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A Case Study of a Teacher's Pedagogical Content Knowledge Development in Teaching Science : Focusing on the Relationship between Knowledge Domains

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과학 교수를 위한 교사의 교과교육학 지식의 발달 : 지식 영역간의 관계를 중심으로

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국문요약

본 연구의 목적은 초등학교 교사가 과학교과 중 '동물' 단원을 가르치는데 있어서 어떻게 교수에 필요한 지식 영역을 활용하여 교과교육학 지식을 발달시키는가를 탐구하는 것이다. 연구를 위해, 초등학교 1학년 교사를 대상으로 사례 연구방법을 사용하였으며, 뉴욕 시에 위치한 빈곤한 도심지역내 공립학교의 수업 사례를 분석하였다. 자료는 인터뷰와 참여 관찰 방법을 통해 수집하였으며, 구체적으로 1) 교과교육학 지식의 구성 요소인 교과 지식, 교육학 지식, 상황적 지식의 영역에서 나타난 교사의 지식기반은 무엇인가?; 2) 각 지식영역들 간의 관계를 통해 교사는 실제 수업동안 어떻게 교과교육학 지식을 발달시켰는가? 의 두 가지 연구 문제가 조사되었다. 연구 결과, 전체 수업 과정동안 교사의 세 지식 영역이 어떻게 긴밀하게 관련되었으며 교과교육학 지식으로 발달되었는지가 드러났다. 특히, 교사의 상황적 지식이 교과교육학 지식을 형성하고 발달시키는 데에 결정적인 역할을 담당한 것으로 밝혀졌다. 단원을 가르치기에 앞서, 해당 교육구의 행정 정책과 학교평가체제에 관한 상황적 지식은 교사가 과학단원을 가르치기 위한 계획을 수립하고 의사결정 하는 것을 촉진했다. 실제 수업기간 동안에는 학생들의 사회문화적 배경과 도심 환경 내 생활여건과 같은 상황적 지식이 교사가 학생들의 특정한 요구와 관심에 상응하는 적절한 교수 전략과 자료를 탐색, 이용하도록 도움을 주었다. 이러한 연구 결과는 교사가 자신이 처한 교수 상황에 대해 알기위해 노력하고 그로 인해 얻어진 지식을 교과교육학 지식을 발달시키기 위해 활용함으로써 '과학'을 특정한 학습 요구에 맞추어 보다 의미 있고 적절하게 가르칠 수 있음을 시사한다.

Key words : pedagogical content knowledge, contextual knowledge, sociocultural context, teacher's knowledge development

I. INTRODUCTION

For a few decades, science education reform documents (e.g., AAAS, 1990; AAAS, 1993; NRC, 1996) in the U.S. has envisioned the sublime catch-phrase, 'Science for All' by prescribing *Standards* to be achieved by all students. Apparently, a premise of the phrase is equity and excellence in science learning (NRC, 1996). However, it provokes criticism as retaining White, male, middle-class sociocultural values. By advocating mainstream norms, it implies that minority children and females need to work and act like their White,

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male counterparts, rather than that science or science instruction will be modified to accommodate them (Calabrese-Barton & Osborne, 2001). Indeed, the achievement gap in science between so-called 'mainstream' and 'non-mainstream' students is large and unchanged (National Center for Education Statistics, 2006) regardless of the arduous reform efforts.

Many children living in central city areas in the U.S. are from nonwhite and other cultures occupying low socioeconomic status. Those urban children's diverse sociocultural background has not functioned as an advantageous factor in school education over the last century. Rather, it was often regarded as a major cause for low academic achievement and lacking ability in school learning. Accordingly, urban children used to be labeled as "at risk" and blamed for their poor school performance (Cuban, 1989). Recently, some alternative view appears that such children and their family should not be accused of the 'learning deficiency.' Instead, school should be responsible for the minority children's achievement by acknowledging their experiences and backgrounds as resources for learning (Brooks & Brooks, 1993; Cohen, McLaughlin & Talbert, 1993; Shields, 1995). According to this perspective, educational efforts should be made to provide genuine equal learning opportunities for underrepresented children to develop their knowledge and skills.

Indeed, current urban environment in many countries creates a unique teaching conditions for teachers to meet diverse students of varying abilities as well as varying values, perspectives, and identities related to their sociocultural backgrounds. Following McDiarmid's (1990) study findings that teachers need to construe academic subjects meaningful to diverse students, it seems reasonable to assume that teaching can be more successful if teachers understand the multiple characteristics of diverse students and connect the knowledge with actual teaching practices. The urban educational 'reality' calls for us to reexamine the purpose of science education and the role of teachers for non-mainstream, marginalized children in poor urban areas. Having a critical mind about such a point, this study attempts to address the issue of science teaching for socioculturally diverse children in poor urban area, focusing on Pedagogical Content Knowledge (PCK) development. PCK has been regarded as crucial knowledge for teaching (Grossman, 1990; Marks, 1990; McEwan & Bull, 1991; Shulman, 1987), which guides teachers' classroom practices within a specific content area in their professional context. In conceptualizing PCK, however, previous research did not pay much attention to the role of 'contextual knowledge' as a shaping factor of PCK. This study was conducted in an urban school, where most of students were racial minorities and economically disadvantaged, and aims to highlight teacher's contextual knowledge as a critical component of PCK.

The purpose of this study is to explore an elementary school teacher's PCK development, focusing on the relationship between diverse knowledge domains for teaching science in an urban setting. In order to provide convincing descriptions of the PCK development, it investigates: a) the teacher's knowledge base necessary for teaching science, in terms of three knowledge domains (subject matter, pedagogical, and contextual knowledge) and b) how the teacher's PCK is developed through the relationship among knowledge domains during classroom practices.

The findings of the study will offer useful insights about how teachers can promote urban children's science learning as they meet the challenges of making science more comprehensible to socioculturally diverse learning population. It hopes to empower teachers to increase their ability to utilize PCK as professional knowledge for teaching science to urban children in creative ways, concerning what kind of science should be taught and in what manner.

II. THEORETICAL UNDERPINNINGS

1. Sociocultural Constructivism for Marginalized Urban Children

As current world becomes much more complicated in diverse aspects of sociocultural human life, it is a huge task for educators to involve different groups of children in science learning, particularly marginalized students, and broaden their understanding of science, themselves, and the world.

Sociocultural constructivism takes into great consideration regarding the complex social and institutional issues affecting students in the classroom. Hence, it is keenly aware of the inequitable school learning situations provided to socioculturally diverse population. From this perspective, what matters to learning and doing science is primarily the socially learned cultural traditions of 'what kinds of discourses and representation are useful to students and how to use them' (Lemke, 2001). Then, an important question in science learning can be posed: "In what kind of discourse do the students participate in the classroom?" O'Loughlin (1992) stresses the importance of the sociocultural issues of learning in the classroom by asking:

> Who decides on the pedagogy and curriculum of the constructivist classroom and in whose interest? Are the voices and interests of some groups privileged at the expense of others or is there a genuinely emancipatory communicative environment in which students begin to construct meaning together on their own terms and in their own interests? (p. 806)

As indicated in the quote above, sociocultural constructivism particularly problematizes the following aspects: "Why should we take it for granted that a child should learn particular concepts in science or that he or she should even want to?" (Calabrese-Barton & Osborne, 2001, p.26); "How can meaningful science learning occur in classrooms where the teacher is a member of a cultural group that is different from the students' or where science classroom is multicultural?" (Atwater, 1996, p. 830). Consequently, the issues of access, equity, and excellence in science education are elaborated upon within this framework.

Traditionally, science has privileged certain students' ideas, thoughts, and interpretations while marginalizing many others (Atwater, 1996; Barnes, 1976; Delpit, 1986, 1988; Lee & Fradd, 1998). School science curriculum is often provided in a prescribed manner based on Western, middle-class culture without regard to children's different sociocultural backgrounds and interests. Therefore, the discourse in science learning may seem irrelevant to some children, who are not from an acknowledged or dominant class or culture in society. As a result, for example, Delpit (1988) indicates that children from middle-class homes tend to do better in school than those from non middle-class homes because the culture of the school is based on upper- and middle-class culture. She further argues that poor children and children of color are possibly excluded from learning because child-centered pedagogy mainly reflects middle-class values and aspirations. Following Hodson (1998), each student possesses a unique personal framework of understanding, in which experience, emotions, values, sense of self and social identity play a crucial mediating role, determining what is regarded as significant and when/how it is utilized. By favoring certain cultural values and behaviors in classroom learning situations, marginalized students become aware of which their voices and cultures are not valued. Frequently, they learn the voice of authority, whether teacher or text is privileged and authoritative (O'Loughlin, 1992). Thus, schools seem to fail to meet the varied learning needs of diverse student populations (Futrell & Witty, 1997).

Sociocultural constructivism, contrary to traditional approaches to science education, regards scientific knowledge as tentative and imbued with the values of the individual and the culture in which it was generated (Calabrese-Barton & Osborne, 2001). Culture can be described as "the confluence of language, beliefs, values, traditions, and behaviors that permeate our lives" (Futrell & Witty, 1997, p. 191). In a culturally diverse environment, such as urban schools, learning is deeply embedded in cultural/subcultural contexts. Therefore, authentic science learning is not occurring as long as knowledge about the different cultures is not included.

Since sociocultural constructivism proposes that science teaching should be responsive to different needs by acknowledging the characteristics of a heterogeneous classroom community, it serves as a theoretical foundation to guide this study.

2. Pedagogical Content Knowledge for Teaching Science

Teacher educators have long struggled to define what teachers should know (e.g., Carter, 1990; Holmes Group, 1986; National Board for Professional Teaching Standards, 1991). As a result, diverse forms of teachers' knowledge have been developed based on different theoretical models. Of those, PCK has been valued as teachers' professional knowledge for teaching, which has great impact on classroom teaching practices.

The prominent feature of PCK is the identification of a type of knowledge that is unique to the teacher profession (Magnusson, Krejcik & Borko, 1999). In defining the concept of PCK, Shulman (1987) postulates that particular content knowledge and pedagogical strategies are necessarily interwoven in the minds of teachers. For him, PCK means specific subject matter knowledge for teaching - "how particular topics, problems, or issues are organized, represented, and adapted to the diverse interest and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). Ever since Shulman introduced the concept, it has been the subject of research by many educators. Several scholars have attempted to describe the nature and characteristics of PCK (e.g., Cochran, DeRuiter & King, 1993; Grossman, 1990; Marks, 1990; McEwan & Bull, 1991). As a result of such efforts, there is a common view of PCK: teachers' knowledge of teaching generated by transforming subject matter knowledge into a form accessible to particular children. In this study, PCK is conceptualized as unique blending of three domains of teacher's knowledge: subject matter knowledge, pedagogical knowledge, and contextual knowledge.

Subject matter knowledge refers to "the amount and organization of knowledge *per se* in the mind of the teacher" (Shulman, 1986, p. 9). This knowledge differs from subject to subject in the ways of discussing the content structure of knowledge. Therefore, teachers need to know the structures of a subject matter beyond facts or concepts of a domain. According to Schwab (1978), the structures of a subject include both the substantive and syntactic structures. The substantive structures are the variety of ways in which the basic concepts and principles of the discipline are organized to incorporate its facts. The syntactic structure of a discipline is the set of ways in which truth or falsehood, validity or invalidity, are established. Teachers' knowledge about the structures in a discipline is critical in selecting and organizing a subject (Grossman, 1990; Shulman, 1986).

Pedagogical knowledge indicates to knowledge of teaching and learning methods (Barnett & Hodson, 2001), and thus, it includes teachers' pedagogical decisions and strategies with regard to representing their subject matter knowledge. The specific components of this knowledge differ from study to study. For example, Morine-Dershimer and Kent (1999) report three major areas that contribute to pedagogical knowledge --classroom organization and management, instructional models and strategies, and classroom communication and discourse; Carlsen (1999) presents them as learners and learning, classroom management, and general curriculum and instruction. Although no common agreement exists in determining constituents of pedagogical knowledge, there seems to be a thread of connections between the studies: it includes knowledge about instructional strategies and classroom management based upon students' knowledge and experience.

Contextual knowledge has become the focus of research as awareness of sociocultural diversity and its impact on actual teaching and learning increases. In education, contexts can be classified into the designed environment (e.g., buildings, equipment), human environment (e.g., students, teacher, parents, administrators), and sociocultural environment (e.g., policy, cultural norms) (Ford, 1992). Teachers are required to have such knowledge of context related to teaching in order to accomplish the task of educating diverse children for success. It is crucial for teachers to comprehend under what circumstances their teaching practices occur. The meaning of contextual knowledge is extensive because it includes not only knowledge about general educational contexts, but the specific educational contexts in which actual teaching and learning occurs. Thus, contextual knowledge involves teachers' conceptions of culture, their knowledge of cultures different from their own, and their images of schools and classrooms as social and cultural contexts (Cochran-Smith, 1997, p. 39).

The distinctive feature of PCK in this study, compared to most other studies, is to put great value on the context in which teaching practices occur. By including contextual knowledge as a component of PCK, the concept of PCK takes on a new aspect in this study. It is no longer viewed as teachers' simple representations of subject matter knowledge in terms of how to teach it effectively. The PCK functions to stimulate teachers to understand the characteristics of particular students and to recreate the classroom setting according to particular circumstances. Ultimately, PCK is synthetic in that it builds up separate knowledge elements into a connected whole. PCK is not equal to the sum of each types of knowledge. It is the knowledge resulting from the teacher's cognitive process of transformation and qualitatively different from each type of knowledge *per se*.

In science education field, a great deal of research about teacher's PCK has been done. However, most research on PCK is merely confined to theoretical review of the concept (e. g. Cochran *et al.*, 1993; Grossman, 1990; Magnusson, Krajcik & Borko, 1999; Marks, 1990; McEwan & Bull, 1991; van Driel, Verloop & de Vos, 1998). Consequently, there is little research that articulates how teachers develop such knowledge in real-life teaching context. This study attempts to explore how a teacher understands urban teaching context, and hence how she develops her PCK though connecting such knowledge to other knowledge domains in actual teaching practices.

III. METHOD

This study adopted a case study approach as a type of qualitative research, for two particular reasons. First, a case study is relevant in obtaining a *thick description*, a detailed re-creation of contexts, meanings, and intentions (Mertler & Charles, 2005). Because this study attempts to investigate one teacher's PCK development in the context of her daily work, the research method is useful to gain vivid descriptions of 'what' and 'how' the teacher teaches science in a particular urban classroom. Second, a case study can provide a deep understanding of 'why' she teaches in certain ways as observed in classroom practices. The careful and detailed investigation of her teaching practice is helpful to identify particular patterns and/or relationships between knowledge domains during the teaching process.

1. Research Setting and Context

Following the case study research frame, this study was conducted in a public elementary school, located in New York City, where school population is a mixed group of racial minorities, predominantly Hispanics (80%). About 90% of students participate in the free or reduced lunch program.

A first grade teacher (Emily - pseudonym) was selected to participate in the study, based on professional development school (PDS) relationship between public school and local university. The PDS program was designed to promote urban children's engagement and understanding in science. Under the PDS framework, Emily and the researcher (as a research fellow) had worked together to develop new science curriculum and creative methods for teaching urban elementary school students, for two years.

Emily was 48 years old, White, upper-middle class, and English speaking woman. She had three years of teaching experience in the first grade, all of it in the district where she currently taught. Emily started teaching after a long-time business career. Her undergraduate degree was in early childhood education. Even though she dreamed about being a teacher, she gave up her dream back then because she had to support herself after college. As she wanted a job with a higher salary than teaching and also wanted to remain connected to her major, she worked for children's game and toy company. Finally, she started teaching in the school after she had become certified. She said that she wanted to be a teacher because "I believe it is important for all children of any cultural or socioeconomic background to have the opportunity to develop their gifts and competence." Even though she did not have many years of teaching experience, she seemed to have good skills and knowledge about teaching science to those children. Also, she was very enthusiastic about teaching science as evidenced by her previous efforts to write and receive grants and to participate in science education meetings and conferences. She lived near the school and was familiar with the school neighborhood. It might be helpful for her to get more in-depth knowledge of the context, such as what the children's everyday lives were like, where they usually spend time after school, how their parents support their children's learning experiences, etc. Consequently, her educational background, previous career, passion and belief on education might be connected together and contribute to make her teaching practice to be a representative case, particularly teaching science to her socioculturally diverse students in the urban site.

During the research period, she was teaching first grade children. In her classroom, the number of the children varied because some children were transient. The average number of the children who attended at her class ranged from 18 to 22. The children's ages were from 6 to 7. Their ethnic backgrounds included Asian, African-American, Latino, and European, and Latino was predominant. Many of the children were from working-class families. Some were homeless. Few were from middle class families. Several children had ADHD (Attention Deficit Hyper-Activity Disorder). She taught a self-selected life science topic, 'animal,' during the research period.

2. Data Collection

Data were collected from multiple sources to enrich the case (Cohen & Manion, 1985; Merriam, 1998) and enhance the validity (Gall, Borg & Gall, 1996; Merriam, 1998). The two major methods for data collection are interview and participant observation. In order to reinforce the data from the two methods, other means also were used, including documentation and physical artifacts. The data collected from various sources were used to construct "a richly detailed picture of human life -- a picture that is interesting, informative, and potentially filled with implication (Mertler & Charles, 2005, p. 228)." The data collection for this study was done under the participants' consents (from the teacher and the parents of the students) with the approval of the Division of Assessment and Accountability from New York City Board of Education. Data was collected from 2003 to 2004, for the course of the school year.

1) Interview and Participant Observation

This study was conducted in three phases over the school year by utilizing the interview and participant observation method. First, interview method was used prior to teaching the unit in order to explore Emily's existing knowledge base, in terms of subject matter, pedagogical, and contextual knowledge. Long-time interview (about 1 hour) was done four times. Second, participant observation method was adopted to observe her teaching practices in everyday life context. For the school year, a total of 40 lessons, each about 50 minutes, were observed. Among those, 10 lessons were videotaped for detailed analysis. During the observation period, participant observer's role was limited to help students' learning, to the extent of not causing distraction of Emily's original teaching plan or intention. Third, interview method was reemployed to probe teacher's reflective thinking and understanding of her own knowledge and practices. For the period of the unit teaching, a total of 20 short-time interviews (approximately 3~15 minutes) were done in order to capture her decision-making process and reflections before and after individual lessons. Long-time interview was also conducted 3 times after the unit teaching.

2) Documentation

Together with the interview and participant observation method, a variety of documents were collected during the field research period, including Emily's lesson plan, the official science curriculum document used in the school district, a concept map, a grant proposal, pamphlets from a teaching aid company, e-mail replies, and so on. In addition, children's individual research and other journal writing were included in the database as an important resource to understand the particular way she guided their learning. All of those documents were collected to gather other specific details, and to corroborate and augment evidence from other sources (Yin, 2003).

3) Physical Artifacts

Physical artifacts in the classroom were the final source of data, which were collected to increase the validity of the study. For more precise understanding of the classroom teaching environment, which might impact on Emily's teaching, physical artifacts, such as charts related to science activity, maps, children's art work, etc., were collected in original form or photographed.

3. Data Analysis

The collected data were analyzed to provide a detailed explanation for the research inquiry about how the teacher utilized knowledge base for teaching science and developed PCK in the particular urban context. In the course of interpreting data, the set of interviews, field notes, lesson plans, children's science journals, and other documents/photos were carefully examined to obtain meaningful interpretations of what she thinks and does, with consistency.

1) Coding

In qualitative research, the process of coding is analysis. In order to code data, an analytical framework was developed as shown in Table 1. Within the analytical framework, the massive data were broken down into manageable chunks in finding patterns/themes and labeled as units of meaning. Codes were attached to words, phrases, sentences, or whole paragraphs that were connected to a specific setting (Miles & Huberman, 1994) to produce adequate interpretations of Emily's knowledge and teaching practices.

After the coding process, data analysis was done *logico-inductively*, a thought process that uses logic to make sense of observations (Mertler & Charles, 2005). Emily's thinking and action during her teaching period were dissected through the thinking process. This study also adopted an analytical technique, Qualitative Content Analysis (QCA), in order to find the specific themes/

Table 1. Analytical framework for the study

Research inquiry for analysis	Categories for data collection/ analysis	Patterns/themes of language and behavior	Methods for data collection
Teacher's existing knowledge base before teaching the topic	Subject matter knowledge	Importance of teaching the topic Structure of the science topic: Main concepts and ideas Relationship with the official curriculum	Interview Concept map Curriculum document
	Pedagogical knowledge	Pedagogical decisions for teaching the topic Instructional strategies: Use of urban resources and materials Knowledge about learners and learning	Interview Lesson plan Teaching note
	Contextual knowledge	General education context in NYC Socioculturally diverse urban children and their living context Making connections between the children and science	Interview
Teacher's PCK development in actual teaching practices	Relationship between subject matter knowledge and contextual knowledge	Science content teaching and learning	Participant observation Video-taping Picture-taking Field notes Teaching notes Emails Children's writing Children's artwork Classroom artifacts Interviews
	Relationship between pedagogical knowledge and contextual knowledge	Instructional strategies Classroom management Assessment	

patterns. The practical steps used in the analysis were made by modifying QCA process used in Veal (1997)'s study about evolution of PCK.

2) Analysis for Research Inquiry 1

In order to probe the teacher's existing knowledge base, the data from multiple sources were analyzed following specific steps: 1) all of the data (text and image) were examined and organized into a chart by coding the information into three knowledge domains, subject matter knowledge, pedagogical knowledge, and contextual knowledge, 2) data was reduced to a set of statements which reflect Emily's thinking and understanding in respective knowledge domains, in tabular form, according to the subcategories (patterns of language and behavior for coding) in the analytical framework, and 3) analytical and methodological notes, shown in Table 2, were used in the interpretive process.

3) Analysis for Research Inquiry 2

The development of Emily's PCK through actual teaching practice was represented as the relationship between knowledge domains in this study. Since contextual knowledge was recognized as a crucial knowledge in developing PCK in this study, the analysis focused on finding themes/ patterns derived from relating contextual knowledge and subject matter/pedagogical knowledge during her actions of teaching. In

Table 2. The Analytical Notes Used in Interpretive Process: Emily's Three Knowledge Domains

Existing Knowledge Base	Analytical Notes
Subject Matter Knowledge	- Why Emily chose the topic for the first grade children and how she connected it with children's experience - The way she interpreted main concepts and their relationships in terms of children's knowledge level - Her knowledge about official curriculum and its relationship with her teaching
Pedagogical Knowledge	- Emily's pedagogical concerns and decisions for teaching the topic - Plans and ideas of how to guide children's meaningful learning instruction and the urban resource utilization - Her knowledge about the learner's understanding about the topic and her role as a teacher
Contextual Knowledge	- Her knowledge about the educational policy and administration for science in the urban area - Knowledge and information about her classroom children's sociocultural background and living context - Understanding of how to make a connection between the children and science in the given situation

Table 3. The Analytical Notes Used in Interpretive Process

Development of PCK during Teaching	Analytical Notes
The Relationship between Subject Matter Knowledge and Contextual Knowledge	- The scope of the science content: the reasons/purposes of selecting and emphasizing particular science concepts and skills - The way that Emily presented the content to her students (used materials and resources) - The types of scientific inquiry skills that she taught the students (why she taught the skills?) - How she acknowledged student's prior knowledge about animals and linked it to their science inquiry - How she recognized students' strengths and weaknesses related to their sociocultural backgrounds and used them to improve their learning - The schemes that she used to overcome various constraints in her teaching context
The Relationship between Pedagogical Knowledge and Contextual Knowledge	- The instructional sequence: the way that Emily organized her instructions and the reasons - The types of teaching methods and strategies and the connections between students' prior knowledge and experience of science learning/students' sociocultural background and living context - The types of students' learning activities: the reasons/purposes of providing them and its connection with children's sociocultural characteristics - Classroom management: how she guided children's learning activities - The types of resources in the community that Emily used to help students' inquiry learning (why and how) - The types of resources in the school that Emily used to help students' inquiry learning (why and how) - The schemes that she used to overcome various constraints in her teaching context

the analysis of the data, if the two different domains associated and contributed to the achievement of the same teaching purposes/goals persistently, it was considered as a common 'theme' to indicate Emily's PCK development. The emerged themes were considered as the essence of Emily's PCK development in teaching animals. The specific steps of analysis were: 1) all of the data (text and image) were read and examined, 2) coding occurred for the units of the relationship between knowledge domains, 3) categories were established based on the unit of meaning and their relationship to the research questions, 4) analytical and methodological notes, shown in Table 3, were used to help in the interpretive process, 5) categories were defined and clustered together with the supportive evidences, 6) themes/patterns of the relationship between knowledge domains emerged, which represented findings relevant to the second research question.

IV. FINDINGS

1. Emily's Existing Knowledge Base of PCK

The findings from the interviews and other related sources were analyzed in three parts, corresponding to the three domains of knowledge. The knowledge domains are the building blocks of Emily's PCK in her actual teaching practice and hence, those have been examined before her unit teaching began.

1) Subject Matter Ksnowledge

The analysis of Emily's subject matter knowledge demonstrated how she understood major concepts and ideas that supported her teaching approach to teach 'animal.' In specific, her subject matter knowledge was analyzed in three aspects: the importance of teaching the topic; how she structured main concepts and ideas about the topic; the way that she related the topic to the school's official curriculum.

First, her choice of the topic was an expansion of the official curriculum, based on her belief about children's learning competency.

> I want them to learn as much about individual animals and new information about that, but I also want them to learn about the process of research. That's what scientists do. They are typically curious about something, they ask questions about it and they go through an investigative process that involves gathering information, taking notes about it, reading and writing about it, and sharing it with other scientists. That's all part of the process that we're going through for the unit. (9/26/03 Interview)

As shown in the quote above, Emily thought that the learning of 'animals' was important as pointing out the purpose of teaching the topic as two sides: construction of new science knowledge and the development of science-specific process skills. She had a firm belief about children's ability to conduct scientific research and defined her role as a 'supporter' for children's science learning.

Second, Emily exhibited her science knowledge in terms of major concepts and principles regarding the topic. Emily's basic strategy for structuring her knowledge was to use 'classification.' She appeared to bring focus into how living organisms fit within the system of classification, in describing and categorizing all living things. By means of a concept map, she displayed the way to categorize organisms such as kingdom, phylum, class, order, family, genus, and species (she missed a couple of terminologies in her map). She also divided major groups of living things as kingdoms: animal (animalia), plant (plantae), fungi, protista, and monera. She explained her concept map as:

> I'm not sure if I'm very articulate about it because I've forgotten a lot of scientific terms that I don't use. I think of it in terms of the two forms, major forms of classification, one of them dividing the world of the living things as kingdoms; plants, animals, fungus, monera, and protista. But my thought is that children in first grade could certainly explain plants and animals. The other areas of kingdoms are too…advanced, maybe children for older years. And classification is something, a part of *standards* for first grade. So, I try to think in terms of that, whatever I'm doing with living things. For example, we got some leaves over at Riverside Park and children are identifying the shapes and classifying them…to keep that idea going with

them when we work with animals. One part of that work is to look at grouping animals together according to their characteristics. That might be habitat, or food, or a type of animals, like big cats···

Basically, I'm using some classification, according to the children's own ideas and their level of classification, not like this (indicating classification of her concept map). They can classify animals following their own ideas; where do they live, what do they eat, and so on. (9/26/03 Interview)

In the quote above, it is evident that Emily narrowed the five kingdoms down to two - plant and animal - for her first grade students while she tried to remember a conceptual understanding and the structure of the main concepts based on major taxonomy in science. The concept map and Emily's statement above show that she tried to adapt her knowledge structure about the topic to first grade children's cognitive level.

In demonstrating her knowledge above, Emily felt confident about it because what matters to her the most, in terms of subject matter knowledge, was how to meet children's needs and interests at the elementary school level. For Emily, it seemed important to comprehend the content not from a highly advanced scientists' knowledge level, but from children's cognitive level and understanding. Therefore, even though she did not seem to have highly developed knowledge about the topic, she was positive about her conceptual understanding in teaching the topic.

Third, regarding the official curriculum, Emily stressed the 'flexibility' to choose what to teach in the areas of science by viewing the curriculum as a 'reference.'

It's an actually good guideline to me, to remind me, it's not just for this unit but also some other scientific knowledge. I like to refer back to *standards* and I'm trying to use it as basis in every unit. I would say that, for me, I like to expand beyond the minimum of living things in *standards* - a lot of them focus on growing plants, but not so much animals. Our district introduces 'Snail' into science. But I think children might have had time doing it here in the New York City. I'd like to have a class pet. You know many teachers do that, not all. But many teachers will have a classroom pet and they do something with that animal related to science, maybe not. I don't think it's carefully monitored. (9/26/03 Interview)

As the quote shows, Emily considered the official curriculum as a reference, which allowed diverse options in teaching the subject as well as presented general guidelines for what students should learn. Since she perceived that it provided much room for selecting what to teach, she tried to be flexible in adding more content, depending on the scope and sequence. The 'animals' unit was her curricular choice for deepening children's understanding about living things, which was not mandated by the district. She planned to expand children's learning in the area of life science, using various materials within the scientific inquiry framework.

2) Pedagogical Knowledge

Emily's pedagogical knowledge was investigated in three categories, and centered on her initial thoughts about how to teach the topic: pedagogical decisions to teach the topic for children; instructional strategies and use of resources to teach the topic in the urban environment; and knowledge about learners and learning.

First, Emily planned an interdisciplinary approach to teach the topic, based on her pedagogical belief that this approach not only provides more time for science, but also helps enrich children's learning experience. Among other subjects, Emily's major pedagogical concern was to make a strong connection between science and literacy. By making such a plan, she seemed to meet twofold teaching demands: to improve children's literacy learning, particularly for language minority students as well as to provide them opportunities to cultivate science knowledge and skills.

In terms of implementation of her plan, she brought focus into 'inquiry-based' science, which enables children to conduct scientific investigations. She presented specific objects for planning inquiry learning in an interdisciplinary teaching framework as: a) to improve basic literacy skills in spelling and grammar; b) to gain scientific knowledge and skills about the topic; c) to develop higher order thinking skills of analysis, synthesis and evaluation as they gather information to answer their inquiry. Emily talked about her expectations for this inquiry: that children would initiate learning and take ownership of it because they would investigate answers for their questions, which come from their own thoughts and curiosity.

Second, Emily planned children's 'individual research' as a way for children to practice diverse inquiry processes. It was designed based on children's own interests and research abilities. She talked about the importance of guiding children to validate their questions as researchable ones from a scientific standpoint, in the initial stage of the individual investigation. Whole group and partner sharing time might be helpful strategies to do this, according to her.

After going through the inquiry learning process, Emily planned a 'publishing party' at the end of the unit, for assessing the children's inquiry learning. It was her own idea to evaluate her students' learning by encouraging accomplishments for every child. In addition, her special strategy for the party was to invite parents so that she could listen to their voices about children's learning and the progress.

In order to support children's inquiry learning, Emily was enthusiastic about finding locally appropriate resources, such as trip to a zoo, museum, aquarium, pet store, etc., which her students may or may not be experienced in their everyday lives. She definitely seemed to utilize those resources in that the resources would be beneficial for children to develop their abilities necessary for scientific inquiry as well as to enhance their understanding from nonfiction reading and writing.

Third, Emily displayed detailed knowledge about first grade children's understanding about the topic. Regarding the science topic, she had very practical knowledge of what first grade children already knew and what questions they might ask. Such knowledge was useful resource for her to make plans to guide children's learning. She wanted to provide children opportunities to ask their own questions, by which she also learned about their ideas regarding the topic and would be able to help them build upon their ideas. She also recognized the importance of expanding children's knowledge beyond their current knowledge level, which originated from her prior knowledge that most of children would be likely to choose animals, concentrating on pets or familiar animals in everyday life.

> I believe it is a very important process to identify what children already know and want to know as I mentioned, because those are the starting line of my teaching. Then, my role is to encourage children to express what they have in mind and help them construct meaningful knowledge by making connections with their initial thoughts and ideas. In that process of learning, children develop a scientific way of thinking as well. (10/17/03 Interview)

As Emily pointed out, she perceived her role as a supporter of children's inquiry by helping them make connections of their knowledge as well as to practice thinking skills of scientific inquiry. Overall, Emily's pedagogical knowledge about how children think and learn seemed to shape the way she teaches students.

3) Contextual Knowledge

Emily's contextual knowledge was analyzed into three aspects which emerged from the literature review and data collection process: general educational context in New York City; knowledge about urban children and the community; making connections between the children and science.

First, Emily's knowledge about administrative policy about school mandates and expectations for teaching science revealed problems and issues regarding teaching science in the urban area. According to her knowledge, the academic performance levels of schools in a district or region seemed to control the schools' choices and competences to adopt curricula. Also, the particular emphasis on two subjects, literacy and mathematics, was a typical example of centralized, top-down educational policy, which excluded voices of the most important and direct agents such as students and teachers. Emily's understanding of such a context presented the reality of 'science education' in this urban area: The equal opportunity to learn science would not be guaranteed for certain children.

Second, Emily's knowledge about the population composition around the school and community revealed diversities in students' ethnicity as well as how those characterized their living situation in that urban area. She reported that the school area was surrounded by a multicultural and multilingual community. Her students were mostly new immigrants and occupied low socioeconomic status. Owing to such a living context, Emily pointed out that there might be some difference between her students and the so called 'mainstream' children in terms of knowledge, experience, language, expectations of learning in school, etc.

> A middle class child is likely to have a lot of science-related-experiences and other kinds of cultural experiences within their family and within their home as family life evolves. For example, they have opportunities to visit museums, like the American Museum of Natural History, ···to go places like the Kennedy Space Center, and are exposed the things that weren't typically the part of the family routine and daily life of my children ··· My kids··· they are from families that have immigrated here are first generation as I just told you. They typically have a tough living situation and then, you know, they have issues of immigration. That's a lot of stress within the family and so they may not have familiarity with some of these places, in addition to not having time and resources [needed for parents] to expose the children to those kinds of things on a regular basis ··· (11/7/03 Interview)

Emily's statement shows that her students from non-mainstream background did not have the opportunities to engage in scientific inquiry activities as mainstream children did. Besides such issue, Emily's contextual knowledge revealed that the low level of parental involvement and/or support for her students' learning, mostly owing to their difficult living situations, might be one factor that restricts children from pursuing their interests.

Third, Emily seemed to fully recognize the differences in children's knowledge about the specific topic. Emily acknowledged different worldviews and cultures of her students in the classroom. She knew that the different sociocultural backgrounds were related to children's prior knowledge and experiences. In such a context, science was identified as a unifying subject by Emily to harmonize urban children's diverse knowledge and values.

In conclusion, the findings of the analysis demonstrated that Emily had a firm knowledge base for teaching the topic. Emily already integrated the three knowledge domains through planning and designing her teaching practices. Specifically, she used her contextual knowledge that was closely related to other domains of knowledge, deciding on what and how to teach the topic. Emily's comprehensive understanding about the administrative policy and the urban students' living context stimulated her to make plans for science teaching. Also, in valuing urban children's diverse sociocultural experiences and prior knowledge, she defined her role as helping children bring their specific experiences and knowledge into the classroom in teaching science. Her pedagogical decisions, such as stimulating student-generated questions and inquiry had a close relationship with such contextual knowledge and beliefs. Emily identified urban resources as an important tool for children's inquiry learning, in terms of providing an access for doing science in their everyday life. Emily's contextual knowledge seems valuable in adjusting her knowledge and thoughts to the existing educational context.

2. Emily's PCK in Action: Relationship between Knowledge Domains

The development of Emily's three knowledge domains as PCK was analyzed in terms of the relationship between knowledge domains in this study. The analyses of the relationship were centralized on her contextual knowledge because this study has a particular interest about how the teacher's contextual knowledge influences on 'content (what to teach)' and 'pedagogy (how to teach)' in the PCK development process.

In actual teaching, Emily taught the science topic 'animal' under an interdisciplinary teaching combining science and literacy as she planned before. Her teaching practice was divided into two terms: Nonfiction book reading and individual research writing. The analysis of Emily's teaching exposed how her PCK become robust by making connections between these knowledge domains

1) The Relationship between Subject Matter Knowledge and Contextual Knowledge

The findings about the relationship between Emily's subject matter knowledge and contextual knowledge disclosed how she scaffolded children's content learning in her teaching context.

During the children's reading period, Emily provided her students with nonfiction books about animals as a primary learning resource. The following episode is an example of how she interacted with children.

> Emily began the class with a big book, 'A Butterfly Is Born.'
>
> Emily: Yesterday, when we did our reading, we were figuring out how to name a subject in our book. Today, we are going to bring our knowledge to a subject when we read books. You can make sense of the information from the books by using what you already know. I'd like to help you do it. Can you guys tell me how much you know about butterflies? [She shows the cover page of the book to children.]
>
> Children: Caterpillar! The butterfly has a cocoon!
>
> Emily: All right! Somebody knows about cocoons and somebody knows that the caterpillar is involved. Mealworms have pupa and butterflies have cocoon. I want you to think about what information comes up about a butterfly. I also want you to think about what you don't know about it. Let's find out when a butterfly is born. [She shows the students the pictures in the book.]

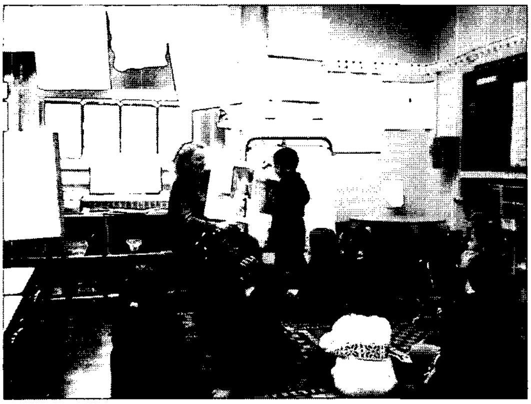


Fig. 1. Sharing knowledge about butterflies.

> Emily opened the page and started reading it showing pictures inside. When she read the first page of the book, 'Butterfly lays eggs,' she pretended as if she is confused, "I think the butterfly has a cocoon. Wait a second! Do butterflies begin their life as a caterpillar?" The children couldn't help but wonder as Emily posed a question like that. They tried to think about what they already knew about butterflies. Emily and the children read the next page a loud together. A couple of children raised their hands and said what they knew about it. For example, Anthony came to the book and pointed to the picture on the page, saying, "They hatch like this first." Josh said, "Before it was an egg, it was a caterpillar."
>
> After the discussion, Emily opened the page with a picture of eggs.
>
> Emily: O.K. So, first it is an egg. Oh my goodness, is this a butterfly?[She pretended if she is surprised by the fact.] Then, it says the egg hatches. It eats its eggshell.
>
> Children: It is so hungry. It eats a lot of leaves.
>
> Emily: Look at how big this caterpillar is! It makes a cocoon. And slowly, the caterpillar turns into….
>
> Children: Pupa!
>
> Emily: Wait! You said a mealworm has a pupa? Hmm m… [She paused for a few seconds] Today, when we go off to reading, I want you to think about what you already know about the book that you chose to read. And you can use it and make sense of what you don't know, like cocoon and pupa. You are making sense of the book by using information of what you already know.
>
> (1/23/2004 Observation)

As described in this classroom episode, children had opportunities to share. their knowledge about diverse animals through whole group discussion. In this period of Emily's teaching, her subject matter knowledge and contextual knowledge seemed to be related in three aspects.

First, Emily's contextual knowledge that children had limited knowledge and experiences about the science topic influenced her decision-making process about what to teach. She decided to introduce new vocabularies and concepts about animals using nonfiction books, in order to expand children's knowledge and experience.

Second, since she acknowledged the fact that many of her students were non-native English speakers, she used specific features about animals in the nonfiction books, such as pictures and diagrams, to teach them basic research skills. Such links between her contextual knowledge and science content knowledge helped to improve all of the children's (including non-English speaking learners) research skills, in finding information for their own investigation.

Third, Emily tried to help children make connections between their prior knowledge about animals and new findings from nonfiction book reading. She knew that her students with socioculturally diverse backgrounds might have different views and ideas regarding science. Such contextual knowledge was connected with her knowledge about children's level of knowledge regarding animals since she valued children's own knowledge and their knowledge construction.

For the second term of science teaching (the individual research periods), Emily tried to help children ask and answer their own questions based on the scientific inquiry process. Accordingly, she connected her subject matter knowledge and contextual knowledge in a way to promote children's own inquiries and writing process.

First, Emily encouraged children to ask questions and express their own understanding about animals through inquiry. She made this decision because she knew that children lacked the opportunities to display their scientific knowledge and experiences in the form of questions through their thinking process.

Consequently, Emily's knowledge about the children's prior learning experience in science was linked to her knowledge of science inquiry, in order to develop children's minds of doing science.

Second, the two knowledge domains were closely related to help children construct positive self-images as science learners. Her contextual knowledge suggested that the reasons of children's difficulty in learning science was related not to their learning competence but to their non-Native English language background and/or prior school education background. During the science writing period, the children's initial excitement for the science writing tended to immediately because they were unable to write what they thought. These children surely were not constructing a positive self-image as learners. The examples of the children's unfinished writing are shown in the Fig. 3.

In such a situation, Emily connected her contextual knowledge with subject matter knowledge about science and literacy. She utilized invented writing as a means to promote children's successful learning experiences in science by focusing on meaning construction over spelling.

As displayed in children's writings in Fig. 4, Emily's teaching strategy helped to improve the children's wri-

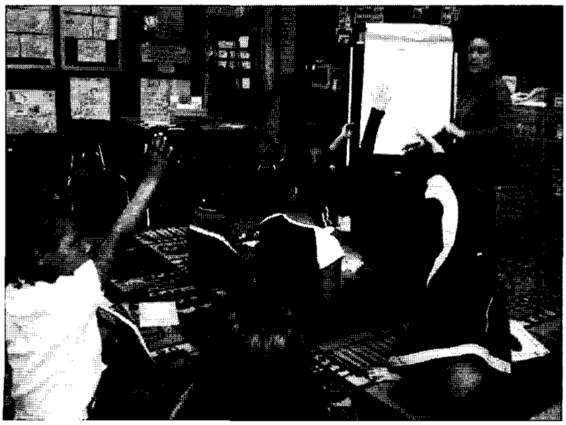
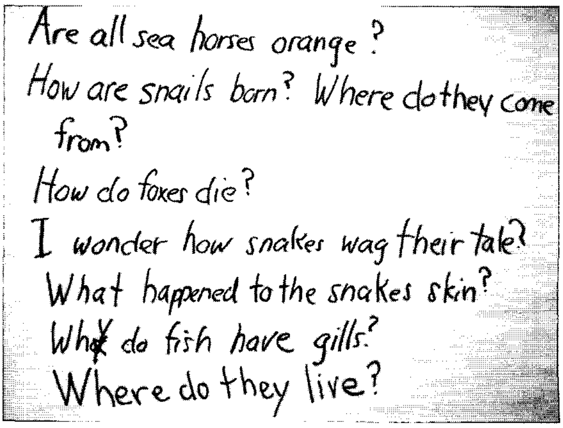


Fig. 2. Choosing an animal for individual research (3/2/2004 Observation).



Children's questions about animals (3/9/2004 Observation).

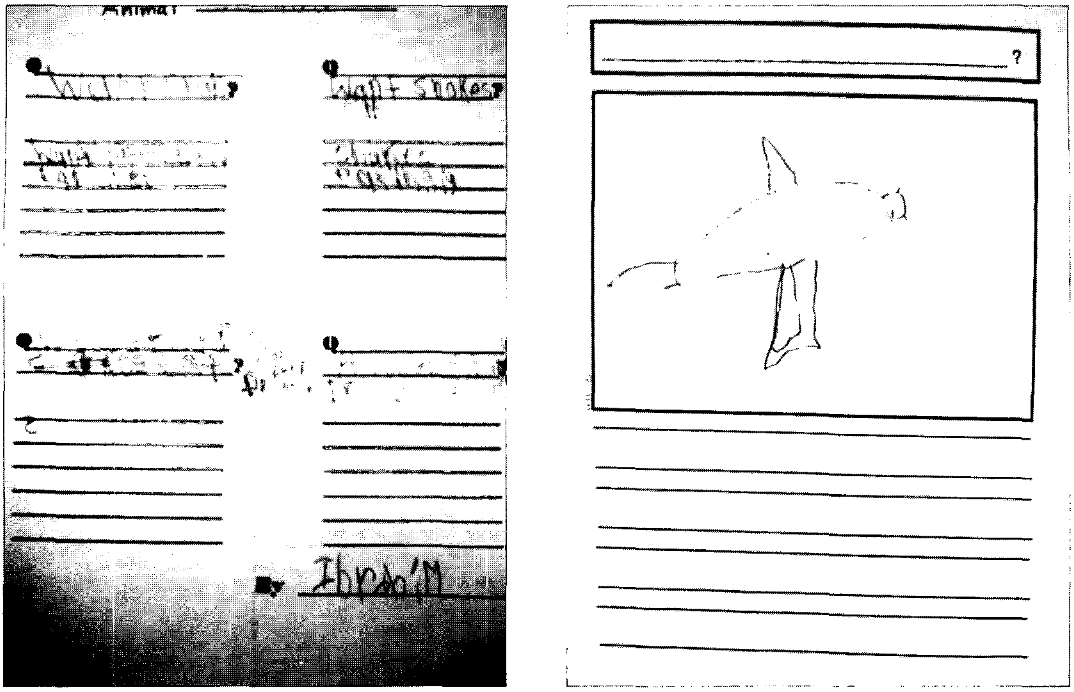
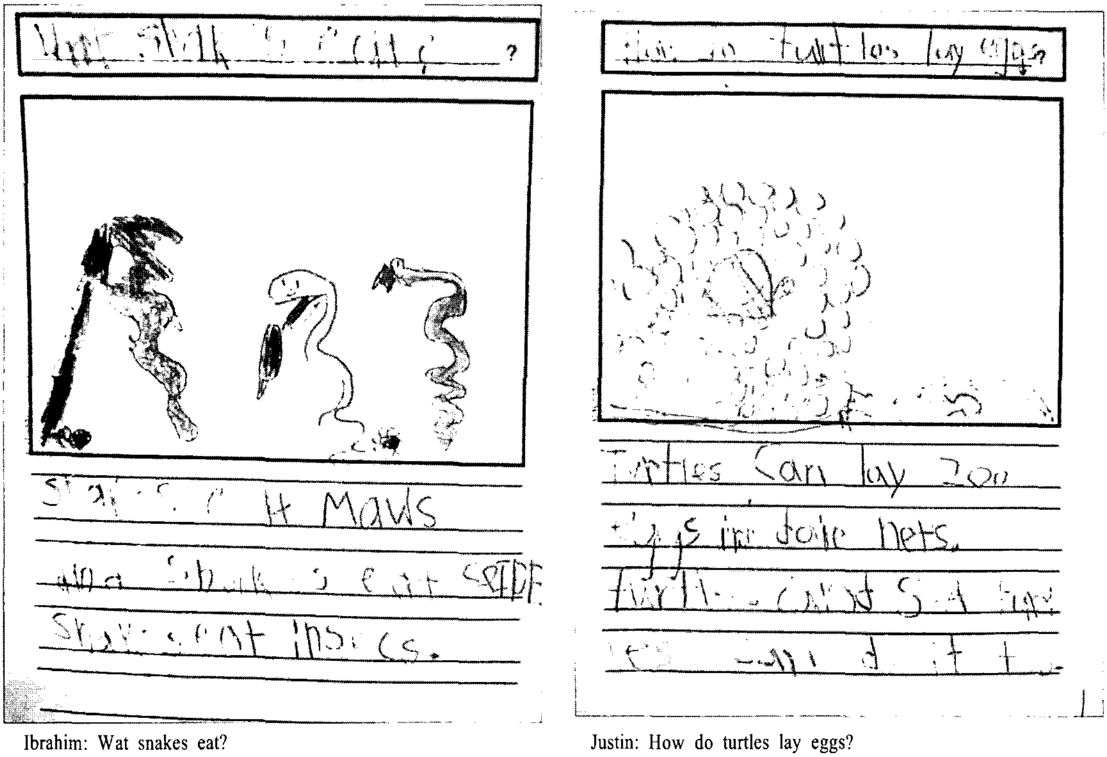


Fig. 3. Examples of children's unfinished writing (3/18/04 Observation).



Ibrahim: Wat snakes eat?
Snakes eat Maws and snakes eat spider.
Snakes eat insecs.

Justin: How do turtles lay eggs?
Turtles can lay 200 eggs in dair nets.
Turtles and seA turtles can do it too.

Fig. 4. Children's writing using invented spelling (3/19/2004 Observation).

ting skills.

Third, Emily's knowledge about children's initial understanding about animals played an important role in her ability to help children learn how to make sense of their ideas from a scientific point of view. She guided children to elaborate their writing by providing evidence sentences from scientific standpoint. It was hard to find the relationship between Emily's two knowledge domains in this period of teaching.

To sum up, the major relationship between Emily's subject matter knowledge and contextual knowledge was found how to provide suitable science content learning experiences to meet the urban children's needs and interests. She developed her PCK in such a way to improve children's ideas and knowledge about the topic by giving them opportunities to demonstrate what they learned and understood through inquiry.

2) The relationship between pedagogical knowledge and contextual knowledge

The findings about the relationship between Emily's pedagogical knowledge and contextual knowledge revealed her approach to promote children's inquiry learning, particularly in confronting the constraints and challenges in the urban teaching context.

During the nonfiction book reading, the major relationship between Emily's pedagogical knowledge and contextual knowledge were solidified in promoting children's science research skills for the animal investigation project.

First, Emily's contextual knowledge about children's particular needs in science and literacy prompted her to be more explicit as linked to her pedagogical knowledge in actual teaching. In specific, her knowledge about children's limited experiences in science and reading nonfiction books was connected to her pedagogical knowledge of instructional strategies.

Emily: Yesterday, we were looking for some information from nonfiction books. We looked at details, like pictures and words that help us find what we want to know. Today, we are going to learn how we can find what we are looking for in the book more easily.

(She picks up a big book called 'Plant Eaters of the Pond.')

Emily: When you open the book, you will see the page like this. [indicating the 'table of contents.'] It is called 'table of contents' or 'contents.' What do you see here?

Children: Words!

Emily: Yes, you can see the words here. These tell you different things about what the book has. What else do you see?

Children: Numbers!

Emily: What are these numbers supposed to mean?

Children: [no answers.]

Emily: I'll read this to you now [indicating first subtitle with her finger] 'Plant eaters,'..go across like thi s···O.K. page number 2. Let's go to page 2. Here is 'plant eaters!'

Children: Yay! [excited]

Emily: You'll use the 'table of contents' to find what you want to read. Today, when you go to read nonfiction books, check the table of contents. Ask for help to go where you want to be!

As shown in the episode above, Emily not only gave children concrete examples but also clearly demonstrated how to use special features in nonfiction books. Also, she explained children how to apply the research skills to find information from nonfiction books as a way to cultivate children's science research skills.

Second, Emily's knowledge about children's learning needs/characteristics and its relationship with their sociocultural background helped her to select and orga-

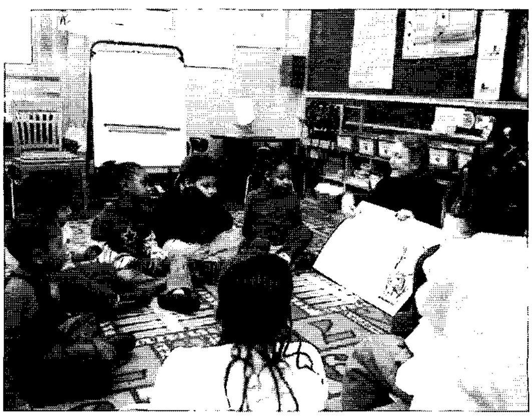


Fig. 5. Explaining 'table of contents' (1/13/2004 Observation).

nize classroom-learning activities. For example, she recognized that 'quiet' children generally talked more and engaged more in their learning in pairs or small groups with peers. She explained that it might be partially connected to their socio-economic status to some degree, in her teaching context.

> Many of my children live in a low socio-economic strata. Consequently, there are many cases that both parents are working. Children's social interaction with parents or adults is quite limited in such a context. However, they spend most of their time with brothers or sisters. It might affect their learning, I think,··· they feel more comfortable talking with peers. (1/15/04 Interview)

As she came to understand her students' learning context in their homes, she increased peer-learning opportunities. Children who showed limited verbal responses in whole group learning or teacher-directed situations talked more actively in peer learning situations. She reflected how peer learning was successful in her teaching context.

> Students stimulated each other's thinking through reading and sharing what they see and what they learn. I believe that's part of the purpose of science learning. For example, I observed Anthony talking about the 'life cycle' of butterflies with his partner in a small group learning activity. He may have shared it at home, like his mom told, or it's something he read in the book. Anyways, the information was coming out and the children were learning from each other. That's an important part of a good teaching experience. Children can share information as well as share strategies. (1/23/04 Interview)

Children's cooperative learning through partnership was always promoted in Emily's teaching practices. It functioned as a motivational source and built the classroom as a 'learning community,' as well. Consequently, for passive children, she provided 'small group' learning opportunities because they talked more and engaged more in pairs or small groups. At the same time, for English learners, Emily encouraged independent reading activity in which they could learn more about science knowledge in English.

Third, Emily used her contextual knowledge about children's living environment to address classroom management issues. During the instructions, children often displayed disruptive behaviors. She identified the fundamental reason for the behaviors: their home environment.

> There are children who have a very disruptive home life. It comes out of the classroom because their home life is so disrupted. They have additional difficulty in school. The school culture is problematic for them because they are preoccupied with their home situation. That's one thing. And the other is that they're not supported at home, so they need to get more support at school and then they get it. But they also have···the preoccupation gets in the way. (1/9/04 Interview)

As Emily learned more details about children's living context, she came to understand why they behave in certain ways. As a means to transform the classroom into a strong learning community, she explicitly introduced cultural values and rules of doing science acceptable at school to the children, as shown in Fig.6.

Such teaching was possible because she made a clear distinction between children's academic ability to learn and behavior problems stemming from their difficult living situations.

During the individual research period, Emily's major concerns and efforts about 'how to teach' centered on finding ways to help and support children's investigation process. Thus, the relationship between her pedagogical knowledge and contextual knowledge can be found in terms of what kinds of cultural resources she introduced to students in the urban context.

First, Emily's pedagogical knowledge about 'what experiences would be more meaningful for scientific inquiry' was connected to her contextual knowledge about children's everyday life. In her teaching context, providing access to the resources has a special meaning for the children's science learning: when children gained access to the local resources, which were closely related to their life but not available to them, they experienced authentic activities of doing science. Consequently, Emily decided to utilize the urban resources

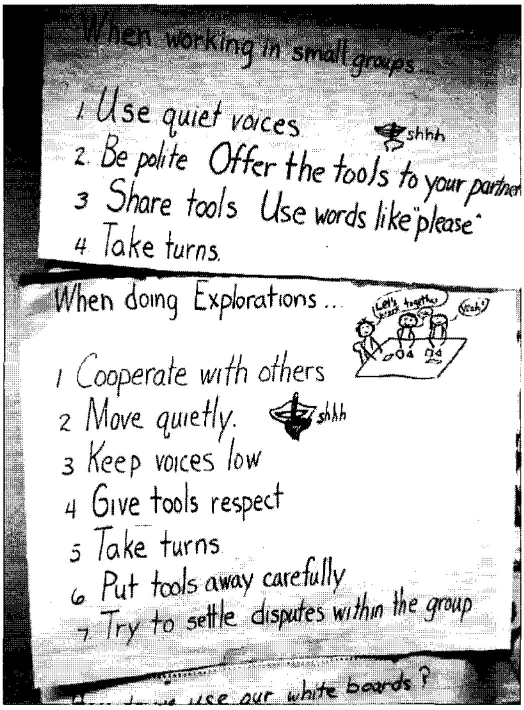


Fig. 6. Example of rules and expectations for doing science.

(e.g., pet store, public library, local museum, etc.) that existed in their community but were not easily accessible as shown in Fig. 7. The knowledge relationship was found in engaging children in authentic inquiry learning.

Second, the two knowledge domains were related to utilize school resources in more practical and effective ways. Emily's interdisciplinary teaching was expanded to diverse subject areas, such as the computer lab instruction, cooperative virtue teaching (Reading Buddies), and art class. Particularly, Emily had concerns in children's computer learning because her students' home environment did not support learning in terms of technology use. She talked about the issue of access to computer.

> They don't have the opportunity to practice with the mouse and keyboard. But, they need to know the technology today. Kids need to learn. Using computer at home produces the gap between [poor and wealthier] children. They are a part of the technology age, and also, a lot of mainstream parents buy computers for their children because they need them for school. They have the disposable income to do it and it's important to them. (3/9/04 Interview)

The quote shows that Emily believed that the difference in family support would eventually result in the gap between children's achievement in school. Considering this, she made a decision to integrate science and computer learning into her teaching. Emily thought that the computer lab learning experience might help for children to learn and practice science investigation skills as well as technical computer skills.

Her contextual knowledge about curricular options and resource availability was helpful for her to devise such interdisciplinary lessons.

Through the whole teaching period on the topic, Emily aimed to transform the classroom into 'a learning community.' In order to accomplish it, Emily de-

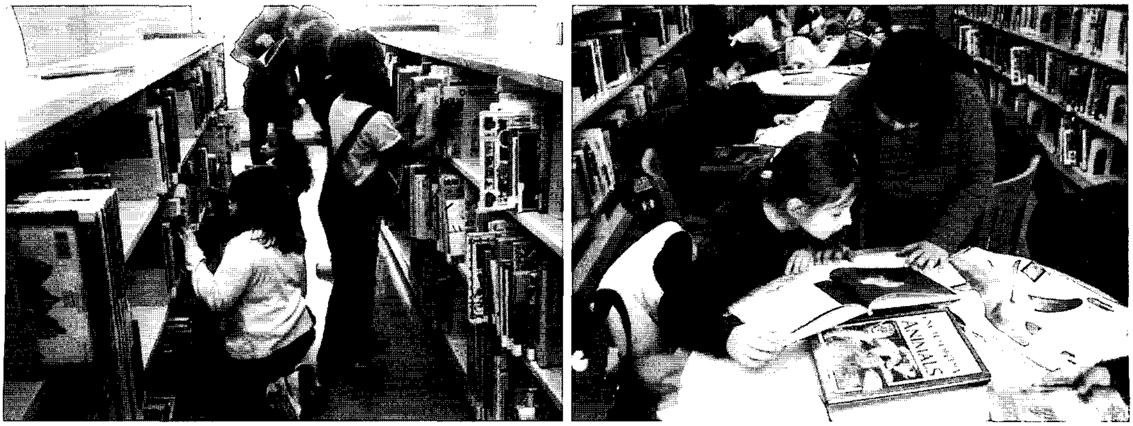


Fig. 7. Children work cooperatively in the New York public library (3/11/2004 Observation).

Fig. 8. Emily demonstrates how to use the software program and children's learning with partner (3/10/2004 Observation).

signed a 'publishing party' for the assessment. The party was very unique idea to assess children's understanding and was based on Emily's views of 'what and how to assess children.'

> There's often a desire to compare students' learning based on a standard. That's a sort of competition. But what I'd like to do over this full year is to keep their work from the beginning and all the way through [the year] and then show them how they've progressed because it's really important [for them] to know what they've done, compared to where they were and where they are now. Because every child was in a different place and they need to know that "Look at how much I've done!" I think it's not healthy and productive to compare one child to another. (4/22/04 Interview)

As displayed in the quote above, Emily's assessment focus was not on a standardized measurement of children's learning but on the progress that they had made from the beginning of the school year. Emily was interested in 'each' and 'every' child's success in learning. The success did not mean that children achieved a certain type of formalized standard or high performance. From Emily's point of view, it would be successful if they finished their assignments and made progress. Throughout the year, the target of comparison was the child her/himself, not others. Based on this thinking, she decided to have a 'publishing party' for which every child published their own nonfiction book about an animal. Emily thought that the children's individual nonfiction books, the final product of their inquiry learning, might be an excellent assessment tool because it would represent how they came to their own understanding as they read, observed, compared, classified, described, inferred, and wrote about their findings. During the publishing party, children had the opportunity to share and appreciate their successful experience of science learning with each other. The children's parents and family members were invited to the party and talked about their thoughts about children's science learning. After all, Emily, the children, and parents were able to interact with each other by sharing knowledge and thoughts about science and science learning, as a science learning community.

In summary, the notable relationship between Emily's pedagogical knowledge and contextual knowledge was detected in the course of providing the resources to enrich children's learning experiences, which were often not accessible to them owing to diverse contextual factors. Under the particular situation of teaching racial and language minority students, she realized that the more she knew her children's knowledge, values, and practices of science, the better she was able to teach science in a more relevant and meaningful way for them. Her PCK became robust in this way.

V. CONCLUSION

This study investigated how an elementary school teacher, in a poor urban neighborhood elementary school in NYC, developed PCK by utilizing her knowledge domains when she taught a specific science topic 'animal.' The teacher, Emily, had the solid knowledge base for teaching the topic, in terms of three domains of knowledge before teaching. During the actual teaching practices, it seemed that the success of her teaching largely depended on how tightly she integrated essential knowledge from different domains with the dynamics of teaching and learning. In the process, her contextual knowledge, such as knowledge of the school and district policies and urban students' diverse sociocultural backgrounds, was a crucial factor to develop PCK. Utilizing such knowledge, Emily was able to identify possible choices and support regarding 'what and how to teach' the topic to socioculturally diverse children in the urban city.

Although it is a single case study conducted outside Korea, the findings provide useful insights about science teaching in urban areas. In particular, Emily's utilization of contextual knowledge, in the process of developing her PCK, stimulates us to ponder the issue of equity, access, and power concerning underrepresented children's science learning.

First, Emily developed her PCK primarily based on 'how to expand students' knowledge' in teaching the science topic. Prior to teaching the unit, she noticed the differences between her students and mainstream children in terms of their general store of knowledge and experience in science. She explained this with the concept of 'equity': urban children often did not have same 'science-related cultural experiences' within their routine life, owing to the economic status and sociocultural conditions stemming from their immigrant status. Many of Emily's students had little or no prior schooling experiences and thereby were lacking some science content knowledge as well as literacy and study skills. Under the circumstance, she tried to give her students more exposure and opportunities to explore what they wondered about the topic related to science. She finally put her plan of 'scientific inquiry' into action as a way to enrich children's learning about science knowledge and skills, through structuring science content using children's questions and answers about animals.

Even though we do not have cultural diversities in relation to race as in the U.S., we certainly do have various cultures and subcultures. Diverse cultures articulate across diverse subcommunities; they are never uniform or universally shared in their entirety among all or even most members; rather they constitute an organization of heterogeneity (Lemke, 2001). In urban educational settings, cultures are diversified depending on regions, which often reflect socio-economic status. Therefore, the 'equity' issue is often discussed in terms of how children's socio-economic backgrounds impact on their opportunity of acquiring important cultural learning experiences. A considerable number of studies in Korea indicate that there is a solid link between social class and educational success (e.g., Bang & Kim 2003; Cha, 2002; Lee, 1997). The results of these studies imply that urban students living in poverty might be in a disadvantageous position to begin their learning, compared to mainstream, middle-class children. Cummins (1986) argues that the nature and extent of students' previous educational experiences significantly impact their current and future academic performance. Seong (2003) points out that difference in home cultures cause serious educational gap among children's academic achievement. In this situation, teachers should be knowledgeable about children's needs and interests, particularly in connection with their own sociocultural backgrounds. Science teachers should acquire such knowledge by understanding science teaching in macro level and increasing knowledge about context of their specific educational settings. Such knowledge is expected to play a crucial role in developing teachers' PCK for teaching particular groups of students.

Second, Emily's PCK was developed to support children's inquiry learning by providing 'access' to community-based resources, which were closely related to their everyday life, but rarely used. As similar to the issue of equity, 'access' is also linked to prevailing negative social conditions, such as poverty, in urban areas. Emily reported a poor and stressful home environment as the primary cause of academic difficulty with some of her students.

As a matter of fact, Korean society currently undergoes 'polarization' in various aspects of everyday life. In the field of education, such phenomenon particularly appears between different socio-economic groups and communities. Since numerous learning aids and institutions have been overflowing on a national basis (Oh, 2000; Won, 2001), it is not overstated that educational success probably depended on how to gain access to the learning resources. And those resources are more utilized by students in cities, with high school records, with large income earners, with many educational careers parents, in elementary schools (Won, 2001). If so, children from high poverty areas might not have the same access to learn science like those living in plenty. It finally would exacerbate the gap between the children from middle or upper middle class and the children from low socio-economic class, in school achievement.

In such a situation, the 'access' to diverse resources available in the community should be established for socioeconomically stressed students in our society. Social environment of learning is particularly important in science learning. Learning only makes sense within the context of participating in the ongoing activities of a particular community of practice. Therefore, by making connections between knowledge about students' needs and resource availability, teachers should develop PCK toward helping children to become major players in science practices of the community.

Third, Emily's PCK became robust as she practiced how to deal with different cultural values in her science teaching context and as she mediate the differences to promote children's science learning. As sociocultural constructivists argue, in teaching contexts in which teachers interact with socioculturally minority children, the issue of teaching is no longer focused on efficient teaching but on more fundamental questions of philosophy of science. Then, teachers might challenge the basic assumption of science with the question of 'How universal and objective is science?' (Sjoberg, 1997). In general, the term "scientific" is commonly used to denote a sphere of human activity characterized by special qualities: rationality, precision, formality, detachment and objectivity (Lee, 2002). This view is broadly held in society at large, in schools, and by most scientists. However, science is not culture-free because it contains particular cultural values and norms, mostly from Western society as previously mentioned. In terms of the issue of 'power,' such a fact poses problems for many learners. In particular, it causes a significant problem to non-mainstream students because those students are required to accommodate main values ignoring their own experiences as well as ways of knowing. The norms and values of science learning advocated by mainstream culture and community may be incompatible with those of non-mainstream students. Science educators must take it to heart. In particular, teacher, the first-line reform agent, should have knowledge about children's different ways of knowing by understanding their everyday life context and sociocultural backgrounds. Playing with such knowledge in developing PCK, teachers can eventually make suitable decisions of what to teach and how to support their understanding in science.

Science should be taught in ways that are locally appropriate and culturally sensitive. The findings of the study suggest that science instruction can be more feasible to meet demands of particular groups of students if teachers make an effort to be knowledgeable about their own teaching context and utilize it in developing PCK.

VI. ABSTRACT

The purpose of this study was to explore how an elementary school teacher developed PCK by utilizing her knowledge domains in teaching practice, regarding the specific science topic of 'animals.' A case study approach was adopted with the participation of a 1st grade teacher, in a poor urban neighborhood elementary school in NYC. Data was collected through interview and the participant observation method in order to investigate: a) the teacher's existing knowledge base in terms of subject matter knowledge, pedagogical knowledge and contextual knowledge; b) how she develops PCK during classroom practice, centering on the relation-

ship between knowledge domains. The findings illustrate the ways in which the three knowledge domains are closely related and developed as PCK through the whole teaching process. In particular, the findings indicate that the teacher's contextual knowledge plays a critical role in shaping and developing PCK. Before instruction, her contextual knowledge regarding the administrative policies and the school test system in the district enabled her to make decisions and plans about teaching science. During classroom teaching, her knowledge of students' sociocultural backgrounds and living conditions in the urban setting helped her to identify specific teaching strategies and resources suitable to the students' needs and interests. The study results imply that science instruction can be more feasible in meeting the demands of particular groups of students if teachers make an effort to become knowledgeable about their own teaching context and utilize it in developing their PCK.

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