils that have many components made from several kinds of materials	- observe kinds of materials - classify kinds of materials	carefulness
Properties of materials	-	-	-	- explain properties of materials - explain usefulness and select suitable and safe materials	- experiment properties of materials - compile information of the usefulness of materials	carefulness, interest, curiosity	- explain properties of materials - explain usefulness and select suitable and safe materials	- experiment properties of materials - compile information of the usefulness of materials	carefulness, interest, curiosity
Change of materials	-	-	-	-	-	-	explain change its usefulness and dangers of materials when pressed, twisted, hammered, bent, pulled, heated and cooled.	- compile and present information of materials changes, its usefulness and dangers - experiment material - invent and present toys and utensils from local materials.	carefulness, interest, curiosity

2.3.2 The Modification of Activities in Accordance with Students' Funds of Knowledge

To take into account with students' lived experiences, their knowledge of familiar and relevant kinds of toys and utensils involving their everyday lives was used as a learning organizer in developing material concepts. In addition, community experts served as partners in sharing meaningful cultural experiences in science learning.

In term of learning organizer, pictures of students' own toys obtained during home visits were utilized to create interest at the beginning of many lessons, and to generate ideas about how they worked and what they were made of. Moreover, pictures of toys and utensils sold in shopping malls and newspapers were also used as materials for student investigations about the concept of kinds and resources of materials. In addition, these pictures were also used to develop games and worksheets to assess students' understanding about material concepts. Furthermore, toys and utensils students brought with them were used as learning media in the lesson on kinds of materials for grade three students.

In term of community experts, knowledge from community members including a dying cloth expert and a maker of earthenware pottery in Koa-Kret was used to extend students' knowledge of water absorption properties in grade two and changes of materials in terms of shape and size when pressed, pulled, twisted, hammered in grade three, respectively.

2.4 Step 4: The Planning Session

In this process, the research team was initially presented with the three guiding principles of the curriculum. This was followed by discussion of how to put the instructional unit into practice and the outcomes, content, learning activities, materials and assessment strategies stated in the unit were ascertained to be viable.

2.4.1 Focus of the Planning Session

Key focus areas during the planning session were the alignment of content with the current National Science Curriculum, the viability of learning outcomes, scientific concepts, learning activities, materials, and assessment strategies, the appropriateness of learning activities in terms of students' ability levels and their existing knowledge, the appropriateness of relevant materials as learning organizers, any school resources available, consistency of assessment and learning outcomes as well as major form of student worksheet.

2.4.2 Planning Session Outcomes

Typical outcomes from a planning session included overall expected learning outcomes, an outline of major concepts aligned with the current National Science Curriculum Standard, instructional strategies for each content area that corresponded with students' funds of knowledge, learning materials that were interesting, varied and relevant for students, and time outline of the activities.

A. Learning Outcomes

Overall expected learning outcomes covered three aspects of knowledge, skills and attitudes. The knowledge component emphasized students' abilities to explain, compare and give examples. The skills of posing questions, planning observations, carrying out, investigations or experimentations, using apparatuses and instruments for observation, measuring, investigating and recording data in simple ways, classifying data into groups, expressing opinions, participating in learning and carrying out of group activities, and communicating and presenting the studies were as well focus the main. Moreover, students' honesty, creativity, and rationality were included.

B. Key Concepts

The abstract and redundant concepts were released in this step. Most of this elimination was conducted in grade one. The learning for this grade students was limited by their academic abilities. Grade one teacher and science educators commented during the meeting that the learning to formulate meaning of term “object” was difficulty for grade one students. Moreover, grade one teacher recommended that grade one students had leaned five senses from another subject. It would be redundant to teach this concept again. One lesson in grade three was also released. Teachers mentioned that the concept of floating and sinking was not aligned with content standard for grade three students. Therefore, it was not included in the unit.

C. Learning Activities

According to the result of meeting session, research team agreed to focus the learning activities for grade one to three students on 5-E model of inquiry. It started with creating student interests through relevant objects and events, followed by allowing students in experiments to investigate properties and changes of materials from varied materials prepared by teachers. After students developed their own explanations during investigations, they were encouraged to investigate their own relevant objects to build connections between what they learn in and out of school, and use a variety of assessments.

1) Creating Student Interests through Relevant Objects and Events

To teach about kinds and properties of materials, grade one, two and three lessons started with sharing experiences in using toys and utensils. The grade one students were asked to share ideas on what school items such as tables, chairs, etc. were made of; grade two students were encouraged to share ideas on the use of familiar objects such as jump ropes (made of rubber) in the lesson on elasticity, and cleaning activity in a lesson of water absorption. Grade three students were encouraged to share their experiences in using kitchenware, participating in Baddish Lent and experiences with production of pottery.

2) Allowing Students in Experiments to Investigate from Varied Materials Prepared by Teachers

The next set of learning activities focused on experiments to investigate different properties of each kind of material and the construction of the concept of kinds of materials based on properties. However, in the planning process teachers could not agree on how to allow student input to drive the lesson. Some teachers mentioned that students lacked the ability to ask questions, construct hypotheses, make predictions, and used multiple methods to solve problems. These teachers argued that students could not be expected to initiate the investigation. However, they felt that the effort to encourage students' posing questions led to investigations still focused on the lessons.

3) Developing Their Own Explanations

In this step, students were asked questions and encouraged in whole class discussion to encourage their explanations, justifications and clarifications of their investigation.

4) Investigating Their Own Relevant Objects

The students were encouraged to investigate their own relevant objects to apply what they learned to explain their own objects. Moreover, the activities for each topic were discussed deeply in terms of implications for learners. Some issues discussed were the possible confusion between stretching of fabric and ability to return to original shape after being stretched, the similarity of objects that could be made of both rubber and plastic and the clarification of everyday language such as "leather rubber", "plastic fabric", and "mirror glass".

5) Use a Variety of Assessments

The research team agreed to use a variety of assessments and agreed that teaching and assessment strategies were consistent with the goals. The assessment included observation of students' participation in each activity, assess students' responses during participation in activities, using games and students' worksheets.

D. Learning Materials

1) Real Toys and Utensils: Student and School Items

The real toys and utensils both available in school and brought by students from home served as a learning organizer to develop the concept of materials. In the lesson on "Toys, Utensils, and Objects", the colorful and varied toys and utensils such as balls, dolls, Legos, wooden blocks, cooking sets, etc available in school served as a starting point and tool for helping developing a deeper understanding of the concepts of shape, size and weight. Further investigations of color, shape, size and weight of toys and utensils occurred by using the object students brought to school from home. Similarly, grade three students had an opportunity to learn the concept that one object consists of one or more than one kind of material, and that each part can be made of different kinds of materials through interactions with the toys and utensils that students brought to school from home. In the lesson on properties of materials, materials used in experiments about hardness, elasticity, water absorption and heat conductivity were provided by the teacher. The materials used in the experiment on change in materials were students' own items.

2) Worksheets

The teachers suggested that font size of worksheets and learning materials (games, index cards, etc.) had to be large for young students. They also felt that format of all worksheets had to consistent, fit on one page and include aims, procedures, and questions.

E. Time Available

An instructional segment of 24 hours was utilized to accomplish the teaching of the unit; eight hours for grade one, nine hours for grade two and seven hours for grade three. Most of the grade one lessons required two hours because students needed a number of experiences with observation and classification of the objects. All of grade two and three lessons required an hour except for the two activities of dying and making pottery where students learned from local experts.

2.5 Step 5: Pilot Study and Curriculum Revision

In this step, the curriculum was piloted with three participant teachers serving as member of the research team to explore of the viability of expected outcomes, the content, instructional strategies, assessment, and materials and to estimate the appropriate time needed for each activity.

2.5.1 Focus of Pilot Study

Key focus areas of interest during the pilot delivery were the meeting of the learning outcomes, the clearness and completeness of instructions, the appropriate sequence of the learning, and the time for each lesson. Based on feedback during discussion meeting, the units were revised and lesson plans enhanced with input from the participating teachers and their previous experiences and practices. The difficulties of items or activities causing the problem were identified and eliminated or changed before the final product was released.

2.5.2 Pilot Study Outcomes

The finding from classroom observation, interview of teacher, interview of students, and teacher journal entries found that the meaning of terms such as material, property, hardness, elasticity, and heat conductivity was difficult for students. Moreover, the concept of material resources was too complex for grade two students. The finding also found that the students' investigations and explanations were limited by school items prepared by teacher because it was not relevant to students. Some students could not talk and share experiences with toys and utensils that were not relevant to them. Moreover, experiences about dying cloth making, pottery making in grade two lessons, and candle making in grade three were not relevant to student lives. As a result, students showed interesting but not value the linkage between these activities with their everyday lives. Furthermore, the recording data into worksheets was difficult for low ability students and took much time. As a result, research team agreed to modify the content, activities, materials and time.

2.5.3 Curriculum Revision

The revision of the curriculum included six points on rearrangement of content, integration of science with other subjects, learning activities that students' own items and daily experiences served as a starting point for engaging instruction leading to relevant investigations, appropriateness of culturally experiences and learning materials and the time factor.

A. Rearrangement of Content

In term of rearrangement of content, the research team agreed that the concept of material resources was too complex for grade two students. This concept was replaced by the grade three concept of material, namely one material can made of one or more than one kinds of material.

B. Integration of Science with Other Subjects

The integration of science with the subjects of Thai language, art, mathematics and social study was emphasized in all lessons. For example, in the grade two kinds of materials lesson, students could develop the concept of materials used in making home items through home explorations, the use of numbers and graphs in gathering data, and the use of Thai language in naming kinds of objects such as furniture, kitchenware, dressing, and bedding.

C. Learning Activities

After pilot study, inquiry based activity was modified to meet with students' interests and experiences. The five key focuses of inquiry based learning activities are described below.

1) Addressing Students' Real Lived Experiences with Toys and Utensils to Engage Students' Learning

Learning activities were modified to be more relevant to students by using and asking questions about students' own items and daily experiences as a starting point for engaging instruction. These experiences included different kinds of materials used in making eating sets, cleaning and cooking.

2) Allowing Students' Decision Making in Conducting Investigations on Their Own Interests

In this step, students were encouraged to participate actively in hands-on activities and construct understandings of topics and materials that were relevant to their lives and interests. Teachers allowed students to make decisions in conducting investigations to pursue their own interests and topics relevant to them. The students' own toys and utensils were used as learning materials in experiment to investigate kinds, properties and changes of materials. Activities also focused more on students working cooperatively to explore their different home items and share their findings in class.

3) Allowing Students' Formulating Their Own Understandings

After students work collaboratively in groups, they were asked to formulate their own conclusions. Next, students in each group were asked to present the group findings and conclusions that led to whole class discussion.

4) Asking Relevant Questions to Make Connection to Students' Everyday Lives

Students were asked relevant questions to discuss on science knowledge connection to their everyday live. In addition, the knowledge students learning about local products with students' grandparent as well as learning through participation in Religious rites were emphasized.

5) Assessment Students' Development

The observation of students' participation in group and class and their responses to questions by teachers were emphasized. Moreover, students' ability to make connection of science concepts they being learned to everyday lives appeared at the end of lesson and students' worksheets were used to assess students' conceptual understanding about materials concepts.

D. Culturally Experiences

Knowledge from community members including artificial flower making by students' grandparent was used to extend students' knowledge of kinds and properties of materials in grade two. Moreover, making candle in Khao Phansa Day at temple was used to develop students' understanding about changes of materials when heated and cooled, and experiences in making bendsteel was also utilized to develop understanding about changes shape and size of materials when pressed, pulled, twisted, hammered, respectively in grade three.

E. Learning Materials

1) Materials: Student Items

Another change after pilot study involved the use of learning materials that students brought with them instead of students' familiar items prepared by teachers. Research team agreed that materials from students were more varied than those prepared by the teachers, especially in term of toys. Moreover, familiar materials encouraged students' participation through simultaneous talking in activities.

2) Worksheet

In addition, the worksheet format was modified to provide increased space or gathering more information from their own and other group knowledge of toys and utensils. The research team felt that this could facilitate students daily to develop explanation patterns. The problems on concept construction at the end of lessons were decreased. Moreover, the research team felt that the grade one worksheet format should be shifted from writing to drawing and matching, to take into account grade one students' abilities.

F. Time

To provide opportunities to think and talk freely, the appropriate time was taken into consideration. The additional time was provided for activities on observable properties of objects in grade one, and changes of materials in grade three. In the activity on observable properties, two hour were provided for students to observe and classify objects in basis of color, size, shape and weight. Moreover, in the lesson on changes in materials, three hours were provided for students in experiment to investigate physical change in materials when heated, cooled and three hours for physical changes when pressed, twisted, hammered, bent, and pulled.

3. Complete Curriculum Package

The instructional unit about materials is developed for teaching in Level 1, Grade 1-3, based on the National Science Curriculum of Thailand. There were two science sub-strands being integrated in the instructional unit.

Sub-strand 1: Matters and Properties of Matters

Standard Sc. 3.1: The student should be able to understand properties of matters, relationship between properties and structure and forces among particles, have skills in investigative processes and process a scientific mind, communicate acquired knowledge and make positive application of knowledge.

Standard Sc. 3.2: The student should be able to understand the principles and nature of change of state of matters, formation of solution, chemical reaction, master investigative processes and possess a scientific mind, communicate knowledge acquired and apply it positively.

Sub-strand 2: Nature of Science and Technology

Standard 8.1: The student should be able to use the scientific process and scientific mind in investigation, solve problems, know that the most natural phenomena have definite patterns explainable and verifiable within the limitations of data and instrumentation during the period of investigation, understand that science, technology and environment are interrelated.

3.1 Expected Learning Outcomes

The expected learning outcomes of grade one, two, and three students in two sub-strands is described in Table 4.3-4.4. The table 4.3 shows the expected learning outcomes aligned with the 3rd sub-strand of Matter and Properties of Matter. The table 4.4 shows the expected learning outcomes aligned with the 8th sub-strand of Nature of Science and Technology.

3.2 Lists of Matter Concepts

3.2.1 Concept in Grade 1

1) Concept of Objects

- Object is a term used to identify specific samples of matter.
- The properties of each object, including color, shape, size and weight are different
- Color, shape, size and weight are observable properties of objects. Colors: pink, blue, green, red, yellow. Shape: round, , triangle, oval. Size: big, small, long, short. Weight: heavy, light

2) Concept of Materials

- Objects are made of different things such as wood, plastic, metal, glass, etc.

3.2.2 Concept in Grade 2

1) Kinds of Materials

- Object is surround thing made of what called “material”
- Each object made of different kinds of materials depended on its use.

2) Properties of Materials

- Kinds of hard materials are plastic, metal, wood, and glass
- Kinds of elastic materials is rubber

- Kinds of materials that could absorb water are fabric and paper
- Different kinds of materials are used in making an object based on its intended properties and uses of that object

3.2.3 Concept in Grade 3

1) Properties of Materials
   - The best conductors of heat are metals
2) Changes of Materials
   - Heat and cool causes of changes of shape and size of materials used in making the objects
   - Force that press on objects causes of changes of shape and size of materials used in making the objects

3.3. Material Instructional Unit

The curriculum included seven subunits; three for grade one, two for grade two and other two for grade three. The seven subunits are called as following

Grade 1 Unit

Subunit 1. “Object”

- Lesson 1: Toys, Utensils and Objects
- Lesson 2: Toys and Utensils in Everyday Lives
- Lesson 3: Color- Shape, Size-Weight
- Lesson 4: Observable Properties of Surrounding Objects

Subunit 2. “Materials”

- Lesson 5: What Objects are made of?
- Lesson 6: What do You Know about Toys and Utensils?

Grade 2 Unit

Subunit 1: Kinds of Materials

- Lesson 1: “Material”
- Lesson 2: Materials and Toys-Utensils

Subunit 2: Properties of Materials

- Lesson 3: Hardness and Elasticity
- Lesson 4: Water Absorption
- Lesson 5: Local Materials

Grade 3 Unit

Subunit 1: Properties of Materials

- Lesson 1: Heat Conductivity

Subunit 2: Change in Materials

- Lesson 2: Physical Change When Heated and Cooled
- Lesson 3 Physical Change When Forces were Applied

The detail of concepts, outcomes, learning activities, materials, and assessments of each lesson is shown in the table 4.3-4.4. The table 4.5-4.7 shows the overall lesson plans for grade one, two and three, respectively. The table 4.5 shows the lesson plans for grade one. The table 4.6 shows the lesson plans for grade two students. The table 4.7 shows the lesson plans for grade three students.

Table 4.3 Sub-strand 3: Matters and Properties of Matter

Standard 3.1: The student should be able to understand properties of matters, relationship between properties and structure and forces among particles, have skills in investigative processes and process a scientific mind, communicate acquired knowledge and make positive application of knowledge.			
Level standard	**Expected Learning Outcomes**		
Grade1-grade 3	**Grade 1**	**Grade 2**	**Grade 3**
1. observe, investigate appearance of properties of materials used to make toys and things of common usage, compare and classify materials into groups, also specify criteria for such classification.	1. gather information and explain the observable appearances, namely shape, color, weight, size surface of the materials used to make toys and things of common use	1. observe, compile information and present materials used for making toys and everyday utensils	1. experiment and explain properties of materials used for making toys and utensils.
2. discuss types and properties of materials used to make toys and commonly used things, explain that toys and things may have many parts and be composed of many kinds of materials with each material serving different purposes, select and use materials and things correctly and safely.	2. observe, explain and investigate types and properties of materials used to make toys and things of common use 3. compare and classify materials, specify criteria for classification	2. experiment and explain properties of materials used for making toys and utensils 3. compile information, explain usefulness of materials used for making toys and utensils, and select suitable and safe materials	2. analyze and explain toys and utensils that have many components made from several kinds of materials 3. compile information, explain the usefulness of materials use to make toys and utensils, and select suitable and safe materials

Table 4.3 (Continued)

Standard 3.2: The student should be able to understand the principles and nature of change of state of matters, formation of solution, chemical reaction, master investigative processes and possess a scientific mind, communicate knowledge acquired and apply it positively.			
Level standard	**Expected Learning Outcomes**		
Grade1-grade 3	**Grade 1**	**Grade 2**	**Grade 3**
1. observe, investigate and explain changes in materials subjected to pressing, twisting, hammering, bending, stretching, heating of cooling, also dangers arising from changes in materials and make use of them positively.	-	-	1. compile information, experiment, and explain physical changes in the materials when pressed, twisted, hammered, bent, pulled, heated and cooled. 2. compile information, explain and present information relating to the usefulness and dangers resulting from physical changes in materials 3. invent and present toys and utensils from local easy-to-find materials.

Table 4.4 Sub-strand 8: Nature of Science and Technology

Standard 8.1: The student should be able to use the scientific process and scientific mind in investigation, solve problems, know that the most natural phenomena have definite patterns explainable and verifiable within the limitations of data and instrumentation during the period of investigation, understand that science, technology and environment are interrelated.

Level standard Grade1-grade 3	**Expected Learning Outcomes**		
	Grade 1	**Grade 2**	**Grade 3**
1. pose questions on subjects or situations as he/she is assigned or as interested in.	1. pose questions on subjects or situations as he/she is assigned	1. pose questions on subjects or situations as he/she is assigned or as interested in.	1. pose questions on subjects or situations as he/she is assigned or as interested in.
2. plan observations, investigations or experimentation based on own ideas or of group of whole class or together with those of the teacher and anticipate findings from investigation and suggestion and suggest ways to investigate or experiment.	2. plan observations, investigations or experimentation based on own ideas or together with those of the teacher	2. plan observations, investigations or experimentation based on own ideas or of group of whole class or together with those of the teacher	2. plan observations, investigations or experimentation based on own ideas or of group of whole class or together with those of the teacher and anticipate findings from investigation and suggestion and suggest ways to investigate or experiment.
3. use apparatuses and instruments for observation, measurement, investigation and record data in a simple way	3. use apparatuses for observation, measurement, investigation and record data in a simple way	3. use apparatuses and instruments for observation, measurement, investigation and record data	3. use apparatuses and instruments for observation, measurement, investigation and record data
4. classify data into group that can be investigated and compared and contrasted with preconceptions and present the study	4. classify data into group that can be investigated and present the study	4. classify data into group that can be investigated and compared and present the study	4. classify data into group that can be investigated and compared and contrasted with preconceptions and present the study

Table 4.4 (Continued)

Level standard Grade1-grade 3	Expected Learning Outcomes		
	Grade 1	**Grade 2**	**Grade 3**
5. pose new questions from results of investigation		5. pose new questions from results of investigation	5. pose new questions from results of investigation
6. express opinions, participate in learning and carrying out of the group activities so that data from the group can be used to created new knowledge	5. express opinion, participate in learning	6. express opinions, participate in learning and carrying out of the group activities so that data from the group can be new knowledge	6. express opinions, participate in learning and carrying out of the group activities so that data from the group can be used to created new knowledge
7. record and explain result, observations straightforwardly from actual observation by drawing pictures, diagrams or providing explanations	6. record and explain result, observations by drawing pictures, or providing explanations	7. record and explain result, observations straightforwardly by drawing pictures, diagrams or providing explanations	7. record and explain result, observations straightforwardly from actual observation by drawing pictures, diagrams or providing explanations
8. communicate and arrange to present the study orally or by writing on concepts, process and results arising from objects and works carried out	7. communicate the study orally	8. communicate the study orally on concepts, process and results arising from objects and works carried out	8. communicate and arrange to present the study orally or by writing on concepts, process and results arising from objects and works carried out

Table 4.5 Framework of 1st grade unit

Concept	Knowledge	Skills	Attitude	Activities	Learning Materials	Assessment
Toy, utensil, and object	Terms of toys, utensils, and object	Observation	- eager to share experiences with peer - respect for the view of others	Engage: use game to elicit students' prior knowledge about name of objects Explore: share experiences on how their toys and utensil work in groups Explain: asking questions lead to group discussion	toys and utensils students bring to school	students' worksheets, observation of students' participation in each activity, assess students' response during participation in activities,
	toys and utensils in everyday live	Classification Presentation	-creativity	Elaborate and Evaluate: make toys and utensils collage, and asking questions	Picture from magazine, new paper and flyer	
Observable Properties	color, shape	Observation Classification Communication	- Connect what learn about observable properties to their live - work carefully	Engage: share students' experiences in playing with plasticines Explore: create different shapes of colorful plasticines and grouping Explain: asking questions	Students' plasticines	
	size, and weight	Observation Classification	- eager to investigate - work carefully	Explore: play and compare size and weight of different kinds of balls Explain: asking questions	Students' balls	
	Color, shape, size and weight	Observation Classification	- eager to investigate - work carefully	Elaboration and evaluation: play games by finding things according to stated properties	Classroom and students' own objects	
Type of materials		Observation Asking questions	Work carefully - eager to share experiences with peer - rationality	Engage sharing eating experiences Explore investigate kinds of materials used in making eating equipment in group Explain: asking question	Students' dishes, glasses, and spoons	
		Observation Asking question	- connection to real live	Elaborate and evaluate play game to access students' understanding in the concept of objects, its observable properties and kinds of materials it made of	School and students' own items	

Table 4.6 Framework of 2nd grade unit

Concept	Knowledge	Skills	Attitude	Activities	Learning Materials	Assessment
Kinds of materials	Kinds of materials	Classify	Work carefully	Engage show real objects and ask questions to elicit students' prior knowledge about objects Explore ask students to investigate kinds of materials used in making surround items in groups Explain asking questions lead to student conclusion	- school and students' own items	students' worksheets, observation of students' participation in each activity,
	Kinds of materials used in making each kind of object	Compile information Use number Presentation	Rationality	Elaborate explore and share information about kinds of materials used in making home items Evaluate worksheet	- students' home items	assess students' response during participation in activities,
Physical properties	Hardness, elasticity	Experiment Ask question Use simple equipment	- Honesty - work carefully - rationality	Engage: show students' rubber jump ropes, and then ask questions Explore: plan and do experiment Explain: asking question to construct the explanation and concept	Students' jump ropes Students and school items	
	water absorption	Plan and experiment	- Honesty - rationality	Engage: share experiences of cleaning by soaking rag into bowl of water Explore: do experiment Explain: asking question to construct the explanation and concept	Students and school items	
	Local materials	invent	- awareness - rationality	Elaborate: learn how to make artificial flower from students' grandmother Evaluate worksheet	Local materials	

Table 4.7 Framework of 3rd grade unit

concept	Knowledge	skills	Attitude	activities	media	Assessment
Properties of materials	Heat conductivity	Observation Experiment	- rationality - carefully	Engage: share ideas about different kinds of spatula used in cooking Explore: do experiment Explain: asking questions Elaborate and Evaluate explore home items	Spatula students bring to school Home items	students' worksheets, observation of students' participation in each activity,
Change in materials	Change in materials when cooled and heated	Experiment Use equipment	-eager to participate in experiment - value of Religion rite	Engage: share experiences about making candle in Khao Phansa day Explore: make candle at the temple Explain: whole class discussion Elaborate and evaluate: give example of everyday cooled and heated things	- local material at temple	assess students' response during participation in activities,
	Change in materials when pressed, twisted, hammered, bent, and pulled	Observation Experiment Ask question Use equipment Invention	- Eager to participate in experiment - Creativity	Engage show bendsteel, the familiar product in school community, and then asked questions Explore do experiment on the change of materials Explain whole class discussion Elaborate watch video about making pottery Evaluate: invent their own pottery	- Bendsteel examples from local shop - video about bendsteel making and pottery making	

Table 4.8 Grade 1 Material Lesson Plans

Sub-Unit 1: Object						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
1. Toy , Utensils and Objects	120	Students are able to - explain meaning of toys, utensils and object - describe characteristics and uses of their toys and utensils - give examples of everyday toys and utensils - observe characteristics and uses of their toys and utensils - classify objects into groups of toys, utensils - share idea freely and actively with peers	Object is a term used to identify specific samples of matter. Toy is a plaything of children aimed at providing fun and developing and expanding a child's potential. Utensil is an object used to do a job for a specific purpose.	Engagement: Elicit students' prior knowledge about objects' names by playing with a colorful ball glued with pictures of toys and utensils Exploration: have students explore and share many examples of toys and utensils in groups, Next, have individual student state about their toys whether it is "something you play with" or "something you for a specific purpose to do a job" and place objects on two different table Explanation: whole class discussion by asking questions	- Colorful interested ball - Students' own toys and utensils	- Observe students' participation in each activity - Assess students' response when they classify toys and utensils into group their collages
2. Toys and Utensils in Everyday Lives	60	- compare the difference between toys and utensils - classify and gather surrounding objects into groups of toy and utensil - present their task - crate task creatively		Elaboration and Evaluation - have students make an individual toy and utensil collage from pictures of toys and utensils available from magazines or newspaper	Picture available from magazines or newspaper	

Table 4.8 (Continued)

Sub-unit 2: Observable Properties of Objects						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
3. Shape-Color, Size-Weight	120	Students are able to - describe color, shape, size and weight of objects - compare color, shape, size and weight of objects - observe difference of color, shape, size and weight of objects - classify objects into group of color, shape, size and weight - communicate with others	Color, shape, size and weight are observable properties of objects. Colors: pink, blue, green, red, yellow Shape: round, , triangle, oval Size: big, small, long, short, Weight: heavy, light	Engagement: - Create students interest with many color of plasticine Exploration: Activity 1: have students shape their plasticine independently and grouped them Activity 2: have students compare and sequence their own balls by size and weight in group Explanation: whole class discussion about different ways students describe plasticines and balls.	Students' favorite toys	-Observe students' participation and answer in each activity
4. Observable Properties of Surrounding Objects	60	- describe and compare differences of color, shape, size and weight of surrounding objects - identify what properties are used to classify common objects - observe and gather objects by color, shape, size and weight	The properties of each object, including color, shape, size and weight are different	Elaboration - have groups of students collect at least three objects in classroom on the basis of the property appearing on index card Evaluation - ask whole class to conclude observable properties of objects and give examples of each properties and then work individually on work sheet	Surround objects in classroom	

Table 4.8 (Continued)

Sub-unit 3: Materials						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
5. What objects are made of?	60	Students are able to - explain that objects are made of wood, fabric, metal, plastic, glass, etc. - identify and compare types of materials used in making objects - observe difference of each kind of material - ask questions about materials used in making toys and utensils - share ideas and experiences about different materials used in making same objects. - reasoning selection of toys and utensils	Objects are made of different things such as wood, plastic, metal, glass, etc.	Engagement - Raising questions about students' experiences with eating activity Exploration - Explore kinds of material used in making their own dishes and glasses in small groups Explanation - ask students to conclude on what they eating set are made of	Students' own eating sets	- Observe students' participation and answer in each activity
6. What do you know about toys and utensils?	60	- use observable properties and kind of materials to describe unique of each object - observe observable properties and types of materials used in making each object - relate concept of observable properties and kinds of materials to familiar objects	Each object contain unique observable properties of color, shape, size, weight and made of specific kinds of materials	Elaboration &Evaluation - Game: Find the Object the student leader uses property words and uses to give the other players clues about the object (color, shape, size, etc.). After each clue has been given, the other group should make a guess. The leader continues to give clues until a team guesses what the object is.	Objects available in classroom	

Table 4.9 Grade 2 Material Lesson Plans

Sub-Unit 1: Kinds of Materials						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
1. Material	60	Students are able to - describe kinds of materials used in making toys and utensils - compare the difference between object and material - give examples of object and materials - observe and classify objects and materials - work carefully	Object is surround thing made of what called “material”	Engagement: teacher show classroom objects and ask questions to elicit students’ prior knowledge about objects Exploration: work in groups to investigate kinds of materials used in making classroom they involved in their everyday Explanation: asking questions lead to student conclusion	- School and students’ own items	- Observe students’ participation in each activity - Assess students’ response
2. Materials and Toys-Utensils	60	- describe and compare kinds of objects used in making their home items - compile information about kinds of materials used in making home items - numbering kinds of materials used in making each kind of object - Present their finding	Each object made of different kinds of materials depended on its use.	Elaboration: explore kinds of materials used in making furniture, kitchenware, bedding, clothing, stationeries, and toys at home, followed by gathering data in group in terms of graph, and then share the information with peers in the classroom Evaluation: have students work individually on worksheet to conclude what kinds of materials usually furniture, kitchenware, bedding, clothing, stationeries, and toys are made of	- Students’ home items - Simple table to make graph - Worksheet	

Table 4.9 (Continued)

Sub-Unit2 Properties of materials						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
3. Hardness, and elasticity	60	Students be able to - describe and compare hardness and elasticity of materials - experiment the hardness and elasticity of materials - asking questions about hardness and elasticity - use equipments to investigate hardness and elasticity of materials - record data straightforwardly from actual observation - work carefully and safety - reasonability in the selection objects in their lives	Kinds of hard materials are plastic, metal, wood, and glass Kinds of elastic materials is rubber	<u>Engagement</u>: ask students to share experiences on how they play jump ropes rubber to see ability to be stretched and return to original shape of them that let to students' posing question <u>Exploration</u>: ask students to figure out the way to experiment the hardness and elasticity of materials - have students experiment to investigate hard soft and elastic objects from a variety of materials by their own interests <u>Explanation</u>: ask questions to help students find common patterns of kinds of materials that are hard soft and elastic. <u>Elaboration and Evaluation</u> Have students explore a hard, a soft and an elastic toy and utensil, and then bring them to share with peers in the classroom	Students' jump ropes Many kinds of materials from students and available in classroom	- Observe students' participation in each activity - Assess students' responses

Table 4.9 (Continued)

Lesson	Period (min)	Learning Outcomes	Key Concepts	Learning Activities	Materials	Assessment
4. Water absorption	60	Students be able to - describe and compare water absorption of materials - experiment the water absorption of materials - record data straightforwardly from actual observation - reasonability in the election objects in their lives	Kinds of materials that could absorb water are fabric and paper	Engagement: ask students to share experiences of cleaning Exploration: ask students to experiment the ability to absorb water from a variety of materials based on their own interests, record finding on worksheets Explanation: have students present their finding, and then ask questions to help them see common patterns of kinds of materials that could absorb water and could not absorb water Elaboration and Evaluation: ask students about their everyday objects that normally use to absorb water and things used to protect water	Many kinds of materials from students and available in classroom	- Observe students' participation in each activity - Assess students' responses
5. Local materials	180	- describe kinds of materials used locally in student community - describe properties of local materials used in making local products - invent local products - Value on local products and career - reasonability in the selection objects in their lives	Different kinds of materials are used to make an object based on its intended properties and uses of that object	Engagement: ask students to share idea about local product Exploration: have students learn to make artificial flower from a student' grandmother and record about kinds and properties they used in making artificial flower on worksheet Explanation: ask students to present their finding, followed by classroom discussion Elaboration and Evaluation Have students do worksheet about the relation of kinds and properties of materials	Material from local experts Worksheet	- Observe students' participation in each activity - Assess students' responses

Table 4.10 Grade 3 Material Lesson Plans

Sub-Unit 1: Properties of Materials						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
1. Heat conductivity	60	Students be able to - describe that an object have many components made from several kinds of materials - describe and compare heat conductivity of materials - experiment heat conductivity of materials - reasonability in the selection objects in their lives	The best conductors of heat are metals	Engagement: have students share their spatulas to peers in the classroom and then asked to compare and discuss why different kinds of material used in making spatulas Exploration: have students experiment to investigate heat conductivity of their different spoons (plastic, metal, and ceramic) to compare heat conductivity of different kinds of materials by putting into hot water and then observe what spoons hot fastest Explanation: ask students what kinds of materials conduct heat most and then what of spoon and spatula should be for cooking hot foods. Elaboration and Evaluation: have students explore kinds of materials used in making each composition of other five kinds of kitchenware at home	Spatula students bring to school Spoon prepared by teacher Home items	-Observe students' participation in each activity -Assess students' responses

Table 4.10 (Continued)

Sub-Unit 2: Changes of Materials						
Lesson	**Period (min)**	**Learning Outcomes**	**Key Concepts**	**Learning Activities**	**Materials**	**Assessment**
2. Change in Material	(180)	Students be able to - describe and compare changes of materials when heated and cooled - give example of change in everyday cause by heated and cooled - experiment the change of material by heated and cooled - use equipment to do experiment - eager to work - see value and benefit of changes of materials for everyday life and religious event	Heat and cool causes of changes of shape and size of materials used in making the objects	Engagement: share experiences about making candle in Khao-Phansa Day, the day that people present candles to monks at temples Exploration: have students learn how to make candle for using in Khao-Phansa Day at the temple from monk. Students also made their small candles from paraffin wax at the temple to observe carefully on the changes After they back to classroom, students are asked to burn the candle and observe what happen Explanation: ask student about change of paraffin, metal candle and fabric used in making candle before and after heated Elaboration and Evaluation: have student give examples of everyday cooled and heated things	Local material at temple	-Observe students' participation in each activity -Assess students' responses

Table 4.10 (Continued)

Lesson	Period (min)	Learning Outcomes	Key Concepts	Learning Activities	Materials	Assessment
3. Physical Changes	180	Students be able to - describe and compare changes of materials when forces are applied - experiment by pressed, twisted, hammered, bent, and pulled on materials - use equipment to do experiment - eager to work - see value and benefit of changes of materials for everyday life	Force that press on objects causes of changes of shape and size of materials used in making the objects	Engagement: show bendsteel, the familiar product in school community, and then asked students to share experiences with the bendsteel production. Next allow student to watch VDO about bendsteel making of that shop in the community. This led to experiment about change of material Exploration: have students pressed, twisted, hammered, bent, and pulled on plastic, metal, wood and clay to observe their changes. Explanation teacher asked group of students to present their findings and then whole class discussion Elaboration: have student watch video about pottery making. Have students select to design they own bendsteel or pottery Evaluation: asked students to work independently on worksheet	Bendsteel from local shop - Video about bendsteel and potter making	- Observe students' participation in each activity - Assess students' responses

Summary

A culturally relevant and inquiry based curriculum design began with the investigation of students', parents' and community' funds of knowledge by studying, recording, and interpreting the context within which students, their families and neighbors live. The key researcher shared this knowledge with research team colleagues in order to better understand the community and the students' households. In order to make learning more appropriate and effective for students, awareness of students' learning styles and the use of students' culture as a basis for learning was emphasized in the design of an instruction unit on matter. The curriculum incorporated wide varieties of instructional strategies to accommodate diverse students' learning styles, used students' lived experiences, materials, local environment and community resources as a learning vehicle to link school science to the everyday lives of the students, and provide authentic and multiple forms of assessment for students to demonstrate what they have learned. The team planning sessions on how to put the instructional unit into practice and the viability of outcomes, content, learning activities, materials and assessment strategies was an important part of the development process. The pilot delivery was conducted to ascertain the viability of the meeting of the learning outcomes, the clearness and completeness of instructions, the appropriate sequence of the learning, and the time needed for each lesson. A description of this culturally relevant and inquiry based curriculum unit, developed in collaboration with three elementary science research team teachers, is presented in the next chapter.

CHAPTER V

CURRICULUM IMPLEMENTATION

This chapter discusses the implementation of an inquiry based curriculum on matter for grade one to three which drew on students' funds of knowledge. The chapter starts with a discussion of the implementation of the curriculum by three participant teachers during the first semester of the 2007 academic year. A description of how the three teachers implemented the unit, how students participated in the learning activities and factors that constrained or facilitated the teaching of the unit is provided. The curriculum implementation is discussed separately with respect to each teacher. This section includes a discussion of teacher and student background, classroom setting, the implementation of the curriculum and the students' understanding of material concepts, students' responses, and factors influencing each teacher's implementation of the curriculum. After individual implementation is presented, a cross case analysis of factors that constrained and facilitated the implementation of curriculum incorporating culturally relevant and inquiry-based approaches is provided.

School Context

Kwanpracha School was located in Nonthaburi Province, a suburban of Bangkok. Students attending this school mostly came from low socioeconomic backgrounds. The majority of students were Buddhist. The rest of the student population was comprised of Christian and Muslim. The Kwanpracha School was a middle school, providing education for K-6 students with 27 classes. There were four classes for each grade at the lower elementary level. One of these was a genius room, which had forty high achievement students. The rest of the classes had between 30-32 students, with a roughly equal distribution of boys and girls. There were 36 teachers working at the school. Most of them had graduated with a Bachelor's degree in varied disciplines such as science, sociology, Thai language, art, etc. There was only one teacher with a Master's degree and one teacher graduated in lower than Bachelor's degree.

When the bell rang to begin school at 7.45 every morning, all students in uniform stopped what they were doing in the classroom, cafeteria and playground, and came to see their teacher advisor in an area placed in the middle of school. At 8.00 a.m. students and teachers sang the national anthem, clasping their hands and giving thanks to the country, to Buddha and to the king, which upholds the Buddhist faith. Students then spent ten minutes doing aerobic dances to refresh their body and mind. In the last five minutes before the first period started, teachers talked about students' behaviors in relation to school rules and made some announcements. The teaching period started at 8.30 a.m. and finished at 3.30 p.m. There were six one-hour teaching periods, a small break after the first period to drink milk in accordance with government policy, and one hour of lunchtime. Every Friday, monks from the temple close to the school were invited into the school early in the morning. Parents and students came early to offer food to the monks. After students prayed to express religious faith to Buddha, they were asked to listen to a sermon to purify their minds.

Case Study One: "Vanvisa"
Grade One

1. Teacher and Student Background

The description of teacher and student background is divided into three sections, including educational background and teaching experiences, classroom setting, and students' information as shown below.

1.1 Educational Background and Teaching Experiences

Grade one science lessons were taught by a 56 year old teacher named Ms. Vanvisa. Ms. Vanvisa had neatly-cut, short, curry hair and usually wore slippers shoe, black pants, and a light-colored blouse. Ms. Vanvisa was married and had two adult daughters. She chose to teach at the school because it was close to her home making it more convenient to care for her family. Ms. Vanvisa had a Bachelor's degree in the field of sociology. She had taught elementary science for thirty five years at her current school. Moreover, Ms. Vanvisa, at the time of this study, was assigned to teach subjects of science, mathematic, social studies, work-oriented experiences and Thai language. In other words, she taught her class students all subjects except English, art and physical science for twenty one hours a week. Two of these hours were science periods.

1.2 Classroom Setting

Ms. Vanvisa was assigned to teach the first graders whose classroom was located on the second floor of the old school building. Students sat in pairs in four even rows all facing Ms. Vanvisa's desk and the front chalkboard. Next to the chalkboard was a bulletin board displaying colorful posters of Thai alphabets and vowels. On the left side of the classroom were big metal closets to store classroom supplies, students' profiles and reports. At the back of the classroom, there was a students' wooden bookcase for storing students' worksheets and textbooks. In a corner of the class, there was equipment used for cleaning. Along with the custodial staff employed by the school, the students also had the responsibility of taking care of the classroom. The wall opposite the door had large windows that faced the playground (See figure 5.1).

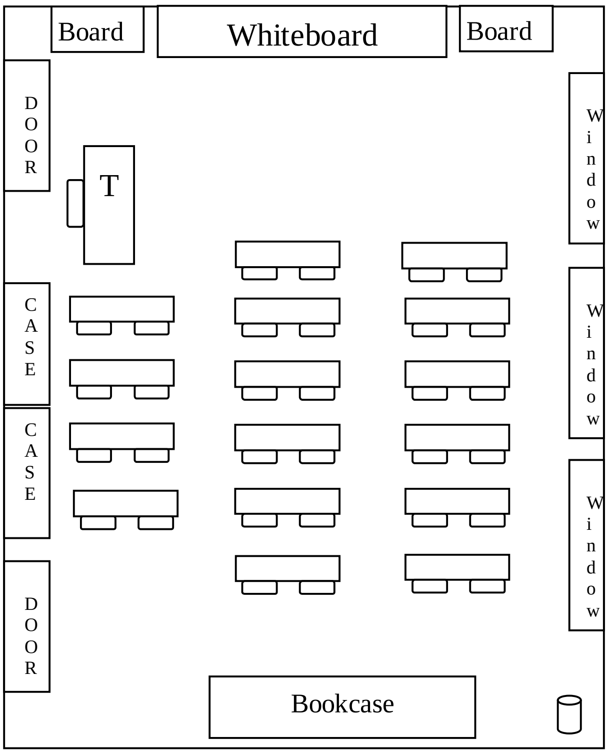

Figure 5.1 Ms. Vanvisa’ s Classroom Setting

1.3 Ms. Vanvisa’s Student Information

Ms. Vanvisa’s grade one science class contained fifteen girls and eighteen boys. Twenty five were aged seven, six were aged six, and two were aged eight. They were assigned to study science two hours a week. She described the class dynamic of the students as heterogeneous. Some of the students could not read or write because they never had the opportunity to study previously in a kindergarten class.

There were three students who were selected purposively to be studied in depth concerning their development of material understanding. The selection was based on gender and ability to give good reflections and descriptions of how they participated and what they learned in activities. The three students were called, Prapavee, Panuwat and Pollawat.

Prapavee was an eight year old girl. She was the header of the class, an active learner who was attentive in the classroom. She always answered teacher questions and was actively engaged in the classroom activities. She was a literate student who could read and write.

Panuwat was a seven year old boy. He was a literate student and an active learner in the classroom; however he sometimes shifted his attention to his friends. He was selected to participate in this study because he showed a willingness to be a participant during the lessons.

Pollawat was a seven year old boy who could not read and write well. He did not pay attention in the classroom, always played with friends who sat next to him, and sometimes wandered out of his seat to play with other friends.

2. Ms. Vanvisa's Implementation of the Curriculum and the Students' Understanding

The implementing of the instructional unit by Ms. Vanvisa is described in terms of the teacher's practices in classroom in parallel with the impacts on the students' achievements. Three students selected by purposive sampling in Ms. Vanvisa's classroom were studied in depth to reveal the development of their understanding.

2.1 Ms. Vanvisa's Practice

The description of Ms. Vanvisa's practices is provided in two sections according to aspects of culturally relevant practice and inquiry based teaching that served as a basic framework of the curriculum.

2.1.1 Ms. Vanvisa's Instruction and Culturally Relevant Practice

Evidence from classroom observations, teacher interviews and journal entries indicated that Ms. Vanvisa put her teaching on the value of relevant teaching by allowing students to share experiences about their varieties of objects. However, asking related questions to provide student opportunities to make connection of what they learned in school to real situations was not apparent.

According to classroom observation, Ms. Vanvisa facilitated her students to participate and share personal experiences on relevant objects to develop understanding about material concepts. In every lesson, students were allowed opportunities to share knowledge and experiences to demonstrate and explain their relevant understanding of their own toys and utensils that they brought with them. In interviews conducted after each lesson, Ms. Vanvisa provided evidence that she valued of relevant materials. Ms. Vanvisa mentioned that examples students brought with them had more varieties of materials than those prepared by the teacher and students could talk about and share experiences related to them. Therefore, Ms. Vanvisa agreed to use students' toys and utensil as learning organizers for students to develop understanding about material concepts in all lessons. In the lesson about objects, the students' favorite toys and utensils were allowed to be incorporated into the learning activities. Students were asked to share ideas about how their items worked at home. The items that students brought with them included dolls, robots, toy cars, raincoats, rulers, pens, scissors and spoons. In the lesson on shape and size, the varied colors of the students' plasticines were used to make different round, triangle and oval shapes and were then grouped together by the same color and shape. Different kinds of balls were used to develop the concept of size and weight. These included a football, basketball, tennis ball, golf ball, and ping pong ball. Furthermore, students' plastic glasses and dishes, metal spoons, melamine dishes, and the teacher's ceramic glass were used to explore different kinds of materials used in making objects.

However, it did not appear that Ms. Vanvisa asked related questions to provide students opportunities to apply what they learned in school to real situations. Ms. Vanvisa' s journal entry provided evidence that she did not place much value on connection of knowledge in other situations. Ms. Vanvisa commented that students could connect what they learned about objects, toys and utensils whenever they went to the shopping mall with their parents. Therefore, the ability of students to apply knowledge to new situations was not apparent.

2.1.2 Ms. Vanvisa's Instruction and Inquiry Based Approach

Ms. Vanvisa's classroom practice when analyzed in relation to the science teacher inquiry rubric (NRC, 2000 and Beerer and Bodzin, 2004) was somewhat inquiry oriented as it contained some aspects of inquiry, but not all aspects of inquiry. She could implement aspects of engage and allow students to investigate on their own; however, she could not accomplish inquiry aspects such as students' knowledge formulation and application.

A. Engaging Students' Attention and Eliciting Their Prior Knowledge and Experiences

Ms. Vanvisa engaged students in activities to get all student attention and elicit their prior knowledge and experiences on the topics at the beginning of the lessons. For example, in the lesson on "Toys, Utensils, and Objects", students were engaged in the activities by playing games and singing songs. This activity could elicit students' prior knowledge about names of surrounding items. In other lessons, students' experiences with their favorite toys and utensils were used as a starting point to foster student involvement in Ms. Vanvisa' s instruction. This showed the student-centered aspect of Ms. Vanvisa's instruction.

B. Conducting Investigations by Students

According to classroom observation, Ms. Vanvisa facilitated her students in learning by providing active hands-on activities. She provided opportunities for students to work together with some directions but not leading students step by step to a solution. She assisted students in participating and sharing personal experiences on relevant objects to further develop understanding about material concepts. Students were encouraged to participate actively in hands-on activities and construct understandings of materials that were relevant to their lives and interests. Responses in interiors conducted after each lesson provided evidence of her belief in the value of students' participation in hands-on activities. She mentioned that learning by doing hands-on was better than looking at pictures. She also stated that students were better able to construct their own understanding when they had opportunities to participate directly with real objects. However, Ms. Vanvisa, in a journal entry, commented that the implementation was not successful because students did not play much attention on her; rather, they played with their toys and utensils.

C. Making Conclusion by Teacher

Ms. Vanvisa concluded lessons instead of asking questions to help students formulate own explanations and make connection to everyday lives. It did not appear that she asked relevant questions to facilitate students in formulating their own explanations, and conducting linkage to students' everyday lives. According to observation and teacher interviews, it appeared that Ms. Vanvisa strongly explained key concepts to students. She did not ask guiding questions to probe their deeper understanding or encourage them to formulate their own explanations. Most of her questions were simple questions that were used to describe what students see and learn from their investigation. Ms. Vanvisa's interview response also indicated her role in explaining key concepts. She mentioned that the teacher needed to summarize key concepts being taught and give examples of the concept for students after they participated in activities to make sure that students gained all knowledge included in textbook. The key concepts provided by Ms. Vanvisa were observed in every lesson. Moreover, Ms. Vanvisa ignored students' resistance and mistakes and focused her teaching on students' participation. According to classroom observation, it appeared that she did not keep student track of when students encountered wrong turns or wrong answers. Ms. Vanvisa always called on competent students to answer her questions, and made demonstrations, and presentations of their findings. This did not match with student-centered aspect of inquiry.

In addition, encouragement of students to discuss the application of science concepts being learning in the lessons to real life situations was not appeared. Ms. Vanvisa just summarized what students were expected to know and then asked them to complete their worksheets. Ms. Vanvisa's interview responses after implementing the instructional unit indicated that she did not realize value in the application of knowledge and skills to new situations. Ms. Vanvisa felt that students could apply knowledge by asking their parents and looking at surround items at home and shopping malls by their own.

2.2 An Example of "Toys, Utensils, and Objects" Lesson

The follow learning activities illustrates Ms. Vanvisa's instruction, which an emphasis on previous aspects of culturally relevant practice and inquiry based teaching. The objective of the lesson was to teach students the concept that an object is a term we used to call samples of matter including all toys and utensils. The main activity focused on the classification of students' items into groups of toys and utensils based on their different uses leading to learning the new word of "object".

At the beginning of lesson, students were engaged with an activity to elicit their prior knowledge about the name of everyday toys and utensils. Students were asked to sit in a circle and then sing songs. They were then asked to pass a colorful ball glued with pictures of toys and utensils while they were singing a song. When the song stopped the student who held the ball was asked to tell what kind of things they found on the ball.

Ms. Vanvisa emphasized her students' classroom participation in the exploration of their own toys and utensils. Students were asked to sit in small groups and engage actively in exploring many examples of toys and utensils they brought with them over a set time limit.

Next, Ms. Vanvisa asked students to clear an area in the middle of the group. She had students bring out the collection of their objects, put them in the center of the cleared area, and asked them to describe their own items. In this way students were able to share their different experiences and learn how these items work through the information they gave and also received from other experiences. For example, a boy described to the group that small beads were his toys in stead of the utensils that people normally used in making ladies bags. He told the group how he tried to make magic in the same way as what he saw people do on the television, but could not. During the sharing time, Ms. Vanvisa walked throughout the classroom and talked with children in each of the groups and asked them to share ideas with their peers; however she did not use questioning to facilitate her students' explanations on the uses of their items. She just called on the students who were sitting quietly and asked them to participate in groups.

When the time was up, individual students were asked to pick their own items, name the object, and give explanations of how the objects worked. However, the researcher observed that it was not easy for Ms. Vanvisa to get her students to talk about their toys by themselves without asking guiding questions. One example of this could be seen in the case of Panuwat's explanation about his toy car.

Ms. Vanvisa: "What is this?"
Panuwat: "A remote control car"
Ms. Vanvisa: "Tell your friends how does it works".
Panuwat: "Control it!"
Ms. Vanvisa: "Tell more on how do you use or play with this toy"
Panuwat: "Control by remote"
Ms. Vanvisa: "Tell more"
Panuwat ………
Ms. Vanvisa: "This is a remote control toy car."

By contrast, this way of teaching was successful in case of competent students who could conduct a good and clear explanation about their own toys and utensils. An example of this was the case of Jirayut's explanation about his toy turtle.

Ms. Vanvisa: "What is your toy?"

Jirayut: "A turtle"

Ms. Vanvisa: "Tell your friends how you play this toy."

Jirayut: "After we wind the clock of the turtle, it can walk."

He then demonstrated to his friends how to play with his toy turtle.

After students saw the different use of each item, they were asked individually to tell the name of each object and state whether it is something you played with or something you use for a specific purpose or job. Students then placed the objects on a table under "something you play with" or on another table under "something you use to do a job". Students put their dolls, robots, and toy cars, etc. in the group of things they play with, and put raincoats, rulers, a comb, pens, scissors and a spoon in the group of things they used to do a job. During this time, students' mistakes when they put scissors, a spoon and a raincoat into the group of "something you play with" were ignored by Ms. Vanvisa until she noticed one student put a ruler into the group of toys. She then asked questions to redirect students' incorrect classification.

Mr. Vanvisa: "What does a ruler use for?"

Students: "Making line"

Mr. Vanvisa: "Is it thing for play with or use?

Students: "Use"

Ms. Vanvisa asked these questions repeatedly about scissors, a spoon and a raincoat to clarify students' understanding that these objects should be in the group of "things used to do a job".

Students were not required to play an important role in discussion or formulation of their own explanations. Ms. Vanvisa asked students few questions to identify similarities or differences between the two groups of objects. An excerpt from the conversation is shown below.

Ms. Vanvisa:	"What are dolls, robots, toy cars, and other things put on this table used for?"
Students:	"For playing"
Ms. Vanvisa:	"How do you call things used for playing?"
Students:	"Toy"
Ms. Vanvisa:	"What is a raincoat, rulers, a spoon and other things put on this table used for?"
Students:	"For using"
Ms. Vanvisa:	"How do you call things used to do a job?
Students:	"Utensil"

Ms. Vanvisa summarized for students that the terms "toy" was used for calling something you play with and "utensil" for calling something you use to do a job, and then gave examples of toys and utensils for students. Next students were asked to make conclusions about the meaning of toy and utensil and draw pictures of toys and utensils on worksheet at the end of period. After students were distributed worksheets, they were asked to complete two questions about something they used to play with, something they used to do a job. Ms. Vanvisa spelled these terms "toy" and "utensil", wrote them on the chalkboard and asked students to copy what she wrote on the board to worksheets.

Before students were allowed to draw pictures of toys and utensils on the worksheets, Ms. Vanvisa also gave examples of toys and utensils for students and then called on students to give other examples. Ms. Vanvisa normally focused on the importance of the right answer. She was likely to call on the high achievers, such as Sirinapa, Rujira and Ponrawat to give other examples of toys and utensils. This led Ms. Vanvisa to ignore other student reactions and answers. During classroom observation time, it was evident that Ms. Vanvisa felt uncomfortable in teaching the concept. Some students said that bicycle was their toy; while others students said it was a utensil. Ms. Vanvisa asked the researcher whether a bicycle is a toy or utensil. Moreover, she could not clarify the difference between toy and utensil when a student explained her idea that colored pencils were toys because she could use them to create funny drawings and coloring.

In addition to giving examples of toys and utensils to students, Ms. Vanvisa also provided the term "object" for her students. She said that an object is a term used to call things around us, and then asked students to copy this word on their worksheets.

3. Students' Responses

Evidence gained from classroom observation, teacher interviews, journal entries and students' interview responses indicated that Ms. Vanvisa was unsuccessful in improving students' understanding about material concepts. However, the implementation fostered students' attention and participation.

3.1 Students' Conceptions about Objects and Materials

The prior investigation of students' conception about materials before Ms. Vanvisa implemented the instructional unit found that most of the students at this grade could describe objects by uses and names, half of them were able to classify objects by observable properties, including by shape, color, size and weight, respectively. However, some students held misunderstanding about wood, metal, plastic, glass and rubber, respectively.

After participating in the curriculum, students developed better understanding about toys and utensils; but still contained similar understandings about observable properties of objects and materials.

3.1.1 Developing Concepts about Toys and Utensils

After participating in the curriculum, most of the students could describe the differences between toys and utensils and gained an idea that some objects can be both toys and utensils depending on their uses by sharing different experiences in using toys and utensils. Evidence from students' interview responses and worksheets showed that most of the students could describe toys and utensils by giving relevant examples of them. When Prapavee was asked to describe what toy and utensil meant, for example, she replied that "toys are Barbie Dolls, robots and model cars, while utensils are things for cooking and eating including spatulas, spoons, forks, knives, and chopsticks." If students were asked further what these toys and utensils were used for, they explained that toys are things used to play with and utensils are things used to work with. However, there were few students stated that color pencils and pillows were toys.

Ms. Vanvisa stated that students had a chance to learn about their toys and utensils from different perspectives when they were asked to share their own experiences on how various toys and utensils worked with their classmates. Some students played with certain items while others used the same item as a utensil. A bicycle, for example, is a toy normally used for playing after school time for some students. Other students used the bicycle as a vehicle. The bicycle could be both toy and utensil. In another example, Panuwat described his small beads that he saw on television that could be used to play by magician, in addition to being used for making bags. The objects that were mentioned as both toy and utensil in the classroom included bicycles, pencils, spoons and computers.

3.1.2 Containing Similar Conceptions about Observable Properties of Objects and Materials

The finding indicated that students could describe and compare colors, sizes, shapes and weight of objects, but they did not realize about these terms. Based on classroom observation and student interview, evidence suggests that students were able to describe and compare the colors and shapes of their surrounding objects found in the classroom and in everyday life such as bags, books, chalkboards, rules, etc. Moreover, students could also describe and compare different sizes and weights of various kinds of balls, such as a football, basketball, tennis ball, golf ball, and ping pong ball. Ms. Vanvisa's interview responses provided evidence to support students' knowledge. Ms. Vanvisa mentioned that students could develop understandings of color, shape, weight and size. They could describe blue, green, read, pink, yellow, orange, and purple. They also described squares, ovals, circle and triangulates. Moreover, students could compare and describe the size of balls. Students described a basketball as bigger than a football, and tennis balls, golf balls and table tennis balls, respectively. The analysis of worksheets found that around three quarters of students could match similarity of shape of objects. However, students could not describe that words "color", "size", "shape", and "weight" are terms used in naming observable properties of objects.

In concept about materials, Ms. Vanvisa reported that students could describe correctly that plastic was used in making dishes and glasses, and that metal was used in making spoons. However, it was the difficulty for students to describe that plastic and metal used in making the items are called "materials".

3.2 Fostering Students' Attention and Involvement

The inquiry and culturally relevant based instruction fostered students' attention and involvement in learning activities. Ms. Vanvisa's interview responses provided evidence on this notion. She mentioned that students showed more interests and paid more attention in the learning activities when they were asked to bring toys and utensils with them and share their experiences in the classroom. She further mentioned that using students' relevant examples in her instruction could generate students' interests and attention more so than learning through materials prepared by teacher. Moreover, Ms. Vanvisa found that some students' unfamiliar toys attracted the attention of other students. Students' interview responses also supported this ascertain. Students reported that they loved this activity because they had an opportunity to see and play with other toys that they had never played with before. For example, in the first lesson on “Toys, Utensils, and Objects”, Prapavee reported that she had learned how toys for boys such as robots and remote control cars worked. Panuwat reported that this is the first time he had played with golf ball. By contrast, it appeared that students paid less attention in the final activity because there were few students brought their eating sets to school to serve as a learning organizer for the lesson on materials. Ms. Vanivsa, in a journal entry, also provided evidence that the lessons fostered students’ attention after participating in the activities. She commented that students paid more attention, were eager in learning, and developed happiness in classroom participation. Students’ interviews also supported this assertion. They said that they loved being part of group work in sharing ideas and conducting investigation.

According to Ms. Vanvisa, being allowed to learn or share experiences about their relevant objects and experiences, students became active participants in their learning. Classroom observation and Ms. Vanvisa’s interview responses indicated that this curriculum enhanced the learning of low ability students by involving them in the activities. In the activities of size and weight, Pollawat who was not likely to participate in any learning activities, was willing to demonstrate how different kinds of balls work in middle of the classroom. These included a basket ball, tennis ball, and ping pong ball. According to interview the response of Pollawat after this lesson, he said that he enjoyed this activity because he loved playing with balls and he stated proudly that he could play football, basket ball, tennis and ping pong. However, not all students listened to their friends during share time and demonstration. Most of the students wanted to demonstrate how each kind of ball work.

In summary, evidence supported the conclusion that the curriculum as implemented by Ms. Vanvisa was unsuccessful in improving students’ understanding about material concepts. Through sharing and exchanging their experiences about their own objects in the classroom, students showed better understanding about terms toy and utensil; however, they still held similar understanding about observable properties of objects and kinds of materials used in making their toys and utensils. Moreover, students could not provide reasonable conclusions and applications of key concepts to real life situations. This might be the effects of the teacher providing key concepts. Students did not have much chance to think and make connections on what they were learning and experiencing. However, the emphasis of curriculum on student relevant topics and materials fostered students' attention and interests.

4. Factors Influencing the Implementation

The failure of the implementation of an instructional unit of Ms. Vanvisa depends on teacher' misunderstanding about culturally and inquiry-based approach, low ability in conducting scientific inquiry, perception on students' abilities, weak content knowledge and lack of good preparation as well as students' abilities and studying habits**.** The impact of each factor on Ms. Vanvisa' s instruction is described below.

4.1 Teacher's Misunderstanding about Culturally Relevant Practices

Throughout the discussion with Ms. Vanvisa during implementation time, she showed her belief and misunderstanding that culturally relevant practices occurred when students learned from examples they brought with them. Therefore, Ms. Vanvisa's instruction focused on the uses of students' toys and utensil as learning organizers for students to develop understanding about material concepts in all lessons but did not place the value on asking relevant questions to facilitate student connection of science concepts being learned in classroom to their experiences out of school. According to Ms. Vanvisa's interview response, she mentioned that the best learning materials used in science teaching were examples students brought with them because they have accessed to more varieties of materials than those prepared by the teacher and could talk about and share experiences related to them. Some comments Ms. Vanvisa concerning student relevant materials were:

"Using materials students brought with them were much better. Students had more varieties than the teacher"

"Students had a wider variety of (balls) objects. They consisted of small, large, light and heavy objects"

"Students could tell other students in classroom about the characteristics and uses of objects that were relevant to them. They were familiar with balls such as ping pong ball and football"

"It was good way to teach the lesson using real objects that came from the students. Students could describe how they toys work to each other. Moreover, it reduced the time needed by the teacher to prepare learning materials"

4.2 Teacher's Misunderstanding about Inquiry-Based Approach

Ms. Vanvisa believed and showed misunderstanding that the way of teaching science was to provide opportunities for students to be active learners through hands-on activities and direct experiences with real objects. Therefore, she strongly focused her teaching on students investigating on their relevant objects, followed by teacher telling and providing the correct definitions, answers, and concepts. Ms. Vanvisa's interview responses during the implementation also supported this notion. When asked to reflect on her teaching after teaching lesson 1, she said that "The activity today was good. It included the introduction, the activity, and then the summary of the lesson by the teacher". As a result, Ms. Vanvisa always made conclusions and gave her students relevant examples. This way of teaching decreased the opportunity for the students to summarize their understanding of the lesson.

4.3 Teacher' s Ability in Conducting Scientific Inquiry

Ms. Vanvisa' s low ability to provide opportunities for students in planning, and investigating on their own interests that can produce unexpected results reduced opportunities for students to develop clearly understanding about the concepts from classroom discussion. Moreover, it was found that Ms. Vanvisa did not ask probing questions to redirect students' misunderstanding and clarify classroom arguments. For example, in the lesson on "Toys, Utensils, and Objects", Ms. Vanvisa did not ask questions to change their misunderstanding on the idea that oil, snack, milk and other food were utensils because they were used for eating when they were asked to make toy and utensil collages. By contrast, she provided the correct answer to her students. Therefore, they memorized information provided by Ms. Vanvisa.

4.4 Teacher's Perception on Students' Abilities

Ms. Vanvisa's perception that students were unable to construct their own understanding or explanations reduced the opportunities for students to participate in classroom discussion to formulate their own concepts. As a result, students memorized the key concepts provided by teacher. The informal interview and discussion throughout the implementation, Ms. Vanvisa showed the idea that grade one students were unable to construct their own understanding or explanations. They still needed teacher conclusion. Moreover, Ms. Vanvisa noted that inquiry based learning is a way of teaching high-achieving students and does not work with students who have learning disabilities. This perception reduced the opportunities for low competency students to share ideas and explanations in the classroom. Ms. Vanvisa normally focused on the importance of right answers and was prone to call on the high achievers to answer the questions in class while ignoring the other student reactions and answers.

4.5 Teacher Content Knowledge

According to classroom observations and discussion during informal interviews throughout the study, it was found that Ms. Vanvisa who did not have strong content knowledge in science felt uncomfortable and not relaxed when she encountered students' arguments. For example, in the lesson on "Toys, Utensils and Objects", Ms. Vanvisa did not realize the idea that some objects could be both played with and used to do a job and could not explain the differences between utensils and food. When some students argued that a computer was toy because it can used to play games, while others said that it was utensil because it could be used to do job, Ms. Vanvisa came to the researcher and asked what the right answer was. In another example, when her students stated that color pencils were toys because they could be used to draw and paint funny things, she could not clarify the students' misunderstandings about the use of color pencils as utensils. In addition, she could also not explain to her students when they showed an understanding that snacks, milk and water were utensils because they were used for eating. Moreover, she was not comfortable in teaching the concept of materials. In the lesson on "What objects are made of?", students were assigned to bring and share ideas about kinds of materials used in making utensils in their eating sets. When students answered that a melamine (a kind of plastic) dish that a student brought with them was made of plastic. Ms. Vanvisa felt uncomfortable in replying to students. She then came to ask the researcher.

4.6 Teacher Preparation

Throughout the implementation times, Ms. Vanvisa showed unreadiness to the curriculum implementation. Each day before a lesson in the instructional unit about materials was implemented, Ms. Vanvisa needed the researcher to talk briefly about the objectives, content, steps of activities, and equipment. The students were asked to bring their toys and utensils into school by researcher after this discussion. A short time before the science time started, the researcher rearranged students' tables to make a large area in middle of the classroom for students to do activities.

Moreover, Ms. Vanvisa always worried about the steps needed to complete based on the instructional unit.

4.7 Students' Abilities and Studying Habits

Throughout the implementation, Ms. Vanvisa mentioned that the short attention time for young students and their unfamiliarity as active learner with the learning approach were key obstacles of the implementation. Ms. Vanvisa mentioned that young students paid attention and participated in learning activities for short periods of time. They loved to play and talk with their friends during the activities. Students especially paid more attention to their toys and utensils rather than teacher and learning activities when asked to bring their own objects into the classroom.

Moreover, the students were used to intently listening, copying what the teacher said and writing on the board, and completing activities from the worksheets and thus affected their active involvement in the classroom. For example, students were asked to play a "Find the Object" game in which they were asked to collect at least three objects on the basis of the property appearing on an index card such as objects that are red, round, black, and square, etc. When the students returned to class with the objects, they were asked to make predictions about the other groups' collections and the properties that were the basis of the grouping. However, students did not get out of their seat and look throughout the classroom to observe the collected objects. Ms. Vanvisa mentioned that the students were normally asked to keep quiet and speak from their seats. Therefore, they were unfamiliar and uncomfortable with doing this activity because they did not want to get punishment for breaking a classroom rule.

In another example, each group of students was asked to select an object in the room. The group leader then told the class from which part of room (front, back, near a window) the object was located, property words about the object (color, shape, size, etc.) and then asked other groups to make a guess about what the object was. The problem was that the students could not select different objects and give other groups a good explanation of the selected objects. They just selected the same objects as the first group and gave the same clues.

Case One Summary

In this case study, Ms. Vanvisa's misunderstanding about teaching approaches, low abilities in conducting scientific inquiry, weak content knowledge and perception on students' abilities, lack of good preparation as well as students' abilities had a direct influence on the teaching and learning about materials in this curriculum. Ms. Vanvisa implemented the curriculum in different way that it was intended. Ms. Vanvisa's belief on learning through real objects led to the focus on hands-on activities in which students were active learners who participated directly with real objects in groups, and then provided conclusions for her students without concern for their mistakes or misunderstandings. Moreover, she did not feel comfortable when she implemented the instructional unit but tried to keep the instruction according to plan. She also became less confident when students were allowed opportunities to share different ideas which led to classroom arguments because she did not have scientific background. Moreover, it was found that because Ms. Vanvisa exerted little effort to facilitate and provide opportunities for students in constructing their own knowledge, developing connection and application of science concepts to real life situations, students could not develop science concepts through science process; they memorized information provided by teacher. As a result, students did not develop more understanding about terms “objects”, “size”, “shape”, “weight” and “materials”. However, it was found that most of the students paid more attention and were enthusiastic about participating in learning activities.

Case Study Two: "Yada"
Grade Two

1. Teacher and Student Background

The description of teacher and student background is divided into three sections, including educational background and teaching experiences, classroom setting, and students' information as shown below.

1.1 Educational Background and Teaching Experiences

Ms. Yada, in her early fifties, was assigned to teach grade two students. Ms. Yada had a Bachelor's degree in primary education and had 29 years experience teaching at the elementary level. Ms. Yada had taught mathematics and Thai language for more than ten years at the upper elementary level at a public school located in Bangkok. Ms. Yada then moved to teach in Kwanpracha School, the location of this study. Ms. Yada taught grade 1-3 students in Thai language for approximately ten years at her current school. She changed to the subject of science after the curriculum reform of 2002. Moreover, Ms. Yada, at the time of this study, was assigned to teach twenty two hours a week in subjects of science, math, and Thai language.

Ms. Yada lived with her husband and three children-one daughter and two sons. Her daughter had a Bachelor's degree in Russian Language. Her two sons were studying in field of science. Ms. Yada said that her son's education background helped to support her content knowledge. She asked her son to clarify unfamiliar concepts and prepare simple experiments for students. She liked teaching in Kwanpracha School because it was not far from her home and the class size was small; however, she indicated that she had been forced to lower her expectations of students' learning because most of the parents did not care about their children's study. This was different from the fist school she taught at, where students came from families with strong educational backgrounds.

1.2 Classroom Setting

In Ms. Yada's second grade classroom, there were 40 students. Ms. Yada's classroom was located on the second floor of an old wooden building. Students had couple desks with separate metal chairs. The desks were arranged in four rows; the rows of students' desks all faced the chalkboard. The classroom walls were painted white. The windows on two sides of the walls were open, and a breeze moved through the room. On both sides of the whiteboard, bulletin boards were displayed. These boards included Thai and English alphabets (characters), the basic seven colors, and the seven days of the week. At the back of the classroom, a wooden bookcase was used for storing textbooks and worksheets. Teaching materials including varied artificial fruits and abacuses were displayed in this bookcase. In a corner of the class was Ms. Yada's case for storing important information including students' profiles, students' reports, teaching materials, etc. Equipment used for cleaning up, such as garbage cans, mops, and brooms, was stored in the corner. Groups of eight students had responsibility for taking care of the room each day. Ms. Yada's desk was located at the back of the classroom (See figure 4.2).

During the course of this study, Ms. Yada always came early to school because she lived nearby. When she entered the school, she usually went immediately to the library. She was also the school librarian. Unlike the other teachers and staff members who told their students to start their cleaning work and corrected students' worksheets, Ms. Yada always quietly took care of books within the library before school started. During the daily break, Ms. Yada usually took those students who were not doing well in class to the library and gave them individual assistance. Moreover, a group of students was assigned to rearrange books and tables into original places during this time for use again in the afternoon. The library was used by each classroom once a week.

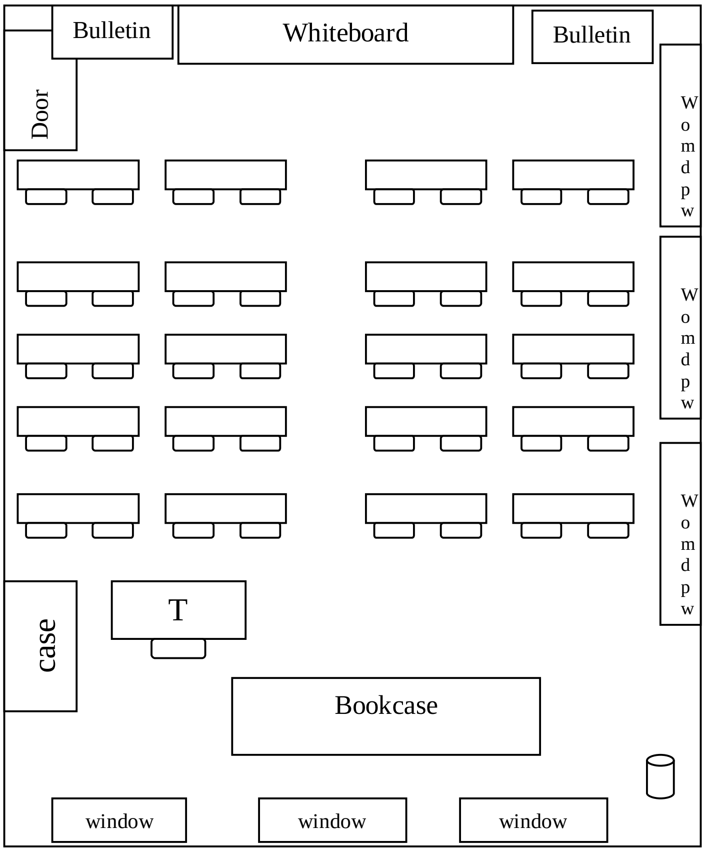

Figure 5.2 Ms. Yada' s Classroom Setting

1.3 Ms. Yada's Student Information

There were twenty six girls and fourteen boys in Ms. Yada's classroom. Most of the students were eight year old. Ms. Yada described the class as a group of great student. The students in this class were the top forty students with the higher achievement scores. Three of these students were selected purposively to participate in the study, in order to assess their understanding of material concepts emphasized in the curriculum. The selection was based on different gender, academic achievement in learning scores in previous semesters, and the extent to which students were capable of providing reflections and descriptions on how they participated and what they learned in activities. The pseudonyms of the three students were Natta, Taradol and Naree.

Natta was an eight year old girl. The research team selected this girl to participate in the study because she was a competent student in the classroom. She had family support for her learning. Ms. Yada also selected Natta to participate in this study because she was an active and talkative learner. Ms. Yada felt that she could give good reflections and explanations of what she did and felt about activities.

Taradol was also an eight year old boy. His achievement level was in the middle range of students in classroom. He was selected to participate in the study because he was also an active and talkative learner in this classroom.

Naree was also an eight year old girl. She was the leader of the classroom. She had low achievement scores, but was an active learner in the classroom. Her thinking and working was slower than other students. She was selected to participate in this study because she was a talkative learner in this classroom and was willing to talk with the researcher during a home visit in the previous semester. It then was expected that she would be able to give good description of what she did and leaned through participating in learning activities.

2. Ms. Yada's Implementation of the Curriculum and the Students' Understanding

Ms. Yada's implementation of the curriculum has been described in terms of the teacher's practices in the classroom in parallel with the impact on the students' achievement. Three of Ms. Yada's grade two students selected by purposive sampling were studied in depth to assess their level of conceptual understanding with respect to key concepts in the unit.

2.1 Ms. Yada 's Practices

The description of Ms. Yada's practices is provided in two sections according to aspects of culturally relevant practice and inquiry based teaching that served as a basic framework of the curriculum.

2.1.1 Ms. Yada's Instruction and Culturally Relevant Practice

Evidence from classroom observations, teacher interviews and journal entries indicated that Ms. Yada put her teaching on the value of relevant teaching by starting with students' real lived experiences with toys and utensils, allowing students to conduct investigations on relevant objects, and asking relevant questions in making connection to everyday lives and clarifying students' dispositions about science at home. The description of Ms. Yada's culturally relevant practice is provided below.

A. Starting with Students' Real Lived Experiences with Toys and Utensils

In Ms. Yada's classroom, students were engaged in questions that drew on their funds of knowledge and experiences at the beginning of the lesson to facilitate students' sharing experiences and developing further investigation on relevant topics. These included students' own experiences in playing rubber jump ropes, using rags and mops to clean up houses, and local expert knowledge in artificial flower making. In interviews conducted after each lesson, Ms. Yada provided evidence that she value the activation by using students' lived experiences. She mentioned that using students' familiar topics or experiences engaged student interests and paid more attention to participate in learning activities.

B. Conducting Investigations on Relevant Objects

In Ms. Yada's classroom, students were encouraged to conduct investigations of topics and materials that were relevant to their lives and interests. The relevant objects used as learning organizer to develop students' understandings about material concepts included students' toys and utensils, their home furniture, bedding, clothing, and kitchenware as well as artificial flowers. In Ms. Yada's journal entry, she reflected on belief that opportunities for students to experience on relevant objects encouraged them to learn easily and construct accurate understandings. Her interview responses provided further evidence of her belief in the importance of investigation of real objects. Ms. Yada, in her interview responses, indicated that access to more varieties of materials than those prepared by the teacher enhanced students' understanding because they could talk about and share experiences related to those materials.

C. Asking Relevant Questions in Making Connection to Everyday Lives and Clarifying Students' Dispositions about Science at Home

After students developed their own understandings, Ms. Yada asked related questions to help them apply what they learned in school to real situations. Ms. Yada's interview responses indicated that she focused her teaching on the encouraging students to give relevant examples and reasonable explanations about key concepts related to their real life situations. Moreover, Ms. Yada provided the evidence to support the value of everyday language that they and their parents used in naming materials. For example, in the lesson on "Hardness and Elasticity", Ms. Yada put efforts to the clarification of students' confusing about everyday language that parents used in naming rubber band. She asked students to justify what rubber bands were made of. When students were asked what a raincoat was made of, they replied that it was made of "Pa-Plastic". Ms. Yada then asked them a question to elicit their idea that the raincoat is used to protect humans from wet/rain; thus kinds of materials that contain this water-proof property are plastics rather than fabrics. She taught students that Pa-Plastic is a word used in everyday life but actually the word plastic.

2.1.2 Ms. Yada's Instruction and Inquiry Based Approach

Ms. Yada's classroom practice when analyzed in relation to the science teacher inquiry rubric (NRC, 2000 and Beerer and Bodzin, 2004) was student-centered oriented as it contained all aspects of inquiry. She asked students a number of questions that led to investigation. Next students were asked to conduct investigations on their own. She then prompted students to formulate their own understanding and application to related situations by asking probing questions. She assessed student conceptual understanding through multiple strategies.

A. Engaging Students' Attention and Eliciting Their Prior Knowledge

Ms. Yada raised relevant questions about toys and utensils to engage student interests or elicit students' prior knowledge and encourage them to share real life experiences at the beginning of lesson. She did not explain concepts, provide explanations, or state conclusions for students. This was consistent with the student-centered aspect of inquiry. Although, Ms. Yada tried to prompt students to formulate their own questions, it was difficult for them to accomplish this step. This might be the case because Thai students were not familiar with asking questions. The questions that led to investigations in all lessons then came from Ms. Yada.

B. Making Decisions and Conducting Investigations by Students

In Ms. Yada's classroom, students were allowed to make decisions in conducting investigations and work together without direct instruction or leading students step by step to a solution. She provided opportunities for students to pursue their own interests and topics relevant to them. Most of the materials used in experiments to investigate properties of materials were selected based on student interests. Therefore, each group of students experimented and learned with different kinds of materials. In interviews conducted after each lesson, she provided evidence that she valued students' decision making. She stated that she asked students in experiment to investigate what they wanted to know. For example, Ms. Yada said that she did not want to limit student investigation within worksheet assignments. She needed students to explore home items as much as they wanted to. Moreover, she said that she respected students' bumps, mistakes—wrong turns. When students encountered wrong turns or wrong answers, they were encouraged to try again and try to understand why they came to the incorrect answers. Moreover, Ms. Yada mentioned that opportunities for students to explore, experiment, and discover on their own help them not just memorize information. It helped them understand how and what they found out.

C. Formulating Explanations by Students

Ms. Yada provided opportunities for students to think and formulate their own explanation in group, and then encouraged them to present their findings to whole class. At this step, she also asked students probing questions for clarification and justification from evidence that was found. Ms. Yada asked student groups to compare their findings and to identify similarities or differences between them. It led students to develop deeper understandings about the same property of different kinds of materials from other groups whose experiments were different. Her interview responses reflected her belief that students could construct their own knowledge. She mentioned that students acquire knowledge by themselves more than through what they memorized from teachers. She also mentioned that opportunities for students to acquire their own knowledge enhanced their inquiry. Therefore, questions were used in Ms. Yada's teaching to promote students' learning. Her students were encouraged to describe what they saw and explain ideas in their own words. She also noted that when a student's response to a question was accurate but incomplete, she asked probing questions to get the student to think deeper about the concept. She tried to ask probing questions to elicit high-level thinking from students and encourage them to think critically about relationships between evidence and explanations, and constructing explanations.

D. Extending Knowledge to Other Situations

Ms. Yada asked students to summarize what they already knew and then encouraged them to apply or extend concepts or skills in new situations. For example, in the lesson on "Hardness and Elasticity", Ms. Yada asked students to summarize the kinds of materials that could be stretched and return back to same shape at the end of lesson. She then asked further questions for students to think about elastic items involving in their lives.

E. Assessing Students' Knowledge and Skills

Ms. Yada assessed students' knowledge and skills by looking at their participation in group works when students were asked to conduct their own investigations, their explanation when they were asked to present their group findings, and their application of knowledge being learned in other situations. For example, the answers of elastic things involving in their lives in the lesson on hardness and elasticity, and the appropriate materials used in making towel, handkerchief, raincoat and umbrella after they leaned about the ability to absorb water of materials in the lesson on water absorption property.

2.2 An Example of "Hardness and Elasticity" Lesson

The follow learning activities provides an example of Ms. Yada's instruction emphasizing on previous aspects of culturally relevant practice and inquiry based teaching. This lesson aims to investigate and compare hardness and elasticity of different kinds of materials.

At the beginning of the lesson, students were engaged in questions that drew on their funds of knowledge and experiences. Ms. Yada did this to get student attention and elicit their prior knowledge. Students' experiences in playing with rubber jump rope, a popular toy of girls at this age, were discussed.

Ms. Yada:	"What do you usually do after lunch?"
Students:	"Playing"
Ms. Yada:	"What do you play?"
Student:	"Play in playground"
Student:	"Running"
Student:	"Playing with jump rope"
Ms. Yada:	"How do you play with your jump rope?"
Student:	"I play with friends; my two friends hold tides of the rope and stretch it to become straight line. I then jump

	up the rope."
Ms. Yada:	"Right!" "Have your friends ever let one tide of jump rope out of her holding?"
Student:	"Yes"
Ms. Yada:	"What happens?"
Student:	"Get hurt"
Ms. Yada:	"Who get that hurt?"
Student:	"Another student who still hold one tide of rope"
Ms. Yada:	"Why?"
Student:	"Jump rope from that released side came to another side"

The students were then actively engaged in planning investigations to experiment with elasticity of materials. Students agreed to investigate and observe the ability to turn back to same shape and size after be stretched of materials. Students were then given choices to explore, experiment, and discover the elasticity of different kinds of materials that interested them. Students experimented with a variety of objects made of different kinds of materials such as wooden pencil, metal spoon, handkerchiefs, hair tidings, pants, shirts, etc. Each group of students worked collaboratively to gather evidence, record their observations on a worksheet and write down other group members' ideas or responses about kinds of materials that were elastic and were not.

While students were doing the investigation, Ms. Yada paid close attention to students' learning. She was always walking throughout the classroom and talked with children in each group. She allowed adequate wait time for students to conduct investigations and answered a lot of questions. She also observed what was happening with groups of students who could not accomplish a task. These observations allowed her to ask probing questions to redirect the group's investigations when necessary. She also provided time to help children with one-on-one assistance with writing and reading tasks. Ms. Yada asked students to rethink what they had written about the kinds of materials used in making objects on the worksheet, rather than just naming of objects. For example, a group of students who had picked pencil had to write the word "wood" as the kinds of materials a pencil is made of on the worksheet. When students wrote "pencil" as a kind of material instead of "wood" on worksheet, Ms. Yada then asked student questions such as "what did you write on your worksheet?" and "why did you write pencil under material name?", "Is this pencil a kind of material?".

Ms. Yada tried not to tell students answers, but required all students to participate in discussions and formulate their own explanations. When the time was up, each group representative stood up and read his or her summary of ideas about the kinds of materials that could be stretched and turn back to same shape. Ms. Yada asked student groups to compare their findings and to identify similarities or differences ability to be stretched and return back to same shape of objects. It led students to develop deeper understandings of hardness as a property of materials they could not be stretched or twisted, while elasticity as properties of materials they could be stretched and return to same shape.

After the students' reporting, Ms. Yada also put their incorrect answers in context, used further follow-up questions to obtain other student responses, and supplied her students with the correct answer. If the students could not reply, Ms. Yada gave them clues to aid them in getting the right answer. Ms. Yada accepted her students' partially correct answers, elicited another student's response, and asked other students to compare both students' answers and decide which one was better. An example of a conversation where Ms. Yada helped to clarify students' understanding of difference between elasticity of rubber and fabric in school is described below:

Ms. Yada:	"Which kinds of material could be stretched and turn back to same shape?"
Student:	"Rubber"
Student	"Rubber and Fabric"
Students	"Fabric"
Ms. Yada:	"Raise your hand if you think that fabric were elastic"

Students raised their hands. Ms. Yada called on a student who raised her hand and asked

Ms. Yada: "What is your fabric item that can be stretched and return back to its shape?"

Student: "My Sport pants"

Ms. Yada: "Could you show classmates how your pants are elastic?"

Students demonstrated by stretching her pants

Ms. Yada: "Could you pants turn back to same shape after it were stretched ?" Observe carefully!

Students: No!

After that Ms. Yada asked all students to investigate the elasticity of their pants to clarify that pants were not elastic. Moreover, she asked students to bring out their handkerchiefs and investigate their elasticity. Students could develop clearly understand that fabric used in making handkerchief could be stretched but could not turn back to original shape.

Students were encouraged to make connections between examples and applications in everyday situations to their knowledge of hardness and elasticity, as this example illustrates:

Ms. Yada: "What are elastic things you used in everyday lives?

Student: "Nang-Yang" (rubber bands)

Student: "Hair tiding"

Student: "waistband"

Students: "shoe floors"

Student: "whist band"

Ms. Yad: "Oh! Excellent"

Moreover, Ms. Yada asked students the clarification of their confusing about everyday language that they used in naming rubber band. She asked students to justify what rubber bands were made of as illustrate:

Ms.Yada:	"How do you call this object (rubber band)?"
Student:	"Rubber band"
Student:	"Nang Yang"
Ms. Yada:	"Who think that rubber bands made of rubber (Yang)?
Students raise their hands	
Ms. Yada:	"Who think that rubber bands made of leather (Nang)?
Student:	Keep quiet
Ms. Yada:	"Why do you think the rubber bands made of rubber?
Student:	"It is elastic."

During the last ten minutes of the lesson, Ms. Yada accessed students' understanding of the concepts by calling randomly on all achievement students to answer questions instead of letting two or three competent students answer every question. She stated names of materials and asked students to identify whether they could be stretched and return back to their original shape or not. If a student just sat quietly and rarely volunteered to her questions, she would call on that student.

3. Students' Responses

After Ms. Yada had implemented an inquiry based instruction unit, it appeared that most of the students improved their understanding about kinds and properties of materials and paid more attention in learning. Data from student interviews, teacher interviews, student worksheets, and field notes provided evidence on students' development as described below.

3.1 Developing Concepts about Materials

Before Ms. Yada implemented the instructional unit, the individual interview about 16 different items was conducted to investigate grade two student conception about materials. The result indicated that more than half of students were able to classify objects by kinds of materials. Students showed scientific understanding about fabric, paper and wood. However, students held misunderstanding about metal, plastic, glass and rubber, respectively. They had confusion between metal and glass, and between plastic and rubber. Moreover, students were able to describe hardness of metal, wood, plastic and glass and water absorption of fabric; however students held misunderstanding that fabric items was elastic.

After participating in learning activities, students developed more understanding about kinds of material concepts and properties of materials, including hardness, elasticity and water absorption. The description of students' understanding in each concept is described below.

3.1.1 Developing Concepts about Kinds of Materials

After participating in the curriculum, students developed three concepts about kinds of materials. These included: 1) developing concepts of wood, paper, fabric and leather used in making their own items, 2) developing concepts about new kinds of materials involving in their everyday life from their parents, and 3) developing understanding about differences in materials used in making an object.

A. Developing Concepts of Wood, Paper, Fabric and Leather Used in Making Their Own Items

The finding indicated that students could observe and identify correctly the kinds of materials used in making their own and classroom items. All students could describe correctly on the concept of wood, paper, fabric and leather.

Students could describe that tables, chairs, a board, pencils and windows were made of wood, and that books and a calendar were made of paper. They also knew that backpacks, boy shoes, socks, and caps were made of fabric, and that school bags and girl shoes were made of leather. Students also could describe that chairs, electric fans, (parts of) shoes, cases, (part of) umbrella, and pencil boxes made of metal. Moreover, all students could describe that television, electric fans, rulers, pencil boxes, and files were made of plastic.

According to Ms. Yada, students also developed understanding about kinds of materials used in making different kinds of objects. Ms. Yada found that students could describe kinds of materials used in making their furniture, kitchenware, bedding, clothing, stationeries, and toys and give typical examples after they shared the information they explored at home with peers in the classroom. Students' interview responses after the lesson also indicated that they could describe wooden furniture such as tables, chairs and kitchenware metal household items such as pans, pots, and spoons, fabric items such as blankets, pillows, clothing made of fabric such as shirts, pants, and skirts, and stationeries and toys frequently made of plastic, such as pencils, rulers, pencil boxes, toy cars, Barbie Dolls, and cooking sets.

However, some students' misunderstandings had about metal and plastic. Based on student' worksheets, it was found that students could not describe correctly metal objects. Half of the students stated that the electric light bulbs made of metal**.** Moreover, a quarter of students held misunderstanding about umbrellas. They stated that umbrellas were made of fabric.

B. Developing Concepts about New Kinds of Materials Involving in their Everyday Life from Their Parents

Evidence from Ms. Yada's classroom observations and interview responses indicated students' understanding of new concepts after participating in the lesson on "Material". Ms. Yada mentioned that students who were assigned to gather data about their toys and utensils at home, could describe more kinds of materials not included in the textbook such as leather, fiber, cotton, sponge, etc. Moreover, Ms. Yada also mentioned that her students learned about a kind of paper used specifically in making artificial flowers. It was called “Flora Tape” by students. She further stated that students learned that the flora tape was different from general paper because it could be stretched similar to rubber. It was a kind of paper containing inserts of glues. When it was stretched, glue would come out to connect the paper with the stem of flower.

C. Developing Concept about Differences in Materials Used in Making an Object

Ms. Yada mentioned that students could develop understanding about differences in materials used in making an object. She stated that her students could differentiate between rubber and plastic used in making school bags, and the case of plastic and wood used in making pencils. In a lesson on kinds of materials, the students discussed differences in materials used in making home items, as a follow-up to a homework assignment. The students explained that same objects from different houses could be made of different kinds of materials. For example, cases could be made of wood, metal or plastic. In a lesson on properties of materials, students developed explanations on the different uses and selections of materials on the basis of their properties.

3.1.2 Developing Concepts about Properties of Materials

After participating in learning activities, students developed more understanding about hardness, elasticity and water absorption of various kinds of materials.

A. Developing Concept about Hardness of Materials

Evidence from Ms. Yada’s classroom observation and interview responses indicated that the experiment to investigate the properties of materials enhanced students' understandings of hardness and elasticity of materials. Ms. Yada reported that students developed understanding about hardness as a property of materials and the idea that hard objects could not be stretched or twisted.

The analysis of students' worksheets showed that eighty nine percent of them regarded kinds of materials, including plastic, wood, metal, and glass as hard materials. Thirty five percent of students preferred to plastic, twenty four percent for metal, nineteen percent for wood, and eleven percent for glass. A wide variety of examples of these hard objects were provided by students, including tables, chairs, cases, glasses, televisions, radios, clocks, spoons, fans and mirrors. The rest percentage of the students held misunderstanding that thick rubber of eraser was hard.

In the case of the experiment about elasticity, Ms. Yada also reported that student' understanding of the difference between elasticity of rubber and fabric was clearly enhanced. Almost all of students could describe that rubber was an elastic materials. She stated that her students could describe how rubber material is able to return to its original shape after it has been stretched. Her students could also give relevant examples of elastic objects and objects that were stretched but not returned to their original shape. The everyday examples of elastic objects provided by the students included hair tidings, rubber bands, elastic for pants (or waistband), whist bands, and shoe floors. There were only few students still described that fabric could be stretched.

B. Developing Concept about Water Absorption

Students developed understandings about water absorption of fabric and paper. Ms. Yada reported that the experiment to investigate water absorption of different kinds of materials encouraged students to develop deeper understandings about similar and different abilities to absorb water of each kind of material. Students could describe how fabric and paper are kinds of materials that absorb water. Ms. Yada also reported that her students could provide explanations of why towels, handkerchiefs and napkins were used when they wet or swept, and why plastics were used in making raincoats. Based on responses in worksheets, all students could describe that fabric and paper were kinds of materials that could absorb water. However, students could give reason on why towels and handkerchiefs were made of fabric in different ways. More than three quarters of students stated that towels and handkerchiefs were made of fabric because of ability to absorb water, while the rest of students concerned to their softness. Moreover, all of them also described that plastic is a water-proof material, and thus should be used in making raincoats.

3.1.2 Developing the Application of Concepts to Their Experiences

Culturally relevant based teaching improved students' understandings of new concepts and helped them to make connections between content and their own experiences. As a result of starting the lesson with relevant objects and experiences and asking related questions, it appeared that students created a strong connection between what they experienced in school and their lives out of school. Ms. Yada mentioned that the connection between content that students learned in school and their prior experiences and knowledge out of school helped students to transfer what they learned in school to real-life situations. A description of such a connection is displayed below.

It was found that when she addressed students' real life situations in teaching, students were more likely to identify examples, and thus make connections to the content being learned. For example, in the case on elasticity, when asked to give example of elastic things, a student described a wristband, a current new fashion object that is normally realized as a regular rubber item. In another lesson on local materials, students explained kinds and properties of materials used in making artificial flowers. Students learned that an object has to be composed of many parts, each part made of different kinds of materials depending on its different properties and uses. For example, the petals of artificial flowers were made of both paper and rubber, its leaves were made of paper, and the stem was made of small pieces of metal. They also developed an understanding that the same metal with different sizes contains different properties and uses. For example, thin pieces of metal could be used in making stems of flower because they could be formed in any shape when forces were applied.

Based on classroom observation and teacher interview, it appeared that the majority of students were more likely to think critically about selection of appropriate kinds of materials used in making things for different use and properties. Most of the students could explain the selection of materials used in making dolls in terms of the property of material. For example, some said they like to play with fabric dolls because they are softer than others. Others preferred rubber doll, because they are elastic or plastic dolls because they are hard and durable. In addition to the concept of hardness and elasticity, students developed understandings about water absorption of fabric and paper. They could provide explanations of why towels, handkerchiefs and napkins were used when they wet or swept, and why plastics were used in making raincoats.

3.2 Improving Students' Self Confidence

Ms. Yada felt that students became more confidences and could talk more about activities than they had previously. Ms. Yada, in a journal entry, provided evidence of how students improved their confidence. Ms. Yada commented that students' confidence levels were improved when they were asked to discuss experiences in an environment that were familiar to them. She reported that the individual student did not have to worry as much about making mistakes. Ms. Yada's interview response provided supporting evidence that students became confident in sharing ideas in the classroom, without making sure he/she was doing the right thing. She said that students normally were quiet when she asked questions to elicit their ideas, but they were less concerned about making mistakes or making sure they were doing the right thing when they talked about objects that were familiar to them. She mentioned an example of a student who answered that rubber is a kind of material could be used in making raincoats after firsthand experience doing an experiment about the difference of water absorption in materials. This student responded immediately that raincoats could be made of rubber because rubber could not absorb water. Ms. Yada also mentioned that students became confident in active involvement by using observation and working collaboratively in hands-on activities. She mentioned that students apposed to just looking and did not more around selecting and using materials they need at the beginning of the implementation. In a later week, from a classroom observation, students had changed their behavior in a positive way, when they experimented in water absorption lesson. They were able to observe and record data by themselves.

Moreover, Ms. Yada' s interview responses indicated that she believed that opportunities for students to acquire knowledge out of school enhanced students' confidence in the communication with parents and local experts, as they asked more questions related to local topics. She mentioned that at the beginning, some students were reluctant to ask questions, but through trust building relationships and time they opened up and were more willing to share and ask questions.

3.3 Improving Students' Perception on the Significant on Relevant Topics

Ms. Yada' s journal entry indicated that the concept of materials emphasized in this study was significant to students, as well as the transfer of what was learned in school to real-life situations, especially when they were encouraged to work with local experts on artificial flower making. Students also developed skills that were necessary for local careers and awareness of local materials. Through the flower making, students developed carefulness in the production of flowers and leaned that materials used in handicraft items in real life were easily distorted. Ms. Yada's interview response also showed that she believed that students developed an understanding of the value in working to earn money. She said that when students were given the opportunity to make flowers to decorate for Librarian Day, students made neat flowers in just a short time. One student whose grandparent worked in this career described how her grandparent received only ten bahts for one hundred flowers. As a result, this led student to value the local career and how difficult it was to earn money.

3.4 Fostering Students' Attention and Involvement

In Ms. Yada's interview responses after implementing the inquiry instructional unit, she indicated her belief that students of all abilities paid more attention to lessons and enjoyed the activities. Ms. Yada said that students frequently asked her what they would be doing in science. She felt that her students were more likely to tell about and share their science experiences with others in classroom. Some comments from Ms. Yada concerning the cultural relevant lessons were:

"Students were more interested in the culturally relevant lessons. They asked what we are doing in every science time."

"Students were interested in learning in local material lesson. 80 percent of them need to make it repeatedly."

Ms. Yada further mentioned that the low ability students who had not participated in any activities previously changed their behavior in positive ways after she introduced culturally relevant activities. Her students' responses provided supporting evidence of their satisfaction in participating in lessons. They mentioned that they loved to be part of a group to share ideas and gather data. This was especially found in the lesson on materials where students explored their home items and made a group chart to present the group findings.

In summary, much evidence supported the conclusion that the curriculum implementation by Ms. Yada was successful in improving students' understandings, application and self-confidences. Through inquiry learning students were allowed the opportunity to engage in decision-making, and active investigation led to students' better understanding about kinds and properties of materials used in making their toys and utensils. Moreover, the emphasis of a curriculum that drew on student relevant topics and materials fostered their connection between home and school science. The finding also found that students could provide reasonable application on the appropriate uses and selection of materials used in making toys and utensils on the basis of what was being learned in classroom. They also improved self-confidence in participating in learning activities as well as an understanding of the significance of local careers. Moreover, they paid more attention and developed stronger interest in learning science.

4. Factors Influencing the Implementation

The success of the implementation of an instructional unit of Ms. Yada depends on teacher's beliefs and understanding about culturally relevant and inquiry based approaches, ability in conducting scientific inquiry, perception on students' abilities, content knowledge and teacher preparation. However, Ms. Yada' s comfort level in students' out of school learning as well as students' ability were obstacles for her implementation.

4.1 Facilitating Factors

The factors that facilitated the implementation of Ms. Yada included teacher's beliefs and understanding about culturally relevant and inquiry based approaches, ability in conducting scientific inquiry, perception on students' abilities, content knowledge and teacher preparation.

4.1.1 Teacher's Beliefs and Understanding about Culturally Relevant and Inquiry Based Approaches

Throughout the discussion with Ms. Yada during implementation time, she discussed her strong belief and understanding about culturally relevant and inquiry based approaches. This led Ms. Yada implemented all aspects of these approaches that it was intended in order to develop students' understanding about material concepts. A description of Ms. Yada's beliefs culturally relevant teaching and inquiry as illustrated below:

A. Teacher's Beliefs about Culturally Relevant Teaching

Ms. Yada also mentioned ideas that represented her belief and understanding about culturally relevance, including the need to provide activities to address diverse abilities and learning styles, using relevant experiences and examples students brought with them to introduce or clarify new concepts. Moreover she mentioned that culturally relevant curriculum could be integrated and interdisciplinary.

1) Providing Activities to Address Diverse Abilities and Learning Styles

Ms. Yada mentioned that culturally relevant curriculum allows students to learn in ways that match with their diverse abilities and learning styles. She commented on students diverse learning styles several times, noting:

"There are high and low ability students in the class. Time should be provided for these diverse students. I should have them work independently after group work to make sure whether they all understand the concepts or not."

"To access diverse students' understanding, teacher could not use observation on student work or test only. The interviews of students were necessary for non-literate students who could not communicate by writing well."

"Student learning the same content in various situations leads low achievement students develop more understanding about the difference between objects and materials, especially when they learn about artificial flower making they can apply what they learn in school to explain kinds of materials used in making objects, its properties, and the selection of appropriate material used in making objects."

2) Using Relevant Experiences and Examples Students Brought with Them to Introduce or Clarify New Concepts

Ms. Yada mentioned that learning materials used in culturally relevant teaching should be examples students brought with them because they had accessed to more varieties of materials than those prepared by the teacher and could talk about and share experiences related to them. In the lesson on kinds of materials, different information was gained from the assignment when students were asked to explore and interview a family member about what home items are made of and then bring them to share in classroom. One example of students' sharing home knowledge was the case of a student sharing funds of knowledge about Barbie Dolls. Ms. Yada said that students surprised her with their notion of the difference between copyright and fake Barbie Dolls. The student observed that copyright Barbie Dolls were heavier than the others. After the final lesson implementation, Ms. Yada developed the idea that not only student objects can serve as organizers in learning science, but also student funds of knowledge and experiences at home could be shared in school science. This included experiences such as rolling of long mats, and bendsteel that are normally found in households.

3) Integrated and Interdisciplinary

Ms. Yada also believed that culturally relevant curriculum is integrated. After finishing the last part of the local materials lesson, Ms. Yada mentioned that materials in our surroundings could be used for science teaching. Moreover, she mentioned that cultural knowledge could be taught in many perspectives and subjects. For example, the flower making process could be used to teach about science concepts and work-oriented experiences. In the subject of work-oriented experiences, the learning could focus on the concept of the composition and materials used in making artificial flowers, while the science lesson could focus more on the properties and selection of materials used in making each part of artificial flowers.

B. Teacher's Beliefs about Inquiry Based Approach

Ms. Yada mentioned her belief that inquiry based teaching is more focused on student involvement in the construction of knowledge through active involvement and development of scientific skills of observation, and practice instead of rote memorization. According to Ms. Yada, the active involvement of students in the classroom included planning and conducting investigations, using appropriate tools and techniques to gather data, thinking reasonably about relationships between evidence and explanations, and constructing explanations. Ms. Yada described her beliefs about inquiry teaching as follows:

"Inquiry provides student opportunities in doing. It is not the good way to teach the concept of material properties by observation, rather it should be focused on doing experiments. Students could explain and construct correct concepts by this participation. For example, at the beginning I showed a piece of plastic and asked about material kinds used in making it, they could not respond correctly, but when they allowed to participate and experiment directly on many kinds of objects they could explain its difference correctly. In another case of elasticity, students said that their sport pants could be stretched. I asked them whether it return to original shape when it was stretched. Students then tried and constructed the concept that elasticity is the property of materials that can be stretched and return back to its original shape."

"Ms. Yada reported that grade two students could describe the kind of materials that items were made of when they touched them, but could not identify correctly the kinds of materials used in making objects by just looking from pictures."

In addition she noted that "the teacher should provide time for students to try and discovery by their own, then put the students' incorrect answers in context, used further and follow-up questions to obtain other student responses, and supplied her students with the correct answer. If the students could not reply, I gave them clues to aid them in getting the right answer. I accept my student's partially correct answers, elicit another student's response, and ask other students to compare both students' answers and decide which one was better"

4.1.2 Teacher' s Ability in Conducting Scientific Inquiry

Ms. Yada's ability in facilitating students to plan, investigate, clarify, and justify unexpected results improved students' understandings about material concepts. In Ms. Yada's classroom, students were encouraged to make decisions in conducting investigations. She provided opportunities for students to pursue their own interests and topics relevant to them. Ms. Yada' s interview responses also showed that she respected her student mistakes. She had opportunities for students to take a risk. When students encountered wrong turns or wrong answers, she asked probing questions to get the students on track and encouraged them to try again and try to understand why they came to the incorrect answers. Ms. Yada took then students' mistakes into classroom discussion and asked probing questions for clarification and justification from evidence that was found. As a result, students could compare their findings and to identify similarities or differences between them that led students to develop deeper understandings the concepts.

4.1.3 Teacher's Perception of Students' Abilities

Ms. Yada's perception that all learners were capable of learning encouraged her to act as a facilitator and coach than a giver of information. Throughout the discussion with Ms. Yada during implementation time, she mentioned that all learners were capable of learning. She then encouraged all students to be confident in their abilities to succeed in school. In her classroom, the students then were given choices and were included in the decision-making processes of the classroom. Students were also provided opportunities to construct and investigate their own interests. In all lessons, Ms. Yada liked students to sit in circles rather than in rows, and allowed opportunities for children to share their materials, knowledge and experiences in small groups and whole class discussion in order to compare and learn from others' experiences.

4.1.4 Teacher Content Knowledge

Ms. Yada's strong content knowledge facilitated her instruction that provided opportunities for students to conduct investigation on their own interests, make arguments, and then asked probing questions to clarify and justify the arguments. Moreover, she also asked her students to give relevant examples and reasonable explanations about key concepts related to their real life situations. Furthermore, she asked questions for clarification of students' confusing about everyday language that her students and their parents used in naming materials at homes.

4.1.5 Teacher Preparation

Although Ms. Yada had to come early to school because she was also the school librarian, throughout the implementation time, it appeared that Ms. Yada always prepared her teaching in terms of content, learning process, and learning materials what would be taught in each lesson. In addition to prepare herself, Ms. Yada asked her students to bring their toys and utensils to school. Before the science time started, Ms. Yada rearranged students' tables to make a large space for students in doing activities.

4.2 Constraining Factors

Throughout the discussion with Ms. Yada during implementation time, there were two factors that constrained the curriculum implementation. These factors included teacher's comfort level in students' out of school learning and students' ability.

4.2.1 Teacher' Comfort level in Students' out of School Learning

Ms. Yada showed low comfort level in working within community members. Ms. Yada felt that the information received from local experts was not significant and unrelated to the curriculum she was mandated to teach. Ms. Yada then acted as co-teacher in order to make sure students understood scientific concepts that were required by the curriculum. This reduced opportunities for students to learn science from the different perspective of a community expert. Moreover, Ms. Yada mentioned her uncomfort level in providing students an experience outside school. She felt that it required time and money. She felt that schools did not have funding to support this kind of activity. In order to take students outside the school setting, two or three teachers were needed to watch the students. Moreover, the expenses for the trip put a burden on students whose parents had a low economic status.

Moreover, Ms. Yada mentioned that low parents' involvement and assistance with student learning at home reduced student success in classroom. Ms. Yada, in a journal entry, described the difficulty in designing assignments for her students to make investigations of their real objects at home. She commented that she felt this was due to the lack of parents' cooperation. She stated that she asked the students to explore kinds of materials used in making items as homework. However, some students could not accomplish their works because their parents did not have the time or the educational background to assist their children's report writing. Some students who came to school with unfinished homework could not accomplish their group work. Ms. Yada's interview response provides evidence on her belief about importance of parents' involvement in student learning. Ms. Yada mentioned that most of her students were from low socioeconomic families whose parents were busy doing their labor work and they had completed only elementary or junior school education, so they were unable to give their children academic assistance at home. Ms. Yada also noted that if parents were active resources of local knowledge, and involved in their children's learning, it positively related to students' achievement. She said that her students in a previous school had better parent learning assistance and support than the school in this study, and they had much higher achievement. Her beliefs were in accordance with parent interview responses from home visits. As a result of the interviews, it was found that most parents tended to shift the responsibility of supervising their children to school teachers.

4.2.2 Students' Abilities

Students' ability in reading and writing, learning vocabularies and using graphic organizers were the key factors that constrained unit implementation. Ms. Yada mentioned that students encountered difficulties in learning vocabulary words such as "object" "material" "furniture", and "dressing". Students did not realize the difference between the two terms "object" and "materials. She then felt it necessary to provide definitions and explanations of the terms. Furthermore, students' ability in reading and writing was an obstacle in their learning. Ms. Yada mentioned that the reason that some students did not participate in learning activities was they were not yet able to read. Moreover, recording data by using a graphic organizer was another difficulty task for students. In the first lesson on kinds and properties of materials, some groups of students did not finish their task because they were not familiar with recording data in a table form. Ms. Yada assisted students by asking questions until students understood what they should do, and allowed them to edit their recordings before sharing with the classroom.

Case Two Summary

In this case study, Ms. Yada's beliefs and understanding about teaching approaches, her abilities in conducting scientific inquiry, strong content knowledge and perception on students' abilities, good preparation impacted her teaching and the learning about materials. Ms. Yada's beliefs and understanding about teaching approaches and her science background facilitated and supported her level of comfort in the implementation of the instructional unit. Ms. Yada's practice focused on incorporating students' relevant experiences, topics and materials to share and investigate in inquiry classroom. Students' lived experiences with toys and utensils were used as starting point for learning, and then allowed them in decision making to conduct investigations on their own interests on relevant materials through group work. Moreover, students were asked questions to formulate their own explanations, clarify students' dispositions about science at home, and make connection to everyday lives. As a result, Ms. Yada's instruction was successful in improving understanding of kinds and properties of materials and their relation to everyday life. Moreover, Ms. Yada noted that most of the students paid more attention and enthusiastically to participate in learning activities. They also became confident in sharing ideas and doing activities in the classroom. However, the implementation success was limited by Ms. Yada's comfort level in working with community members and abilities of students at this age.

Case Study Three: "Pornnapa"
Grade Three

1. Teacher and Student Background

The description of teacher and student background is divided into three sections, including educational background and teaching experiences, classroom setting, and students' information as shown below.

1.1 Educational Background and Teaching Experiences

Ms. Pornnapa was a grade three teacher with twenty one years of elementary science teaching experiences. Ms. Pornnapa had a Bachelor's degree in sociology field. Ms. Pornnapa's house was far from school around twenty kilometers. Ms. Pornnapa took a bus to school. She was a Buddhist. She had neatly-cut, short, straight hair and usually wore slipper shoes, black long pants, and a light-colored blouse.

1.2 Classroom Setting

There were forty students in Ms. Pornnapa's third grade class. Ms. Pornnapa' s classroom, which was next to the science laboratory room, located on the second floor of a concrete building. The students' desks were arranged in pairs. The students sat in assigned groups in order to encourage their cooperation. In each pair, the competent students were expected to assist the students who had difficulty finishing their work. The desks were arranged into three rows. The rows of students' desks all faced Ms. Pornnapa's desk and the chalkboard. The windows on two sides of the walls were open. There were Ms. Pornnapa's two metal cases for storing her belongings and students' important academic information along with the wall. Next to the cases, a wooden bookcase was used for storing textbooks and worksheets. In a corner at the black of classroom, equipment used for clean up such as tank, garbage cans, mops, and brooms were located (See Figure 5.3).

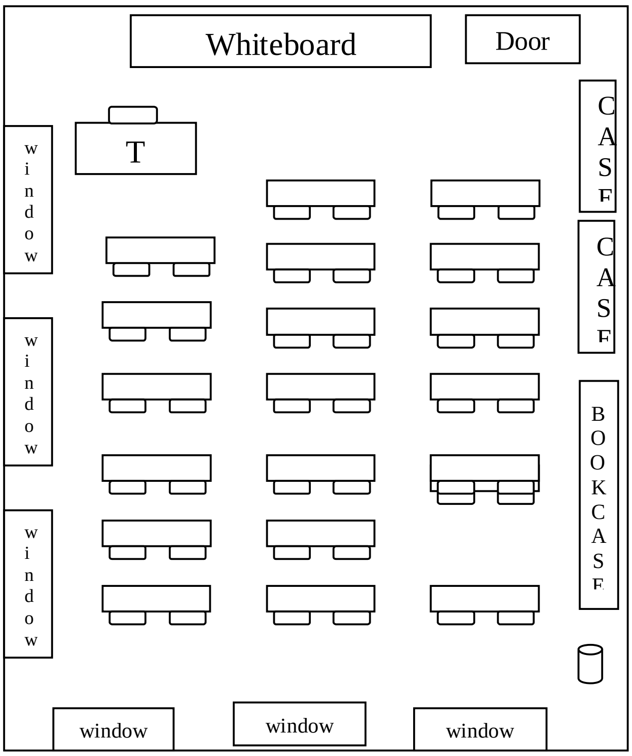

Figure 5.3 Ms. Pornnapa's Classroom Setting

1.3 Ms. Pornnapa's Student Information

Ms. Pornnapa's classroom consisted of sixteen boys and twenty four girls. Most of the students were nine year old. Ms. Pornnapa described the class as great students. The students in this class were the top forty students who had higher achievement scores. There were three students who were selected purposively to be studied in their development of understanding about material concepts after participating in the curriculum. The selection was based on different gender, achievement, and ability to give good reflections about their learning. The three students were called, Chompunuch, Nattawut and Sujeera.

Chompunuch was a girl who was the most competent student in the classroom. She was an active learner. She loved to talk and answer questions in classroom. She then was selected by the teacher to participate in this study.

Nattawut was a boy who was middle level of the classroom. He was selected to participate in the study because he was one of the student who was visited by the researcher when explored students' funds of knowledge to design the curriculum.

Sujeera was a girl who had low achievement in the classroom though; she was active learner in the classroom. Her thinking and working was slower than other students.

2. Ms. Pornnapa's Implementation of the Curriculum and the Students' Understanding

Ms. Pornnapa's implementation of the curriculum is described in terms of the teacher's practices in classroom in parallel with the impacts on students' understanding. Three students selected by purposive sampling in the Ms. Pornanpa' s classroom were studied in depth to reveal the development of their understanding.

2.1 Ms. Pornnapa's Practice

The description of Ms. Pornnapa's practices is provided in two sections according to aspects of culturally relevant practice and inquiry based teaching that served as a basic framework of the curriculum.

2.1.1 Ms. Pornnapa's Instruction and Culturally Relevant Practice

Evidence from classroom observations, teacher interviews and journal entries indicated that Ms. Pornnapa put her teaching on the value of relevant teaching by allowing students to participate in social event and conduct investigations and share experiences about their varied objects; however, asking related questions to provide student opportunities to make connection of what they learned in school to their experiences was not apparent.

In the classroom, Ms. Pornnapa facilitated her student construction of knowledge through active involvement and direct experiences in social event and the environment. Ms. Pornnapa's interview provided further supporting evidence of how her students conducted their investigation. Ms. Pornnapa mentioned that students could acquire knowledge directly through their practices/doing. She felt that learning through direct experience was better than reading from books. As a result, Ms. Pornnapa's students were allowed opportunities to conduct investigations by using relevant materials and local techniques in all lessons.

According to Ms. Pornnapa, she reflected on belief that opportunities for students to experience on relevant objects encouraged them to learn easily and construct accurate understandings. She mentioned that the opportunities for students to use local and relevant materials in classroom fostered students' understandings. For example, a chance for students to make their own candle helped students to develop understanding how it would be changed when heated and cooled. Moreover, the different kinds of spatulas used in experiment to investigate heat conductivities of materials were brought by students. However, it did not appear that

Ms. Pornnapa asked related questions designed for students to apply what they learned in school to real situations.

2.1.2 Ms. Pornnapa' Instruction and Inquiry Based Approach

Ms. Pornnapa's classroom practice when analyzed in relation to the science teacher inquiry rubric (NRC, 2000 and Beerer and Bodzin, 2004) was somewhat inquiry oriented as it contained some aspects of inquiry, but not all aspects of inquiry. She engaged and allowed students to investigate on their own; however, she did not place value on concept formation on students. She did not ask application to related or new situations. She strongly focused her assessment on student responses on her questions at the end of lesson and their completed worksheets.

A. Engaging Students' Attention

In Ms. Pornnapa's classroom, students' relevant experiences were used as a starting point to create student interest and engage them to think about further investigation. She did not explain the concept prematurely or state conclusions about what she expected students to learn at the beginning of lesson. For example, in the lesson on "Physical Changes in Materials", Ms. Pornnapa allowed the monk to engage student attention in the activity. In other lessons, students' experiences in using spoon and spatula in cooking food, and bendsteel production in the shop opposite to the school were used to encourage students' interests and attention. This was a student-centered aspect of inquiry.

B. Conducting Investigations by Students

Ms. Pornnapa provided opportunities for students to acquire knowledge on their own. Her students were put into social events. Through participation in making candles at the temple for presenting to monks at Khao Phansa Day, students were asked to conduct investigations without direct instruction or leading students step by step to a solution. In addition to having a chance to use the same equipments as used in making candles for the Khao Phansa Day, students were allowed to make their own candle in order to observe carefully how it would be changed when heated and cooled. This was a student-centered aspect of her instruction. In other lessons, students were asked in experiments to investigate properties and changes of materials on their own.

C. Formulating Explanations by Teacher' Guiding Questions

Ms. Pornnapa asked guiding questions to facilitate students in formulating their own explanations. According to observation and teacher interview, it appeared that Ms. Pornnapa tried to encourage students to think critically about relationships between evidence and explanations, and construct explanations to develop their understanding about material concepts. But she still guided some answers for students. Ms. Pornnapa's interview response also provided evidence to support this assertion. Ms. Pornnapa mentioned that students develop understanding about concepts after they participate in the activities; however she felt that they could not construct their explanations entirely on their own. She felt that students needed her guidance. She normally asked guiding questions instead of probing questions. It also appeared that most of her questions followed the worksheet. When a student's response to a question was accurate but incomplete, she did not ask probing questions to get the student to think deeper about the concept. Key concepts that students formed were guided by Ms. Pornnapa. Her small number of probing questions led to students' low level of critical thinking. The application of science concepts being learning in the lessons to real life situations did not appear much in her instruction. Students' correct answers and the participation in learning activities were assessed by the teacher. These aspects of inquiry were teacher-centered in nature.

2.2 An Example of "Physical Change in Materials" Lesson

The follow learning activities provides an example of Ms. Yada's instruction emphasizing on previous aspects of culturally relevant practice and inquiry based teaching. To develop understanding about physical changes in materials when heated and cooled, students were asked to engage in making candles to present to the monks in Khao Phansa or Buddhist Lent Day at temple.

After students arrived at the temple, they were engaged by sharing experiences about making candles in Khao Phansa Day. Students were asking questions.

Monk: "When do people usually make candle?
Students: "Khao-Phansa Day"
Monk: "Which province has the biggest/ popular ceremony in Khao Phansa Day?
Student: "Ubon Ratchathani province"
Monk: "Have you ever participated in making candles?"
Students: "Yes"
Students: "No""

The monk allowed an opportunity for all students to participate in the candle making process. Students were provided an explanation about the typical equipments used in making candle in Khao Phansa or Buddhist Lent Day. He said that the equipments used in making candles included wax, mold, candle wick, and burner. The mold could be a can shape or other shapes depending on the shape of candle that people needed. He also showed the modification of old home materials used in making a spatula. The spatula was used to put melted wax into a mold was made of an old bowl tied with bamboo stick. The waxes used in making candle were distributed to individual student to observe before putting into a heated pan. Individual student then was asked to pour melted wax into a prepared mold as the same people do on Khao Phansa Day.

After they participated in the rite, students were asked to make their own candles. Groups of four students were asked to make their own candle by pouring melt wax into small cans, and then leaving them for a period of time. During this time, Ms. Pornnapa walked throughout the area where students were making candles.

She asked students to be careful with the burner. She did not ask questions to facilitate students' thinking.

During the wait time, the monk taught about the importance of Khao Phansa or Buddhist Lent Day in term of religious perspective. He explained that Khao Phansa or Buddhist Lent is one of the important Buddhist Days. This is a time devoted to study and mediation. Buddhist monks remain within the temple grounds and do not venture out for a period of three months. Traditionally, this is done to prevent monks from tramping upon rice paddies when they venture out to receive offerings from the villagers. The celebration of the beginning of Buddhist Lent Day is marked by a ceremony of presenting larger candles to the monks. The wax candles are large enough to last through the three-month Rains Retreat.

After students came back to school, Ms. Pornnapa asked questions that led students to construct their own knowledge. A dialog between teacher and students as commenced:

Ms. Pornnapa:	"What equipments do we used in making candle?"
Student:	"Pan"
Student:	"Burner"
Student:	"Wax"
Student:	"Can (or mold)"
Student:	"Candle wick"
Ms. Pornnapa:	"How did you fell about wax before heated?"
Students:	"It was hard"
Ms. Pornnapa:	"What did you do next?"
Students:	"Put it into hot pan"
Ms. Pornnapa:	"What happen then?"
Students:	"Melt!"
Ms. Pornnapa:	"What happen when leave it around one hour?"
Students:	"Some of liquid became hard again"
Ms. Pornnapa:	"How does wax melt?"

Students: "Heat"

Ms. Pornnapa: "Why does wax solid again?"

Student "It cooled down"

Ms. Pornnapa: "How about candle wick?"

Students: "It was changed. It was burned"

However, teacher did not allow students to formulate their own conclusion about the concepts. She guided and told some parts of the conclusion to students, as illustrated below:

Ms. Pornnapa: "This can conclude that when some kinds of materials were heated, it could be……"

Students: "Melt"

Ms. Pornnapa: "or change of …."

Students: "Shape"

Ms. Pornnapa: "Give me an example of material can be changed its shaped when heated"

Students: "Plastic, Wax"

Ms. Pornnapa: "Right! Wax as we learn yesterday"

Ms. Pornnapa asked students to answer questions independently on their worksheets about what they observed about changes of wax, the metal mold and fabric used in making the candle wick before and after heating and cooling to assess their understanding of the concept.

3. Students' Responses

Evidence gained from classroom observation, teacher interviews, journal entries and students' interview responses indicated that learning through participation with materials and social events enhanced students' understanding about material concepts as well as fostered self-confidence and students' attention.

3.1 Developing Concepts about Materials

According to interview prior to participation in the unit, most of the students had experiences and learned that handles of spatula used to protect heat. Moreover, students had experiences in using candle. They could explain that candle could burn and then became solid.

According to Ms. Pornnapa, being allowed to learn and gain knowledge directly from experiments and local experts, students' understanding was enhanced. Ms. Pornnapa's interview responses indicated her belief that students could acquire knowledge through their directed experiences in doing hands-on activities and working with local experts. She reported that students developed more understanding about material concepts than mandated in the textbook and improved perception on the significance of relevant topics and self confidence as well as fostered students' attention and interests.

3.1.1 Developing Concept about Heat Conductivity

After students participating in the lesson on heat conductivity, students developed better understanding about good heat conductivity of metal. Ms. Pornnapa reported that students could explain that the best conductors of heat are metals (e.g. aluminum, stainless, zinc). This was especially true when they were allowed to collect a metal spoon, wooden spoon, and other kitchen implements and set all spoons in a jar of hot water to look at which ones heated up faster. The analysis of students' worksheets found that all students could describe that aluminum, stainless and zinc could conduct heat. Moreover, all students could describe difference ability to conduct heat of their spatula made of metal and plastic. A Half of the students could provide good reasonable explanation when asked to describe ability to conduct heat of materials their spatula able/unable to conduct heat. The rest of students conducted incomplete explanation. They did not give specific explanation on the relation between kinds of materials and their heat conductivities.

3.1.2 Developing Concepts about Physical Change of Materials When Heated and Cooled

After participating in the lesson on changes in materials, students developed better understanding about physical changes in materials when cooled and heated. Ms. Pornnapa reported that students could describe correctly how candles change when heated. She noted that students explained that heat could change materials. When students burned candles, and then let them melt, they could explain why their candle melted and became solid again. Evidence from students' worksheets and interview responses also showed students' understandings of these concepts. After students were asked to make candles for the religious rite, student could describe that wax can be melted to be become a liquid when heat is applied and returned to solid when cooled. All students knew that metal implements such as spatula, pot, and candle mold could not be changed by heating and cooling, and that fabric could be burned and changed to ashes when heated. Moreover, it found that 89 % of students could give correct examples of material changes when heated and cooled on worksheet; however, most of the answers were copied from competent students' answers during whole class discussion.

3.1.3 Developing Concept about Physical Change of Materials When Forces Were Applied

The finding indicated that students could develop understanding that physical change of each kind of material was different depending on its properties. The information from classroom observation, teacher interview and student interview indicated consistency that students could describe change shape and size of plasticine, and metal used in making wires, while wood could not change. Students described that plasticine could change shape and size, small pieces of metal could change shape but not change size and that wood could not be changed in shape and size when forces were applied. The students' worksheets also showed that all students developed understanding about change of materials. All students could give examples of surrounding things that was produced by applied forces; however, most of them provided same answers. They described that knifes, cloth hanger, bendsteel, pottery were products of physical change of materials when forces were applied.

3.1.4 Developing the Application of Concepts to Their Experiences

According to classroom observation and students' interview responses, it was found that the variations of items students brought to the classroom enhanced students' application of the concepts because students could share and talk about the similarities and differences of how their items were made. However, this was found only the case of competent students. In the lesson on heat conductivity, competent students could describe the selection of suitable and safe materials used in making kitchen implements after they compared heat conductivity of varied materials. When asked what kinds of spoons were appropriate in eating hot soup, students replied that plastic spoons could not use for this situation because they released dangerous chemicals for cancer when heated. In the lesson on changes in material, students could explain the application of concepts about changes in materials when heated and cooled to explain ice-cream and jelly making, and freezing food and drinks to be solid and change in phase to become liquid again. Moreover, students could give examples of everyday objects that are the result of changes of materials. These examples included knife, cloth hanger, bendsteel, and pottery.

3.2 Improving Student Self Confidence

Students became confident in participating and sharing ideas in relation to the activities. According to classroom observations, interviews with teacher and interview with students, it appeared that students improved their self-confidence in sharing ideas, especially on relevant and familiar topics. When students were asked to watch a video about bendsteel making, a girl shouted proudly that she knew about that bendsteel shop because her father used to work in that shop. Based on the students' interviews after participating in the activities, she said that her father were able to bend many styles of steel. She also described the methods and instruments her father used to do in this job. After assigned to create her own bendsteel by using small pieces of wire, she created a bendsteel in the shape of a cooker with her parents' assistance.

3.3 Improving Students' Perception on the Significance of Relevant Topics

Ms. Pornnapa also mentioned that culturally relevant instruction facilitated student abilities to realize local event. Ms. Pornnapa said that students could learn the importance, and origin of a Buddhist rite taught in social studies and in the same time developed the concept of physical change in materials when heated through candle making with the monk at the temple. Moreover, Ms. Pornapa mentioned that learning from the monk helped students concentrate and practice in good behavior that should be used when they stay at the temple. Moreover, students developed their understanding about skills and equipments that bendsteel and pottery makers used in their works.

3.4 Fostering Students' Attention and Involvement

Responses from classroom observation and interviews from students and teacher indicated that students paid more attention and were willing to participate in the activities. Ms. Pornapa mentioned that students liked and were eager to do the experiments. For example, in the lesson on physical changes in materials when heated and cooled, she mentioned that students liked this activity because they had a chance to do it by themselves, especially for some students who never had a chance to made candles in Khao Phansa Day before. She also noted that her students paid attention and tried to successful in their work. After they let their own candle cool down until it was a solid, they were excited to take it out of the can. In another example, in the lesson on heat conductivity, almost of all the students prepared their own spatulas to share and experiment within the classroom and when the teacher asked them to make hot milk, students became quiet; all students were ready to do the activity. Students' interview responses also supported this idea. Students stated that they loved to participate in science time, especially when doing experiments.

In summary, there was much evidence supporting the conclusion that the curriculum implementation by Ms. Pornnapa was successful in improving all students' understanding about material concepts. Through providing active involvement and direct experiences in social situations and environments, students developed better understanding about key concepts of materials, including heat conductivity and changes in materials. Furthermore, the emphasis of local and relevant knowledge helped high ability students demonstrated improve in application of concepts to their experiences. They saw the significance of relevant topics. Students also demonstrated confident in participating, and sharing ideas that relevant to them. In addition to improving students academic achievement, the emphasis of the curriculum drew on relevant topics and materials and fostered students' attention and interests.

4. Factors Influencing on the Implementation

The success of the implementation of an instructional unit of Ms. Pornnapa depends on teacher's beliefs about culturally relevant practices, inquiry based approach, and teacher preparation. However, Ms. Pornnapa' s ability in conducting scientific inquiry, perception on students' abilities, content knowledge, and comfort level in students' out of school learning were obstacles for her implementation.

4.1 Facilitating Factors

The factors that facilitated the implementation of Ms. Pornnapa included teacher's beliefs about inquiry based approach and teacher preparation.

4.1.1 Teacher' Belief about Inquiry-Based Instruction

The congruency of what Ms. Pornnapa believed and did in her classroom facilitated the success of the curriculum implementation in developing students' understanding about material concepts. According to the classroom observations and the discussion with Ms. Pornnapa during informal interviews throughout the study, her beliefs about science teaching was that science teaching was not telling. Ms. Pornnapa then focused her teaching on "doing" hands-on activities.

The information from classroom observation and interview responses indicated Ms. Pornnapa's belief and understanding about inquiry and culturally relevant teaching. Ms. Pornnapa believed that science learning should focus on students' active involvement in hands-on activities to construct their own knowledge instead of receiving information from the teacher and then memorizing it. As a result, Ms. Pornnapa accepted the benefits of inquiry based teaching and felt that it helped students improve their understanding about materials concepts. Some comments from teacher concerning inquiry based teaching were:

"Doing experiment, doing by themselves, acquiring knowledge is good way of teaching science. For example, when I asked them a question on what happens when materials were heated, they could explain what they saw. By contrast, teaching science by teacher telling was not work. Students did not hands-on; as a result, they did not understand and memorize it."

"Students had direct experiences through participating in this activity. They learned by doing that was better than reading from textbooks."

"Students' opportunities to invent toys and utensils, design their own bendsteel, make candle at the temple fostered their understanding about changes of materials."

4.1.2 Teacher Preparation

In each activity, Ms. Pornnapa made many efforts to be successful in her implementation. She always prepared equipments and tried to understand content and learning activities. She was alert about asking students to bring their toys and utensils into school. She told them a few days before the activities started and reminded them every day. In the morning, she prepared a television and CD player for students to look at bendsteel and pottery making, as well as asked permission from the school principal to bring students to learn at the temple.

4.2 Constraining Factors

Throughout the discussion with Ms. Pornnapa during implementation time, there were many factors that constrained the curriculum implementation. These factors included Ms. Vanvisa' s belief and understanding about culturally relevant practice, ability in conducting scientific inquiry, perception on students' abilities, content knowledge and perception on students' out of school learning.

4.2.1 Teacher' s Misunderstanding about Culturally Relevant Practices

The ability of students to apply knowledge to relevant situations was not clearly apparent influenced by Ms. Pornnapa's belief and misunderstanding about culturally relevant practice. Ms. Pornnapa believed that culturally relevant practice was learning through direct examples students brought with them and participating in social events without the value on asking relevant questions to facilitate student connection of science concept being learned in classroom and their experiences out of school. In her classroom, Ms. Pornnapa's instruction strongly focused on the uses of students' toys and utensil as learning organizers for students to develop understanding about material concepts. Ms. Pornnapa mentioned that learning materials used in culturally relevant teaching should be examples students brought with them because students had a greater varieties of materials and could talk about and share the experiences related to them. In the lesson on heat conductivity, melamine spatulas, metal spatulas, and metal spatulas with handles were used to investigate heat conductivity in the classroom.

4.2.2 Teacher' s Ability in Conducting Scientific Inquiry

The low ability in conducting scientific inquiry limited students' understanding. According to observation and teacher interview, it appeared that Ms. Pornnapa worried about out of control of findings when she provided opportunities for students to conduct investigations without direct instruction or leading students step by step to a solution to develop their understanding about material concepts. She then tried to keep students do experiments on materials that were mandated in the curriculum. She did not allow students to conduct investigate freely on their own. Moreover, Ms. Pornnapa did not use probing questions to elicit student deeper understanding. Most of her questions followed the worksheet were used to guide the answers. Therefore, key concepts that students formed were guided by Ms. Pornnapa.

4.2.3 Teacher's Perception of Students' Abilities

Ms. Pornnapa who perceived that low achievement students could not construct their explanations entirely on their own appeared to guide them and let them memorized and copied the correct answers and explanations from competent students in the classroom. Although Ms. Pornnapa mentioned that science teaching happens when students practice in hands-on activities, Ms. Pornnapa showed her felling that students could not construct their explanations entirely on their own. She felt that students needed her guidance. She then normally asked guiding questions instead of probing questions to facilitate students in formulating their own explanations. As a result, low achievement students could not develop understanding about concept of materials.

4.2.4 Teacher Content Knowledge

The low content knowledge of Ms. Pornnapa reduced opportunities for students to conduct investigations on their own interests but improved teacher explanation. Information based on classroom observations and discussion with Ms. Pornnapa during informal interviews throughout the study indicated that she felt uncomfortable and not relaxed when the results of experiment were differ from what she thought they should be and when she encouraged students' complex problems. For example, in the lesson on heat conductivity, when students asked to compare heat conductivity of different kinds of spoons after put into hot water, one group of students reported that the ceramic spoon hot heated up faster than the stainless spoon. Ms. Pornnapa did not try to explain this phenomenon. She just asked to students whether it was the heat of hot water they touched. She did not mention that the thickness of each spoon might be a variable of this finding. After the implementation of physical changes in materials when heated and cooled, Ms. Pornnapa accepted that she could not provide students with an explanation when they asked why the middle of candle were got into lower level than other parts after cooled down.

4.2.5 Teacher's Perception on Students' out of School Learning

Ms. Pornnapa's perception that there were many steps in asking permission of the school principal to bring students out of limited opportunities to provide students an experience outside of school. Moreover, Ms. Pornnapa perceived that bringing one classroom of students out of school required two or three teachers. There were not teachers available for this role. Ms. Pornnapa suggested that the invitation of local experts to teach and demonstrate in school might be an easier way to link the curriculum with community.

Case three Summary

In this case, Ms. Pornnapa's belief on teaching approaches and good preparation impacted positively on her teaching and the learning about materials. Ms. Pornnapa's instruction strongly focused on students' doing on their own while she guided them to think and formulate understanding. Although, Ms. Pornnapa believed that teacher telling was not way to teach science; she guided students in reaching conclusion. It was found that she rarely asked probing questions to elicit students' higher thinking. She asked questions that were included in the worksheets. She felt that it was necessary to guide answers for her students to make sure that they understood key concept. As a result, students developed better understanding about key concepts of materials, including heat conductivity and changes in materials through providing active involvement and direct experiences in social situations and environments. Moreover the emphasis on local and relevant knowledge helped students develop the application and understanding about selection of materials for their life. Students saw the significance of local event and knowledge. Students also became confident in participating, and sharing ideas on topics that were relevant to them. In addition to improving students academic achievement, the curriculum that drew on student relevant topics and materials fostered students' attention and interests. However, the implementation success was limited by Ms. Yada's abilities in conducting scientific inquiry, weak content knowledge and perception on students' abilities.

Cross Case Studies

The findings indicated that the three teachers implemented an inquiry curriculum which drew on students' funds of knowledge differently. One teacher consistently implemented the curriculum as it was intended, while two teachers inconsistently implemented the curriculum based on the tenets of inquiry and culturally relevant based approach. It seems to this researcher that success in improving students' understanding, self-confidence and fostered students' attention and involvement were different for each teacher. Therefore, the different ways in which the curriculum was implemented and factors which influenced the implementations are also discussed below.

1. Teacher' s Beliefs about Inquiry Based Approach and Culturally Relevant Practice

1.1 Teachers' Belief about Inquiry-Based Approach

The teachers' beliefs about inquiry affected their acceptance and comfort level in implementing this teaching approach. The teachers, who believed in inquiry, appeared to focus the instruction on student-centered approach where students were active learners involved in the investigation and discovery on their own. Ms. Yada and Ms. Pornnapa believed that teaching by telling was not the way to teach science; but rather that learning happens when students used observation and did experiments to construct their own understanding. However, both of them implemented the instructional unit differently. Ms. Yada who more strongly believed in inquiry could implement the curriculum in ways that included all aspects of inquiry, while, Ms. Pornnapa's instruction contained some aspects of inquiry, but not all. Both of them tried to provide opportunities for students to pursue their own interests and make decisions in conducting investigations. However, Ms. Yada asked her students to describe what they saw and explain it in their own words, and encouraged them to think critically about relationships between evidence and explanations, and constructing explanations, while Ms. Pornnapa tried to give students ideas to facilitate construction of their own conclusions.

On the other hand, the teachers, who held misunderstanding about inquiry based approach that students had to learn from direct experiences, and need teacher conclusions appeared to focus teaching on telling and explaining to students. This was a case of Ms. Vanvisa. After students were engaged in the investigation of real objects students brought with them, she normally asked students to listen to her when she provided terms, definitions and explanations of concepts.

This study found that teachers who would not allow students to develop their explanations on what they see or investigate first-hand material just memorized information provided without understanding. The opportunities for students to construct their knowledge through direct observation of objects/materials and participate in hands-on activities or do experiments encouraged the development of students' understanding.

1.2 Teachers' Belief about Culturally Relevant Practice

The teacher who believed in the importance of culturally relevance practice to focus on students' learning used relevant materials and topics. For example, Ms. Yada believed that science teaching should be relevant to student and school context. Therefore, she always allowed opportunities for students to bring their home items as a basis for developing science concepts, particular in learning about toys and utensils, and used the topics related to their items to discuss connections with their life. As a result, the emphasis of a curriculum that drew on student relevant topics and materials fostered their connection between home and school science. The students could provide reasonable application on the appropriate uses and selection of materials used in making toys and utensils on the basis of what was being learned in classroom.

By contrast, the instruction of Ms. Vanvisa and Ms. Pornapa, who believed that culturally relevant practice, was the learning that placed the importance of relevant materials and topics were little emphasis on fostering students' thinking about the application of knowledge to every life. In case of Ms. Vanvisa, she expected students to observe and make connection about what they learned in school and out of school by themselves. She did not bring relevant topic for discussion in the classroom. In case of Ms. Pornnapa who strongly relied on instant lesson plans that were not relevant to communities or student context just tried to teach on outlined lesson plan. She did not ask relevant questions to encourage students to construct linkage between what they learned in school and their experiences.

2. Teacher Content Knowledge

The teacher's content knowledge of science affected enhancing the students' understanding of material concepts. Ms. Yada was a teacher who had strong content background. She allowed students to pursue their own interests, asked probing questions, took incorrect concepts into account, and connected learning to other situations.

On the other hand, the teachers who were not confident had in science focused their teaching on explanation and worksheet. Ms. Vanvisa was an example of the teachers. According to the classroom observations and the discussion with Ms. Vanvisa during informal interviews throughout the study, Ms. Vanvisa felt uncomfortable and not relaxed when she encouraged in students' arguments. Similarly, Ms. Pornnapa felt uncomfortable and not relaxed when the results of experiment were differ from what it should be and when she encouraged in students' complex problems. Therefore, they provided the description of terms, and definitions to students. The decision making and encouraging them to ask questions, debate, and negotiate to develop deeper understandings of concepts did rarely found in their instruction.

3. Teachers' Ability in Conducting Scientific Inquiry

This study also found that the teachers, who were able to conduct scientific inquiry, appeared to allowed opportunities for students to investigate on their own interests that could not expect what going on, and then asked them to describe, clarify, and justify effective in foster their higher-order cognitive skills. The example of this was the case of Ms. Yada who monitored student active participation in creating, charting their own learning, debating, and engaging in activities. When students encountered wrong turns or wrong answers, they were encouraged to try again and try to understand why they came to the incorrect answer. Moreover, she emphasized questioning heavily in her teaching. Ms. Yada normally asked good probing questions to allow opportunities for students in describing, clarifying, and justifying. Ms. Yada facilitated students' abilities to justify and explain their response-dealing with the "why" and "how" questions. She involved students in observing and describing an event or object by asking questions. She also asked students to state an idea or definition in their own words. She also asked students to compare two or more kinds of materials to identify similarities or differences between them. She also asked probing questions to get the students to think deeper about a concept when a student's response to a question was accurate but incomplete and for clarification of student arguments. Moreover, she asked related questions to help them apply what they learned in school to real situations. These probing questions promoted students' critical thinking.

On the other hand, teachers who felt uncomfortable to conducting scientific inquiry appeared to place the importance of success and ignored students' mistakes. In the case of Ms. Pornnapa who less comfortable in conducting inquiry appeared to provided opportunities for students to conduct investigate on their own but she still tried to keep students do experiments on process that mandated in the curriculum. This the case of Ms. Vanvisa, she tried to control what students do and then paid much attention on right answers of two or three competent students in the classroom. In Ms. Pornnapa and Ms.Vanvisa classrooms, they could not encourage students to share ideas and learn from each other in groups. During activities, Ms. Vanvisa walked throughout the classroom and monitored children in groups to share ideas with peers without asking questions to guide their discussion. This resulted in some students being ignored when working in groups. Moreover, Ms. Vanvisa ignored students' resistance, mistakes and alternative explanations during activities. When students encountered wrong turns or wrong answers, she did not keep student on track. The easiest way for Ms. Vanvisa to make her students understand the concept was a teacher telling. In the case of Ms. Pornnapa, she just walked around to observe student working without talking and giving assistance to them. As a result, Ms. Vanvisa' s sand Ms. Pornnapa' s students were not as skilled in using communication skills and or as confident in sharing ideas with others.

4. Teacher's Perception of Students' Abilities

Teachers who perceived on the idea that all learners were capable of learning and formulating their own understanding appeared to give students choices and were included in the decision-making processes of the classroom. Ms. Yada was in this case. Ms. Yada liked students to sit in circles rather than in rows, and allowed opportunities for children to share their materials, knowledge and experiences in small group and whole class discussion in order to compare and learn from other experiences

On the other hand, Ms. Pornnapa and Mr. Vanvisa who did not perceive that students could formulate their own explanations appeared to guide and give information to students. Based on Ms. Pornnapa's notion that science teaching was not teacher telling, she then tried to engage students in constructing their own explanation by asking guided questions that relied mostly on worksheets. When student's response to a question was inaccurate or accurate but incomplete, Ms. Pornnapa provided them the correct answers. In the case of Ms. Vanvisa who strongly perceived that young students could not construct their own conclusions, she normally provided her students with explanations. Moreover, Ms. Vanvisa showed the idea that inquiry based learning is a way of teaching high-achieving students and does not work with students who have learning disabilities. This perception reduced the opportunities for low competency students to share ideas and explanations in the classroom. As a result, Ms. Pornnapa and Ms Vanvisa did not promote students' abilities to think critically to construct their own explanation on evidence. Most of the low ability students memorized and copied the correct answers and explanations from competent students in the classroom.

5. Teacher Preparation

There was the difference of three teachers in terms of preparing the lesson. Ms. Yada and Ms. Pornnapa who normally corrected students' worksheets and then giving them individual assistance to students with incorrect answers or mistakes appeared to prepare neatly on learning procedures and equipments. This facilitated implementation of the curriculum. By contrast, Ms. Vanvisa needed the researcher to talk briefly about the objectives, content, steps of activities, and equipment. Therefore, she always worried about the steps needed to complete based on the instructional unit.

6. Teacher' Comfort level in Conducting out of School Learning

Teachers who had to organize out of school activities appeared to fell uncomfortable. In grade two, Ms. Yada felt unfamiliar and uncomfortable in bringing local experts in to share personal knowledge within the school setting. Ms. Yada felt that the information received from local expert was not significant and unrelated to the curriculum she was mandated to teach. Moreover, Ms. Yada reported that her efforts to design assignments for her students to make investigation of their real objects at home did not work well because she lacked parents' cooperation. Furthermore, Ms. Yada and Ms. Pornnapa agreed that the opportunities for students to have an experience outside school were limited because school did not have funding to support this kind of activities and needed many steps in asking permission of school principal.

7. Nature and Abilities of Students

There were different limitations of students' ability in participating with the instructional unit across grade level. Grade one students had limited in term of attention time in participating in activities. Ms. Vanvisa mentioned that young students paid attention to participate in learning activities for a short time. They loved to play and talk with their friend during the activities. Specially, students paid their attention more on their toys and utensils rather than teacher and learning activities when they were asked to bring their toys into classroom. Moreover, grade one students felt familiar with intently listening, copying what she said and wrote on the board, and completing activities from the worksheet. They were not confidence to walk throughout the classroom to collect and observe surround items. Grade two students encountered the difficulty in reading and writing that limited their learning about vocabularies of material concepts and recording data by using graphic organizer. Ms. Yada reported that the reason that some students did not participate in learning activities was students being unable to read.

Summary

This research conducted three case studies of the teachers including grade one, two and three teacher who served as member of research team in co-constructing the inquiry based curriculum which drew on students' funds of knowledge. The studies included different ways that three teachers implemented the curriculum that influenced on students' understanding about material concepts. The findings illustrated that teacher's belief and understanding about inquiry and culturally relevant teaching, their abilities in conducting scientific inquiry, teacher preparation, content knowledge, and perception of students' abilities impacted on the teachers' implementation. The teachers who believed on these teaching approaches, had ability to conduct inquiry, strong content background, perceived on all abilities students and showed good preparation in teaching could foster students' understanding and application about key concepts, and self confidence as well as attention and interests. On other hand, the teachers who held misunderstanding about teaching approaches, less abilities in conducting scientific inquiry, lack of lesson preparation, had weak content knowledge, and perceived on high abilities students appeared to provided answers and explanation to students. Therefore, these students leaned science by memorizing it.

CHAPTER VI

CONCLUSION, DISCUSSION AND RECOMMENDATION

This chapter is a conclusion and discussion of how inquiry- based curriculum about matter which draw on students' funds of knowledge for grade one-three was designed and implemented. The chapter starts with research questions and methodology. Conclusions about the development process of the inquiry based curriculum regarding to each research question are described. It starts with the exploration of student' funds of knowledge, and then the incorporation of this knowledge into curriculum about materials for grade one two three students. The development of students' understandings, self-confidence and attention after participating in the curriculum is then described. Finally, the recommendations of this study are provided.

Research Questions

1. What informal learning experiences do elementary level 1 students have and developed by interacting with toys and utensils and what science concepts have students developed by interacting with toys and utensils in informal learning contexts?
2. How can we draw on students' and parents' funds of knowledge to design an instructional unit on material concepts for elementary level 1 students?

 - How can toys and utensils serve as an "organizer" for students' explorations of material concepts?

 - How can culturally relevant experiences be incorporated into the unit?

 - How can inquiry be used to develop students' knowledge of science content and process skills with respect to material concepts?

3. What happens when teachers implement a unit on material concepts designed around students' funds of knowledge?

 - What do students learn by participating in an instructional unit using toys and utensils?

- What constrains or facilitates the teaching of a unit that incorporates students' funds of knowledge and inquiry?

Methodology of the Study

The methodology used to investigate the process of designing this unit, teacher implementation and students' experience was educational ethnography. The method of the study was case study, which consisted of three case studies of grade one, two and three teacher who were research team members involved in the construction of the inquiry based with three science educators and a scientist. To obtain rich and descriptive information of what happens when a culturally relevant/ inquiry based instructional unit is designed, implemented, and experienced, common techniques of data gathering included interviewing, participant observation, teacher' journal were used.

Conclusions and Discussions

In response to the emphasis placed on relevancy in the Thai National Education Act, there have been efforts in Thai science education to provide opportunities for basic educational institutions to assume responsibility for constructing their own curriculum. This in being done in accordance with local community problems and wisdom (MOE, 2001; IPST, 2002) in order to promote connections between what students learn in school to everyday life. This study aims to examine grade one to three students' funds of knowledge about toys and utensils as a basis for co-constructing an instructional unit regarding material concepts with science educators, scientist and experienced elementary science teachers. It also examines the impact of a culturally/inquiry-based instructional unit on both students' learning and teachers' teaching.

The conclusions and discussions of this study are organized into three sections regarding to research questions. The first section describes the students' informal experiences with toys and utensils. The second is a description of the development of an inquiry based curriculum which drew upon students' informal experiences. Finally, the students' and teachers' experiences with the implementation and the factors that constrained and facilitated the implementation are also described.

Research Question 1: What informal learning experiences do elementary level 1 students have with toys and utensils and what science concepts have students developed by interacting with toys and utensils in informal learning contexts?

As a result of entering the households of nine students and conducting open-ended interviews with parents and students, the key findings from the exploration of students' informal experiences with toys and utensils in this study were: 1) children had a variety of experiences with toys and utensils depending on gender, age and their economic backgrounds, 2) students' experiences with toys and utensils influenced the development of the students' science conceptions, and 3) the similarity of students' current toys and utensils and everyday language that were used in naming objects and materials led to students' alternative conceptions.

In terms of the variety of experiences with toys and utensils in regards to gender, age, and economic backgrounds, it was found that there was a significant difference in the kinds of toys between the boys and girls and between the students of high and low economic status. Boys played with a wider variety of toys than girls. This was influenced by the high value placed on the child's sex when the parents chose their children's toys. The parents responded that they always deliberated their child's gender when buying their child the toys. Nearly all toys are deliberately designed and marketed based on sex difference. Moreover, students who came from higher economic background had experiences with a wider variety of toys, whereas, low income family students had more experiences with a variety of utensils. The students who came from high income families played with electronic games that were expensive, Barbie dolls, action figures, and toy cars that had different colors and patterns. By contrast, students who came from low economic status normally played with only one or two kinds of toys. Most of their toys were kitchenware and home items. Moreover, the students who came from a lower socioeconomic status were assigned to care of younger siblings and were expected to participate in household chores such as cleaning the house, food preparation and washing dishes. Therefore, these students had more experiences in using kitchenware and cleaning equipment in addition to learning materials, clothing and electrical appliances used by higher background students. Furthermore, the higher socioeconomic level students tended to play with electronic items that were more complicate and concentrate than students of the lower level. In terms of utensils, first grade students experienced with clothing and stationeries because they were expected only to take care of themselves and study in school, whereas second and third grade students were expected to use electrical appliances on their without supervision.

Second, the experiences with toys and utensils influenced the development of science conceptions. The finding in this study indicated that there were five science concepts that were generally understood from their explanations when asked students and parents to provide explanation on how toys and utensils work. These included concepts of physical properties of object, kinds and properties of materials, change state of matter, force and motion, and electricity. The finding of the study were supported by evidence from study conducted by Featonby (2005) who suggests the use of a variety of different toys fostered students' understanding about force and motion, energy, movement, electricity and other concepts.

When analyzed how students develop science concepts, it was found that students developed these concepts in different ways: 1) A variety of color, size, weight and shape of Barbie Doll, action figures, balloons and erasers helped to develop the concept of observable properties of objects, 2) Differences between an object made of different kinds of materials such as Barbie Doll, action figures, eating sets, furniture, and learning materials helped to develop the concept of kinds and properties of materials, 3) the noticeable change of state of water in a refrigerator and the movement of car toys and spinning tops helped to develop concepts on the state of matter and force and motion, respectively, and 4) The parents' warning about the danger of electric shock in using electrical appliances helped to develop the concept of electricity.

It seems that students' understandings began with concrete concepts of color, size and shape of toys and utensils. Next was the softness of fabric items such as clothes, socks, towels, pillows and blankets, the fragility of glass, and the elasticity of rubber bands. This was followed by the development of abstract concepts involving electricity, changes in state of matter, force, and motion which they could not see and touch directly. As Piaget (1972) noted, the development of concepts occurs in children through an understanding of the basis ontological categories of cause, objects, space, and times. Children link these though their interactions with the world. Moreover, he stated that in the elementary grade years, the concrete operational child begins to think logically; operations are associated with personal experience and in concrete situations, but not in abstract manipulation.

In terms of the concept about materials that were the key to this study, it was found that students developed an understanding of the concept of softness of fabric and fragility of glass more than those of the elasticity of rubber. This may be due to the differences in noticeable properties of fabric, glass, rubber and plastic as well as opportunities to compare a variation of toys and utensils made of different kinds of materials in each household. Most of the students developed understandings about softness of fabric through normal experiences in using clothes, socks, towels, handkerchiefs, pillows, and blankets. Therefore, it was easy for them to access the softness of these items. Moreover, the development of the concept of fragility of glass was evident in all students, though; some students did not have experience with glass objects directly. This most likely was the influence of parents' warnings about the danger of sharp glass when broken into small pieces.

Finally, the similarity of the students' current toys and utensils and everyday language that were used in naming objects and materials led to students' alternative conceptions**.** These alternative conceptions included the confusion between rubber and plastic, plastic and fabric, mirror and glass and leather and rubber.

The similarity of current toys and utensils that are made of both plastic and rubber influenced students' confusion about these two materials. For example, some students had real Barbie Dolls with copyrights that were made of rubber while others had fake Barbie Dolls made almost entirely of plastic, except for the head. The plastic body Barbie Doll is less durable and flexible; its price is less expensive than other kinds made of rubber. In addition, learning materials (e.g. pencil, pencil boxes, school bags) and furniture (e.g. dressers, tables, chairs and cabinets) are things that can made of more than one kind of material. Pencils can be made of wood and plastic. Pencil boxes can be made of plastic and metal. School bags can be made of leather and plastic. Furniture can be made of wood, metal and plastic depending on its quality. This confusion might possibly be attributed to the variety of kinds of plastics used in the production of toys and utensils in current times.

In term of the confusion of everyday language that parents and students used in naming objects and materials led to students' alternative conceptions. The confusion of everyday language that parents and students used in naming rubber bands as "Nang Yang" (Nang=leather, Yang=rubber) and the word "Pa-Plastic" (Pa= fabric) led to students' alternative conceptions about concepts of rubber and leather as well as concepts of fabric and plastic. This finding was supported with the notion that students sometimes may have an alternative conception stemming from the use of everyday language (Gilbert *et al.*, 1982; Leach and Scott, 2003). Trowbridge and Mintzes (1985) stated that children hold ideas that are developed before and during their early school years, and these ideas may be compounded by the teacher and/or the textbook. It is possible that children develop parallel but mutually inconsistent explanations of scientific concepts-one for use in school and one for use in the "real world". Therefore, it is important to take into account differences between everyday language and scientific terms.

Research Questions 2: How can we draw on students' and parents' funds of knowledge to design an instructional unit on material concepts for elementary level 1 students?

In this study the development of an inquiry-based curriculum which drew on students' informal experiences with toys and utensils started with the analysis and statement of the content and expected learning outcomes. This was followed by research team meetings that were conducted collaboratively with three educators, a scientist, and three elementary science teachers in order to negotiate how to incorporate students' funds of knowledge and inquiry based teaching into the curriculum and then conducted a pilot study to explore of the viability expected outcomes, the content, instructional strategies, assessment, and materials and to estimate the appropriate time needed for each activity.

A key aspect of this study as being important to be success was the collaboration among science educators, experienced teachers, and scientist who negotiated how to incorporate students' funds of knowledge and inquiry based teaching into the curriculum. The research team meetings provided an important way of maximizing time and combing resources and of conceptualizing the pedagogical connection between classroom and household.

During team meetings, there was a space for participants to come together and share experiences about visiting households, classroom science connections, and constrains of teaching contextual science within a curriculum. The meetings centered on constructing knowledge around how children learn best and how science context was created. In this process, the experienced teachers, educators and a scientist learned about the funds of knowledge possessed by students and their families in order to gain insight about connections among ordinary curricular goals and students' experiences within the community. This way enables teachers to detect aspects of children's everyday learning experiences that could be adapted for use in school. Teacher, educators and scientist collaborated on plans for lessons that encouraged students to apply what they already knew to posing and meeting new academic challenges. This finding was supported with McCarty et al. (1991)' studies that students who develop a meaningful context for absorbing new information based on their personal experiences also improve their critical thinking and problem solving skills. According to Fusco (2001), students learn science best by understanding their own experiences and integrating science into the larger community. Fusco also argued that students' interest in learning science has to come from their own "concern, interests, and experiences" (p.871).

The research team also played an important role to identify and connect with the social and cultural resources of their students and utilized those resources to support their students who embody diversity in accordance with the notions of Gonzalez and Moll (2002), Moll *et al*. (1992), and Tobin *et al*. (2001). The incorporation of resources and funds of knowledge available in student households responded more on students' interests and talents. This notion agreed with Gonzalez and Moll (2002) and Moll *et al*.'s (1992) finding that funds of knowledge can be utilized to validate students' identities as a knowledgeable individual who can use such knowledge as a foundation for further learning. Therefore, the use of relevant objects brought by students as a learning organizer to develop an understanding about material concepts was central to curriculum development in this study.

The toys and utensils brought by the students were served as a learning organizer in this curriculum. Students' favorite toys and utensils were served as organizers in learning about objects. Colorful plasticines and the variation of sizes and weights of different kinds of ball were served as an organizer in developing the concept of the observable properties of objects. Dishes, glasses and spoons made of different kinds of materials were also used in developing the concept of materials in grade one students. Students' experiences in playing with rubber jump ropes and cleaning houses were served as starting point in developing concepts of properties of materials in grade two. Moreover, in grade three students' spatulas were served as materials in learning about heat conductivity. The finding of the study is supported by evidence from many research studies that address the use of toys to promote physical science learning. Herald (2001) suggests that using toys to teach physical science can engage students and provide a hands-on experience that stays with students a lot longer than simple paper-pencil exercises. Moreover, Swiniarski (1991) suggests that toys can be used as an organizer in teaching physical science to childhood students, and can serve as a tool to cross different students' culture and background.

Furthermore, experiences from opportunities for students to tap into community funds of knowledge about the production of fabric artificial flowers and bend-steel as well as the participation in candle making in Khao Phansa Day were incorporated in the curriculum. The bend-steel production and artificial flower making were used to extend students' understanding about properties and changes of materials for grade two and three students, respectively. The participation in the Buddhist Light ceremony with monks at the temple was conducted to develop the students' understanding about physical changes in materials when heated and cooled. These topics were selected to be incorporated in the curriculum because they were relevant to the students' households and daily lives.

The 5-E model of inquiry (BSCS, 1989) was a model that used as the basic framework in designing the unit because this model of inquiry could help students to enhance subject matter knowledge, scientific reasoning, cultivate interest and attitude about science (Bybee, 1993). However, it was found that elementary science teachers still placed value on worksheets and perceived on their students' inabilities in posing questions which led to further investigations. The three teachers did not believe in their student abilities in asking appropriate questions. As a result, inquiry based activities oriented by the teachers focused on addressing the students' real life experiences with toys, utensils and social events and was followed by activities that allowed students to make decisions and conduct investigations based on personal interests in objects. The focus was on enabling students to formulate their own understandings and to make connections between material concepts and students' everyday lives.

Research question 3: What happens when teachers implement a unit on materials concepts designed around students' funds of knowledge?

Regarding to sub-research question 1, what do students learn by participating in an instructional unit using toys and utensils? Findings showed that the curriculum helped to increase the students' understanding about material concepts when their funds of knowledge and everyday life experiences were included in the curriculum. The increase of students' understanding about materials concepts is noticeable in the concepts about properties of materials, which was the focus of curriculum in grade two, followed by concepts about properties and physical changes in materials in grade three. The success in improving grade two and three students' understanding by Ms.

Yada and Ms. Pornnapa was contributed to the influence of their focus on inquiry based activities and the opportunities for students to bring toys and utensils with them and learn or share their experiences within the science classroom. Ms. Yada was able to foster her students in developing deeper understandings about properties of materials because she provided opportunities for students to share in variations of items they brought to the classroom. This was also done through experiments that investigated properties of materials based on their own interests and from other groups whose were different. However, students' understating about metal, plastic and rubber through exploration of items at home was difficult for grade two students. Students developed deeper understandings about these concepts after they learned that rubber could be stretched and returned back to its original shape, but plastic could not. It seems that the most important in learning kinds of material concepts involved the opportunities for students to understand material properties. Asking students to directly explore objects did not change their understanding about kinds of materials.

By contrast, grade one students' development about material concepts was not clearly apparent. Students could develop understanding about difference between toys and utensils but contained similar understanding about observable properties and materials. This failure might be the influence by two factors, namely Ms. Vanvisa's instruction focusing on teacher explanation and grade one students' ability in learning vocabularies.

Findings also showed that the promotion of students' sharing and exchanging their experiences also helped them to develop understandings beyond what was in the textbook. Grade two students learned from their parents about new kinds of materials not included in the textbook such as leather, fiber, cotton, sponge, etc. and could develop an understanding about the differences in materials used in making an object.

Findings showed that grade two students who participated in Ms. Yada's instruction that allowed students to bring their experiences and funds of knowledge into the science classes were able to think about the relation of science learning into their everyday lives more than grade one and three students. In this regard, Mc-Carty *et al.* (1991) and Michaels's (1981) studies have suggested that students who develop a meaningful context for absorbing new information based on their personal experiences also improve their critical thinking. It was found that most of the grade two students could give reasonable explanations about how scientific concepts being learned in school related to their lives and could give relevant examples of items that contained such properties, while only competent students in grade three could develop reasonable explanations about the selection of material used in making objects. The different levels of the students' thinking skills were influenced by opportunities for students to think, share ideas and make connections between school science and their own experiences. The grade two teacher's students appeared to develop more reasonable explanations for the key concepts after she asked questions to clarify and justify similarities and differences in experiments and discussed how to apply the knowledge one's everyday life. For example, grade two students could explain why plastics were used in making raincoats and their water-proofing capability. In grade three, high ability students could describe the selection of suitable and safe materials used in kitchen implements and utensils after they compared heat conductivity of various materials. They described how a utensil's handle is used to reduce rate of heat conductivity in metal kitchen implements. By contrast, it was not found that grade one student who participated in Ms. Vanvisa's instruction that did not place the value on experiences students bring to school could apply knowledge being learned to their experiences. This notion agreed with Gonzalez and Moll (2002) and Moll *et al.*'s (1992) finding that students were more likely to think critically about science and share experiences because now they could discuss those experiences in an environment that support their input.

Finally, the opportunities for students to bring toys and utensils with them and learn or share their experiences in the classroom engaged students of all abilities in all grade levels. It helped them pay better attention to the lessons and enjoy the activities and promoted the students' self-confidences This supports with Gonzalez *et al.* (1995) who reported that culturally relevant curriculum was benefit to develop self-confidences.

In regards to sub-research question 2, what constrains or facilitates the teaching of a unit that incorporates students' funds of knowledge and inquiry? The finding indicated that Ms. Yada, grade two teacher, was the most successful in implementation to develop students' understanding about material concepts, followed by Ms. Pornnapa and Ms. Vanvisa, a grade three and two teachers. It was also influenced by their own ability to facilitate scientific inquiry, their personal habits, the level of their content knowledge, their perception on students' abilities, and comfort level in conducting out of school learning. In comparisons among the teachers, three main points were found as described below.

First, the teachers' belief and understanding about inquiry influences their implementation and type of instruction while those who held a better understanding of inquiry conceptions tended to conduct more open-ended inquiries. Ms. Yada, the grade two teacher, who believed in student-centered instruction, appeared to provide a greater amount of flexibility than the other teachers for students to develop ways to solve problems and formulate their own explanations. She gave opportunities for students to make decisions while conducting investigations and encouraged students to work together without direct instruction or leading students step by step to a solution. She also allowed students to conduct investigations based on their own interests. She provided materials mostly selected based on the student's interest for experiments to investigate properties of materials and then observed and listened to them. Therefore, each group of students experimented and learned with different kinds of materials. The comparison of findings to identify similarities or differences between each group of students led them to develop deeper understandings about the same properties from different kinds of materials from other groups whose experiments were different. Studies by other educators support that teacher' attitudes and beliefs regarding inquiry may affect teachers' instructional practice (Nespor, 1987; Pajares, 1992).

Moreover, the teachers' misconceptions about inquiry appear to be connected to their inquiry science instruction. For example one of the misconceptions about inquiry science instruction by Ms. Vanvisa and Ms. Pornnapa was the use of a hands-on approach. After finishing the implementation, they thought that good science inquiry involves learning through direct interaction with materials and phenomena. Ms. Pornnapa, who believed that students learned science through direct investigation of objects and events appeared to provide students with hands-on activities and then ask guiding questions to facilitate the students' knowledge formulation. They did not realize that when children are doing inquiry, they have opportunities to raise their own questions, and plan, design, and conduct investigations to help them answer some of those questions. Matson and Parsons (1998) and NRC (1996; 2000), suggest that teachers without backgrounds in inquiry investigations are not going to be able to teach science through inquiry. Therefore, it is essential for teachers to experience inquiry firsthand before they are mandated to use inquiry pedagogy in their classrooms. In this regard, in order for teachers to understand inquiry learning, they themselves must learn science through inquiry by conducting their own explorations. Similarly, the science education literature suggests that one of the several barriers in the infusion of inquiry into science classrooms is the teachers' lack of the necessary experience with inquiry science during their undergraduate years (Moscovici, 1999). Their college courses traditionally offer little opportunity for them to conduct scientific investigations, other than those of recipe-like investigations. The emphasis in their science courses traditionally has been on products rather than on process of scientific research. As a result, they have learned science through memorization. Because most teachers have been trained in this manner, they often mistake "cookbook" activities with real inquiry activities.

Second, in terms of content knowledge, the amount of science content knowledge influences the teachers' willingness and ability to incorporate inquiry based learning into their science instruction. Ms. Yada who had strong background in science from her child education provided more opportunities for students to think and investigate freely on their interests than, Ms. Vanvisa and Ms. Pornnapa who had the least amount of science background. Ms. Yada provided opportunities for students to make mistakes and brought the mistakes into classroom discussion. The findings of this study suggest that not having enough science background negatively influences teachers' abilities and willingness to implement inquiry-based science lessons. Such a statement is supported by the findings of Smith and Neale (1989) in that teachers who do not have strong knowledge in science content face greater challenges in translating their beliefs into classroom practice. Moreover, teachers' capacity to pose questions, select tasks, evaluate their pupils' understanding, and make curricular choices all depend on how they themselves understand the subject matter (McDiarmid, Ball, and Anderson; 1989). In particular, research supports the idea that inquiry makes significant demands on teachers' content knowledge (Magnusson and Palincsar, 1995). With sufficient content knowledge, a teacher can prepare multiple learning experiences for his students, providing them with ample opportunity to develop deeper understandings of concepts (Tobin and Fraser, 1991).

Content knowledge is not the only factor that influences each teacher's ability and willingness to incorporate inquiry into their science instruction. The teachers also have serious concerns about the pedagogy of inquiry science. Uno (1997) suggests that another common hurdle to implementing inquiry-based teaching is teachers' reluctance to feeling out of control of what is going on in their classroom. Teachers who do not have sufficient background and experience in science perceive the dynamic nature of inquiry science classes as a threat. This is especially the case for Ms. Vanvisa and Ms. Pornna who does not have an extensive background in science, and who is therefore not sure how to act in an inquiry classroom, deal with students' unexpected questions, or assess inquiry based learning.

Content knowledge is not the only factor that influences each teacher's ability and willingness to incorporate inquiry into their science instruction. The teachers also have serious concerns about the pedagogy of inquiry science.

This study reveals that if inquiry is to become the main approach to teaching science in schools, teachers must be trained and supported to be able to deal with the challenges of an inquiry based science instruction. This study suggests that the more science background the teachers have, the better prepared they are to deal with the challenges of inquiry science instruction.

Finally, teachers who perceive the idea that all learners are capable of learning and formulating their own understanding appeared to facilitate scientific inquiry in the classroom in order to promote students' abilities to think critically in constructing their own explanations based on evidence. Ms. Yada was in this case. By contrast, Ms. Pornnapa and Mr. Vanvisa who guided and gave information to students, reduced the opportunities for low competency students to share ideas and explanations in the classroom. As a result, most of the low ability students memorized and copied the correct answers and explanations from competent students in the classroom. Kang (2004) found that teacher perceptions of student ability and motivation constrained their dispositions to implement inquiry. The finding of this study showed that the implementation of curriculum was limited by teachers' perceptions of the ability of students in asking questions and formulating their own understandings. As a result, teachers who perceived that students did not have this ability appeared to guide and provided the answers for students, instead of asking probing questions to facilitate students' construction of their own understandings.

Recommendations

The development of a culturally relevant curriculum that draws upon the students' funds of knowledge can make a difference in regards to school context and students' households. The incorporation of students' and parents' funds of knowledge and local wisdom about toys and utensils as a basis for developing science curriculum that is relevant to elementary students in this study is an example for science educators and teachers of how to develop a culturally relevant curriculum. However, for teachers who interested in developing culturally/inquiry based curriculum in other locations, the following conditions based on this study were discussed.

1. Theoretical Preparation: It was the theoretical concept of funds of knowledge and a culturally relevant curriculum that provided a new perspective for the study of the students' households. Therefore, teachers must receive a skilled facilitator who is knowledgeable about tapping into students' funds of knowledge in their households, incorporating such knowledge into school science. They must also understand the impact of cultural, ethnicity and socioeconomic status on teaching and

learning and be knowledgeable about culturally responsive instruction. Moreover, for the culturally relevant teaching to be most effective, teachers must receive the following aspects: 1) Participating in workshops on culturally relevant teaching and inquiry based teaching to gain first hand experience with actually teaching of a culturally relevant/inquiry based curriculum. The workshop should included a reflective process that can facilitates teachers' understanding of the inquiry process and reinforces the teachers' thinking about teaching methods and strategies that support inquiry-based science instruction. Moreover, science teaching methods courses taught at the universities can be very helpful for teachers to promote an understanding about culturally relevant practices and inquiry based teaching. 2) Continuing assistance from skilled facilitator for teachers to experience the full effect of a culturally relevant curriculum. The facilitator could be a person from a school, district, or other agency who has received appropriate training in culturally relevant instructional strategies.

2. Home visits as Participant-Observation: The key is to enter the home in the role of learner, willing to interact and prepare to document what one learns, to produce new firsthand knowledge about the families and community. The household visit provided an array of activities, strategies, and topics that can form the units that engage the students. Researcher can look for material clues to possible funds of knowledge in gardens (botanical knowledge), restored automobiles (mechanical knowledge) or family yard sale (what is being sold, that indicated carpentry skills, the interactions involved (the older siblings are caring for toddlers), language used which can be incorporated into curriculum. Moreover, it also provided multiple elements that can be used as the bases for math, science, language arts, or integrated units. For example, teachers using this methodology have formed mathematical units based on construction knowledge, ecology units based on ethnobotanical knowledge, a unit on sound and its properties based on music, and a comparative history of clothing, including topics such as inquiry into absorbency of fabrics, among other instructional activities.

3. Home visits as Participant-Observation: The key is to enter the home in the role of a learner who's willing to interact and prepared to document what one learns to produce new firsthand knowledge about the families and their communities. The household visit can help provide an array of activities, strategies, and topics that can form the units that are engaging to the students. Researchers can look for material clues to possible funds of knowledge in gardens (botanical knowledge), restored automobiles (mechanical knowledge) or family yard sales (what is being sold, that indicated carpentry skills), the interactions involved (the older siblings are caring for toddlers), and the language used which can be incorporated into the curriculum. Moreover, it also provides multiple elements that can be used as the bases for math, science, language arts, or integrated units. For example, teachers using this methodology have formed mathematical units based on construction knowledge, ecology units based on ethno-botanical knowledge, a unit on sound and its properties based on music, and a comparative history of clothing, including topics such as inquiry into absorbency of fabrics, among other instructional activities.

4. Research team meeting: These meetings become the center for discussion, reflection, and analysis of the household visits and a catalyst for ideas about teaching. Regular team meetings led by a skilled facilitator included discussions on learning how culture and socioeconomic status impact teaching and learning; designing lessons that exemplify the principles of culturally relevant instruction; reflecting on and discussing lesson delivery and student response to the lesson. In these meetings, teacher could explore their own ideas about what they have found in the household and how it might connect to science practices and science understanding.

5. Voluntary Participation: The participation in the project must remain voluntary. We felt strongly that only teachers who voluntarily desire to participate be included. Any project which adds to teachers' duties and demands on their time has to take into account the extra burden that it places on teachers' schedules and lives. The amount of time necessary to prepare for, conduct, summarize in writing, and develop curriculum materials based on good interviews with families is still a matter of considerable debate.

Moreover, the finding suggests that the integration of inquiry into school science is a hierarchical process (Structured to Guided to Opened). This includes the re-negotiation of classroom roles and responsibilities for both teachers and students as well as an understanding of the difficulties associated with inquiry science instruction. The transformation of traditional classrooms into inquiry based science classrooms is a longitudinal process.

Further research

The next challenge for the science educators is conducting ethnography by teachers to help them become more perceptive learners about students' lives. Emerging from the teachers' own theoretical understanding of ethnography, home visits became participant-observation and insights from the households were tied into broader regional, social, economic, and gender-related patterns. This process can help teachers understand, identify, and sort information about families in ways that more brightly illuminate the possibilities for effective teaching. Moreover, the development of inquiry based curriculum which drew on students' funds of knowledge should be done in parallel with the teacher's own development. The efforts to understand the experienced teachers' beliefs and help them understand how own beliefs can influence their teaching and students' achievements were emphasized. Moreover, the improvement of both in-service and pre-service science teacher's content knowledge should be focused on to improve the teachers' willingness and ability to incorporate inquiry learning into their science instruction.

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APPENDICES

Appendix A

Students’ Drawing about Toys and Utensils

Students' Drawing about Toys and Utensils

grade __________

My favorite toy and utensil

Explanation Have students write the five names of toys and utensils they use everyday. Students should draw a picture of their favorite toy in one box and their favorite utensil in the other box.

My toys are
....
....
....
....
....

My favorite toy is ___________________________

It is my favorite toy because
....
....
....
....

My utensils are
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

My favorite utensil is ________________________

It is my favorite utensil because
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

Appendix B

Week-Long Logbook

Week-Long Logbook

Table B 1 Information about Kinds of Toys and Utensils, How to Select and Use, and Its Dangers

Toy (Day 1)			
Date	1.Do your child play toys today? £ Yes £ No		3. Select 1 toy and tell name, materials it made of, resource and explain use, selection and its danger
……… ………	2. Write √ in the right blank of toys' names that your child play today		3.1 Toy's name is ……………………………………. 3.2 Made of …….……………………………………. 3.3 How it comes £ store bought £ hand-made £ got from others 3.4 If it is a store bought item, Please give reason why you buy it ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 3.5 What sort of things do you believe your child learn when playing with toys? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 3.6 How does your child play this toy? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 3.7 What are dangers of playing with this toy? ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………
	Names of toys		
	Car toy		
	Boat		
	Airplane		
	Doll		
	Action figure		
	Tops		
	Plummet		
	Cooking set		
	Game		
	Ball		
	Jump rope		
	Jigsaw		
	Gun		
	Sword		
	Marble		
	Balloon		
	Bicycle		
	Other (.specify)………………..……………. ……………………………….……………… …….……………………………………………		

Table B 1 (Continued)

Utensils (Day 1)			
Date	4. Do your child use stationery? £ Yes £ No		6. Select 1 stationery and tell name, materials it made of, resource and explain use, selection and its danger
	5. Write √ in the right blank of stationeries' names that your child use today		6.1 Stationary' name is ……………………………………. 6.2 Made of ……..………………………………………… 6.3 What do you consider when you buy it? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 6.4 How does your child use this toy? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 6.5 What are dangers of using with this utensil? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………
	Names of utensils		
	Pencil		
………	Rubber		
………	Ruler		
	Color		
	Note book		
	Book		
	Pencil box		
	File		
	Glue		
	Scissor		
	Drawing book		
	Pencil sharpener		
	School bag		
	Other (...) ……………………..………………………. ……………………………………………… ……………………………………………… ……………………………………………… ………………………………………………		

Table B 1 (Continued)

Toy (Day 2)			
Date	1. Do your child play toys today? £ Yes £ No		3. Select 1 toy and tell name, materials it made of, resource and explain use, selection and its danger
……… ………	2. Write √ in the right blank of toys' names that your child play today		3.1 Toy's name is ……………………………………. 3.2 Made of ……..……………………………………. 3.3 How it comes £ store bought £ hand-made £ got from others 3.4 If it is a store bought item, Please give reason why you buy it …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 3.5 What sort of things do you believe your child learn when playing with toys? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 3.6 How does your child play this toy? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 3.7 What are dangers of playing with this toy? …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………………………
	Names of toys		
	Car toy		
	Boat		
	Airplane		
	Doll		
	Action figure		
	Tops		
	Plummet		
	Cooking set		
	Game		
	Ball		
	Jump rope		
	Jigsaw		
	Gun		
	Sword		
	Marble		
	Balloon		
	Bicycle		
	Other (.specify)………………..……………. ……………………………….………………. ……..…………………………………………		

Table B 1 (Continued)

<table>
<tr><th colspan="4">Utensils (Day2)</th></tr>
<tr><td rowspan="3">Date</td><td colspan="2">4. Do your child use kitchenware?
£ Yes £ No</td><td rowspan="2">6. Select 1 kitchenware and tell name, materials it made of, resource and explain use, selection and its danger</td></tr>
<tr><td colspan="2">5. Write √ in the right blank of stationeries' names that your child use today</td></tr>
<tr><td colspan="2">Names of utensils</td><td rowspan="17">6.1 kitchenware' name is ……………………………………..

6.2 Made of ……..…………………………………………..

6.3 What do you consider when you buy it?
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

6.4 How does your child use this toy?
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

6.5 What are dangers of using with this utensil?
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………</td></tr>
<tr><td rowspan="16">………
………</td><td>Glass</td><td></td></tr>
<tr><td>Dish</td><td></td></tr>
<tr><td>Spoon</td><td></td></tr>
<tr><td>Fork</td><td></td></tr>
<tr><td>Bowl</td><td></td></tr>
<tr><td>Knife</td><td></td></tr>
<tr><td>Cutting board</td><td></td></tr>
<tr><td>Mortar</td><td></td></tr>
<tr><td>Wooden pestle</td><td></td></tr>
<tr><td>Pot</td><td></td></tr>
<tr><td>pan</td><td></td></tr>
<tr><td>Spatula</td><td></td></tr>
<tr><td>Ladle</td><td></td></tr>
<tr><td>Basin</td><td></td></tr>
<tr><td>Other (...)
…………………….………………………..
………………………………………………
………………………………………………
………………………………………………
………………………………………………</td><td></td></tr>
</table>

Table B 1 (Continued)

Toy (Day 3)			
Date	1. Do your child play toys today? £ Yes £ No		3. Select 1 toy and tell name, materials it made of, resource and explain use, selection and its danger
……… ………	2. Write √ in the right blank of toys' names that your child play today		3.1 Toy's name is ……………………………………. 3.2 Made of ……..……………………………………. 3.3 How it comes £ store bought £ hand-made £ got from others 3.4 If it is a store bought item, Please give reason why you buy it ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 3.5 What sort of things do you believe your child learn when playing with toys? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 3.6 How does your child play this toy? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 3.7 What are dangers of playing with this toy? ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………
	Names of toys		
	Car toy		
	Boat		
	Airplane		
	Doll		
	Action figure		
	Tops		
	Plummet		
	Cooking set		
	Game		
	Ball		
	Jump rope		
	Jigsaw		
	Gun		
	Sword		
	Marble		
	Balloon		
	Bicycle		
	Other (.specify)………………..……………. ……………………………….……………… ……..……………………………………………		

Table B 1 (Continued)

Utensils (Day3)			
Date	4. Do your child use electric appliances? £ Yes £ No		6. Select 1 electric appliance and tell name, materials it made of, resource and explain use, selection and its danger
	5. Write √ in the right blank of stationeries' names that your child use today		6.1 Electric appliance' name is ……………………………………. 6.2 Made of ……..…………………………………………………... 6.3 What do you consider when you buy it? ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… 6.4 How does your child use this toy? ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… 6.5 What are dangers of using with this utensil? ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… ………………………………………………………………………………………………… …………………………………………………………………………………………………
	Names of utensils		
	Refrigerator		
……… ……	Electric fan		
	Television		
	Iron		
……… ……	Washing machine		
	Vacuum		
	Radio		
	CD player		
	Rice Cooking		
	Lamp		
	Air conditioner		
	Computer		
	Others (specify) ……………………..………………………. ………………………………………………. ………………………………………………. ………………………………………………. ……………………………………………….		

Table B 1 (Continued)

Toy (Day 4)			
Date	1. Do your child play toys today? £ Yes £ No		3. Select 1 toy and tell name, materials it made of, resource and explain use, selection and its danger
……… ………	2. Write √ in the right blank of toys' names that your child play today		3.1 Toy's name is ……………………………………. 3.2 Made of ……..…………………………………….
	Names of toys		3.3 How it comes £ store bought £ hand-made £ got from others
	Car toy		
	Boat		
	Airplane		3.4 If it is a store bought item, Please give reason why you buy it
	Doll		………………………………………………………………………………………………
	Action figure		………………………………………………………………………………………………
	Tops		……………………………………………………………………………………………
	Plummet		
	Cooking set		3.5 What sort of things do you believe your child learn when playing with toys?
	Game		………………………………………………………………………………………………
	Ball		………………………………………………………………………………………………
	Jump rope		………………………………………………………………………………………………
	Jigsaw		………………………………………………………………………………………………..
	Gun		
	Sword		3.6 How does your child play this toy?
	Marble		………………………………………………………………………………………………
	Balloon		………………………………………………………………………………………………
	Bicycle		………………………………………………………………………………………………
	Other (.specify)………………..…………….		………………………………………………………………………………………………
	……………………………..………………		3.7 What are dangers of playing with this toy?
	……..…………………………………………		………………………………………………………………………………………………
			………………………………………………………………………………………………
			………………………………………………………………………………………………

Table B 1 (Continued)

Utensil (Day4)			
Date	4. Do your child use wearing? £ Yes £ No		6. Select 1 wearing and tell name, materials it made of, resource and explain use, selection and its danger
	5. Write √ in the right blank of stationeries' names that your child use today		6.1 Wearing' name is ………………………………………. 6.2 Made of ……..………………………………………. 6.3 What do you consider when you buy it? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 6.4 How does your child use this toy? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 6.5 What are dangers of using with this utensil? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………………………
	Names of utensils		
……… ………	Shirt		
	Shorts		
	Skirt		
	Sock		
	Shoe		
	Gap		
	Belt		
	others (specify) ……………………..…………………………. ………………………………………………. ………………………………………………. ………………………………………………. ……………………………………………….		

Table B 1 (Continued)

Toy (Day 5)			
Date	1. Do your child play toys today? £ Yes £ No		3. Select 1 toy and tell name, materials it made of, resource and explain use, selection and its danger
……… …… ……… ……	2. Write √ in the right blank of toys' names that your child play today		3.1 Toy's name is …………………………………… 3.2 Made of ……..…………………………………… 3.3 How it comes £ store bought £ hand-made £ got from others 3.4 If it is a store bought item, Please give reason why you buy it ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… 3.5 What sort of things do you believe your child learn when playing with toys? ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… 3.6 How does your child play this toy? ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… 3.7 What are dangers of playing with this toy? ……………………………………………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………
	Name of toys		
	Car toy		
	Boat		
	Airplane		
	Doll		
	Action figure		
	Tops		
	Plummet		
	Cooking set		
	Game		
	Ball		
	Jump rope		
	Jigsaw		
	Gun		
	Sword		
	Marble		
	Balloon		
	Bicycle		
	Other (.specify)………………..……………. …………………………….……………… ……..…………………………………………		

Table B 1 (Continued)

Utensils (Day 5)			
Date	4. Do your child use cleaning equipment? £ Yes £ No		6. Select 1 cleaning equipment and tell name, materials it made of, resource and explain use, selection and its danger
	5. Write √ in the right blank of stationeries' names that your child use today		6.1 Cleaning equipment' name is …………………………………….
	Names of utensils		
	Broom		6.2 Made of ……..…………………………………………………..
……… ………	Mop		
	Rag		6.3 What do you consider when you buy it?
	Vacuum		…………………………………………………………………………………………
	Dust bin		…………………………………………………………………………………………
	Brush		…………………………………………………………………………………………
	Tank		…………………………………………………………………………………………
	Enameled bowl		…………………………………………………………………………………………
	other (specify) ……………………..………………………… ………………………………………………… ………………………………………………… ………………………………………………… …………………………………………………		6.4 How does your child use this toy? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… 6.5 What are dangers of using with this utensil? ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………

Table B 1 (Continued)

Toy (Day 6)			
Date	1. Do your child play toys today? £ Yes £ No		3. Select 1 toy and tell name, materials it made of, resource and explain use, selection and its danger
……… ………	2. Write √ in the right blank of toys' names that your child play today		3.1 Toy's name is ………………………………………. 3.2 Made of ……..………………………………………. 3.3 How it comes £ store bought £ hand-made £ got from others 3.4 If it is a store bought item, Please give reason why you buy it …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 3.5 What sort of things do you believe your child learn when playing with toys? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 3.6 How does your child play this toy? …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… …………………………………………………………………………………………… 3.7 What are dangers of playing with this toy? …………………………………………………………………………………………… …………………………………………………………………………………………… ……………………………………………………………………………………………
	Name of toys		
	Car toy		
	Boat		
	Airplane		
	Doll		
	Action figure		
	Tops		
	Plummet		
	Cooking set		
	Game		
	Ball		
	Jump rope		
	Jigsaw		
	Gun		
	Sword		
	Marble		
	Balloon		
	Bicycle		
	Other (.specify)………………..……………. ……………………………..……………… ……..……………………………………………		

Table B 1 (Continued)

<table>
<tr><th colspan="4">Utensil (Day6)</th></tr>
<tr><td rowspan="3">Date</td><td colspan="2">4. Do your child use furniture?
£ Yes £ No</td><td>6. Select 1 furniture and tell name, materials it made of, resource and explain use, selection and its danger</td></tr>
<tr><td colspan="2">5. Write √ in the right blank of stationeries' names that your child use today</td><td rowspan="10">6.1 Furniture' name is ……………………………………

6.2 Made of ……..………………………………………

6.3 What do you consider when you buy it?
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

6.4 How does your child use this toy?
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

6.5 What are dangers of using with this utensil?
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………</td></tr>
<tr><td colspan="2">Names of utensils</td></tr>
<tr><td rowspan="8">………
……

………
……</td><td>Table</td><td></td></tr>
<tr><td>Chair</td><td></td></tr>
<tr><td>Bed</td><td></td></tr>
<tr><td>Dresser</td><td></td></tr>
<tr><td>Sofa</td><td></td></tr>
<tr><td>Cabinet</td><td></td></tr>
<tr><td>Dressing table</td><td></td></tr>
<tr><td>Other (specify)
……………………..…………………………
……………………………………………..….
……………………………………………..….
…………………………………………….....</td><td></td></tr>
</table>

Table B 1 (Continued)

Parent recommendation about child favorite toy and utensil and others	
Date	**Parent recommendation**
……… ………	What is your child's favorite toys and utensils? ……………………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………… What is your child' favorite utensils? ……………………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………… What else does your child play with or use that is not included in the log book? ……………………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………… What else have you observed your child's experiences with toys and utensils? ……………………………………………………………………………… ……………………………………………………………………………… ……………………………………………………………………………… ………………………………………………………………………………

Appendix C

Parent Semi-Structure Interview

Parent Semi-Structure Interview

1. What are your child toys?
2. What is your child favorite toy?
3. How does your child play with this toy?
4. What are they made of?
5. What are your child toys from?
6. What are dangers of playing with toys?
7. How do you take care your child when playing with toys?
8. What do concern when you buy toys?
9. Can you tell a story about toys that has special meaning to you?
10. Which toys (either homemade or store-bought) that your child plays with has the most educative value? (Particular in terms of science)
11. What sort of things do you believe your child learns when playing with toys?
12. What are your child stationeries/wearing/kitchen ware/cleaning, electricity?
13. What are your child utensils from?
14. What are they made of?
15. What do concern when you buy utensils?
16. How does your child use utensils?
17. What are dangers of using with utensils?

Appendix D

Students' Interview about Toys and Utensils

Students' Interview Students' Interview about Toys and Utensils

Part I

1. What are you toys?
2. What is your favorite toy?
3. How do you play with your favorite toy?
4. What are your homemade toys?
5. What is your favorite homemade toy?
6. What are your store-bought toys?
7. How do you play with each toy?
8. What is your favorite utensil?
9. How do you use your favorite utensil?

Appendix E

Students' Interview about Material Concepts

Students' Interview about Material Concepts

Show 16 toys and utensils and have students explain kinds and their characteristics

Table E 1 Set of Objects

Objects	**Materials**	**Color**
Spoon	Metal	Silvery
Can	Metal	Silvery
Key	Metal	Gold
Pencil	Wood	Blue
Chopsticks	Wood	Natural
Cube	Wood	Red
Fork	Plastic	White
Lego	Plastic	Red
Shirt	Fabric	White
Handkerchief	Fabric	Blue
Sock	Fabric	Red
Ball	Rubber	Red
Rubber band	Rubber	Natural
Balloon	Rubber	Blue
Glass	Glass	Colorless
Marble	Glass	Colorless

Table E 2 Interview Protocol about Material Concept

Grade	Concepts	New questions
1	Toys and utensils	Show 16 objects and ask: - Tell me something about this thing - What do you know about this thing? - What can you do with this thing? - What are toys? - What are utensils?
	Observable properties/characteristics	- Put things go together - Why do you think these things go together? - Put same color things together - Why do you put these together? - Put same shape things together - Why do you put these together?
	Material	- Put things made of same kind of material together - Why do you put these things together? - How do you know they made of the same kind of materials?
2	Materials used in making toys and utensils	Show 16 objects and ask: - Tell me something about this thing? - What do you know about this thing? - What can you do with this thing? - What are toys? - What are utensils? - Put things that are made of same kind of material together - Why do you put these things together? - How do you know they made of the same kind of materials
	Properties	- Put things go together - Why do you think these things go together? - Put same color things together - Why do you put these things together? - Put same shape things together - Why do you put these things together?
	hardness	- Put hard things together - What are they made of?
	flexibility	- Put flexible things together - What are they made of?
	Water absorption	- Put water absorption ability things together - What are they made of?

Table E 2 (Continued)

Grade	Concepts	New question
3	Property of materials	Show 16 objects and ask: - Tell me something about this thing - What do you know about this thing? - What can you do with this thing? - What are toys? - What are utensils? - Put things go together - Why do you think these things go together? - Put same color things together - Why do you put these things together? - Put same shape things together - Why do you put these things together? - Put things that are made of same kind of material together - Why do you put these together? - How did you know they made of the same kind of materials?
	Heat conductivity	- Show spatula used in cooking and ask to predict what part is become hot(heat)
	Change of materials when heated and cooled	- Show candle and ask students to predict what might happen to each part of candle
	Change of materials when forced	- Show wire and ask how to change steel to be paper clip

Appendix F

Teacher Semi-Structure Interview

Teacher Semi-Structure Interview

1. Tell me what happened in science class this period
2. What is your impression of students' learning in this period?
3. What difficulties did you encounter in teaching the concept?
4. What difficulties did students encounter in learning the concept?
5. What, specifically, do you think students learned about material concepts (property, type, selection and change of material)?
6. What evidence do you have to demonstrate this?

Appendix G

Team Planning Meeting

Team Planning Meeting

<u>The team planning meeting details</u>

1st meeting:

The three science educators, an expert elementary science teacher and a scientist will discuss what aspects of students' funds of knowledge and what aspects of inquiry should be addressed in the instructional unit.

2nd meeting:

The research team including three science educators, a scientist and the three participant teachers will discuss what modifications to the instructional unit are appropriate for the classroom and school context.

3rd meeting:

The science educators will discuss the instructional unit implementation with the three participant teachers, including such aspects as objectives, content, activities, media, and equipment and organization of the unit in the classroom.

Weekly Followed up meeting:

The research team members discuss what is going on during the unit instruction, and what factors constrain and facilitate unit implementation. Weekly follow up meetings conduct at the conclusion of the implementation phase. The key questions guiding meeting discussion are as follows:

1. Tell us how you organized each lesson. Why? What other ways might you think about organizing it?
2. What was the most difficult aspect of implementation with respect to each lesson?
3. What do you believe your students learned about material concepts?
4. What evidence do you have to demonstrate this?
5. Tell us about your experience in teaching a unit that incorporates students' funds of knowledge and inquiry
6. What were the strengths and weaknesses of this unit?
7. What do you think about funds of knowledge/ inquiry based science instruction?
8. How did the experience in participating in this study influence your teaching philosophy?
9. How will this experience affect other aspects of your teaching practice next school year?

Appendix H

Teacher Journal

Teacher Journal

Journal instructions and Journal Questions

I would like for you to keep a journal for approximately 4 weeks. I would like for you to record entries into your journal at least once a week. In the journal, I would like for you to reflect upon the week that has just ended and to comment on any issue related to science teaching/ learning. I also give you a specific question each week on which to respond.

Week 1: What are the difficulties in organizing each step of the 5-E inquiry model in science teaching? What are the benefits of using this model?

Week 2: What are the advantages or disadvantages of using students' toys and utensils as an "organizer" for students' explorations of material concepts?

Week 3: What is learning? What is the effect of using the 5-E model of inquiry and students' funds of knowledge on students' understanding of material concepts? How do you know?

Week 4: What is your overall thought about using students' funds of knowledge in an inquiry approach to teach science?

BIOGRAPHICAL DATA

NAME : Miss Akarat Sreethunyoo

BIRTH DATE : February 1, 1980

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EDUCATION:

YEAR	INSTITUTE	DEGREE/DIPLOMA
2006	Univ. of Georgia	International Research Internship
2003	Kasetsart Univ.	Grad. Dip. (Teaching Science Profession)
2002	Kasetsart Univ.	B.Sc. (Chemistry)

GRANTS:

YEAR	INSTITUTE	CONFERENCES
2008	IPST	Conference of Asian Science Education (CASE), Kaohsiung, TAIWAN.
2006	IPST	NSTA/ICASE International Conference, Anaheim, CA.USA.
2006	IPST	National Association Research in Science Teaching (NARST) Conference, San Francisco, CA, USA

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