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Using Facets of Effective Science Learning Environments to Examine Preservice Elementary Teachers' Observations of Their Clinical Experiences in Korea and the U.S.

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Abstract: This study examined the science learning environments experienced by Korean and U.S. preservice elementary science teachers during their 3-week clinical experience. Observational experiences of 97 Korean and 112 U.S preservice teachers were surveyed with an instrument that we developed for the study. Follow-up interviews provided a clearer picture of what preservice teachers observed and experienced in science classrooms during their clinical experiences. Korean preservice teachers experienced a variety of science teaching environments, whereas the U.S. preservice teachers reported limited opportunities to observe science teaching and learning in terms of 6 identified facets that we posed. Along with our interpretation of the contrast in findings, some of the challenges are discussed in providing preservice teachers with opportunities to observe, experience, and teach in effective science learning environments during the clinical experience.

Key words: preservice elementary teacher, effective science learning environments, clinical experience

I. Introduction

Facets are categories and ideas of knowledge and experience expressed by students and teachers in the classroom or other educational settings. Examining the science learning environments (SLE) of elementary science classrooms in two different countries reveals varying facets of the SLEs that are often rooted in socioeconomic status (Keeves, 1992; Kotte, 1992). Conceptually, international research accepts and applies the psychosocial characteristic of the learning environment at all levels of schooling as a good predictor of student learning outcomes (Fraser, 1989; Fraser & Walberg, 1991; MacAuley, 1990). In the literature, the science learning environment is considered as a significant factor of students' science achievement (Young, 1994a; 1994b). Although preservice teachers' field experience may or may not be directly related to or the cause of any factors that influence a country's achievement scores of students, it still remains as an important factor that explains the current status of a science teacher preparation program.

This study surveyed 97 Korean and 112 U.S. preservice elementary teachers to identify differences in science learning environments and how they influence teachers' teaching perceptions. The context of this study was a pre-student-teaching field experience that usually takes place for one semester prior to a semester long student teaching experience. A survey was conducted, followed by a focus group interview to provide further understanding of the prospective teachers' perceptions about science learning environments. The survey was developed for this study to better determine the quality of clinical experiences we were providing our preservice teachers, specifically, in terms of observing science teaching and learning. The term "clinical experience" used in the study is one of the field experiences required in teacher education programs in which preservice teachers are placed in the classroom to learn about teaching routines, managing classrooms, and school administrative processes (see the following section for more details). Each institution may use a different term for the same purposes as 'student practicum,' 'pre-teaching

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experience,' 'pre-student teaching experience,' etc. We were seeking to determine how well clinical experiences in our elementary teacher education programs were supporting the program goals of science education. The premise of this study is as follows: (a) The preservice teachers' clinical experiences, perceptions and interpretation of the science learning environment may well represent varying facets of science education as it is taught in different countries. This study focused on the science learning environment as one dimension of the effectiveness of clinical experiences through perceptions and interpretations of preservice elementary teachers placed in the school settings. On the other hand, (b) from an epistemological and constructivist point of view, how preservice teachers perceive or interpret a science learning environment in the classroom depends on their background knowledge and experiences. This study is based on what preservice teachers perceive and interpret about the learning environment during their clinical experience. Their perceptions and interpretations may reflect the knowledge and experiences from their teacher education programs.

Six facets of the science learning environment as described by Tytler, Sharpley, and Tsiastias (2001) were examined: (F1) encouraging active engagement with ideas and evidence, (F2) challenging students to develop meaningful understanding by catering to students' individual learning needs and preferences, (F3) linking students' lives and interests to the broader community, (F4) assessing the science learning strategy, (F5) representing science in many areas, and (F6) exploiting learning technologies. These six facets were originally derived by Tytler, Sharpley, and Tsiastias' review of 30 years of relevant literature about characteristics of effective science learning environments

This comparative study of elementary science classrooms chose Korea for two main reasons: 1) while Korean schools and culture are considerably different from U. S. schools, something may be learned from comparisons with Korea where elementary students have consistently scored top rankings in science among the OECD countries according to international studies i.e., PISA (OECD, 2005) and TIMSS (Beaton *et. al*., 1996; Martin *et al*., 2000); 2) Korea has a national curriculum that focuses on development of in-depth scientific knowledge rather than locally determined curriculum that focuses more on the breadth of scientific knowledge more typical of science curriculum in the United States (Schmidt *et al*., 1996). These differences have been noticed by many, and draw attention from the world (e.g., Obama, 2009; John, 2010), and yet little has been known about Korean teacher education programs including preservice teachers' clinical experience. Therefore, the purpose of this study was to compare the Korean teacher education clinical experience program with the U.S. in order to better understand how preservice elementary teachers are interpreting the science learning environments they experienced during their clinical by using the above 6 facets.

Ⅱ. Effective Science Learning Environments

Ideally, clinical experiences are intended to demonstrate contemporary, standards-based science teaching, which means that preservice teachers should be placed in clinical locations in which they observe an effective science learning environment (SLE) since science learning environmental factors influence students' achievement in science (Nolen, 2003; CSC, 1987). Although science learning environments have been studied extensively for more than 30 years, consensus on a definition of an "effective" environment still appears to be lacking (Bliss, *et al*., 1996; Fraser, 1994; Guzzetti *et al*., 1993; Hanrahan, 1998; Penick & Bonnstetter, 1993; Smith *et al*., 1993; White, 1993). Nonetheless, effective science learning environments are important to teacher preparation programs. A number of researchers have attempted to describe effective science teaching and learning environments (Brunkhorst, 1992; Duschl & Waxman, 1991; Tobin and Fraser, 1990; Tytler *et al*., 2001), but the goals and descriptions of the studies showed a lack of acceptable alignment with the goals of clinical experiences. The review of 30 years of SLE research revealed a variety of definitions and approaches of effective science learning environments (Bransford *et al*., 2000; Enger & Yager, 2001; Fraser *et al*., 1982; Taylor & Fraser, 1991; Taylor, Fraser, & Fisher, 1997). More recent research has focused on connecting learning goals and learning theories with effective science learning environments. According to Bransford *et al*. (2000), learning environment changes depending on the goals of learning. The goal of science education, recently developed nationally and internationally, pinpoints 'scientific literacy' and 'science for all' as a reform engine. As a practical and effective model, Enger and Yager (2001) suggested that the learning environment to cultivate scientific literacy include environments that promote scientific inquiry, conceptual understanding, application of concepts to students' lives, and understanding the nature of science. These ideas embrace contemporary reformative ideas including a theory of learning and a set of instructional approaches. On the other hand, Fraser *et al*. (1982) studied the learning environment from a social constructivist view, and Taylor and Fraser (1991) developed an instrument, the Constructivist Learning Environment Survey (CLES), which assesses the learning environments using four scales of personal relevancy, scientific uncertainty, shared control, and student negotiation. Later, CLES was redesigned to include cultural aspects of the environment (Taylor *et al*., 1997). In brief, SLE has been studied to meet the following reformative ideas: (a) reforms of science education (AAAS, 2003; NRC, 1996; Osborne, 2003), (b) theories of understanding (Bransford *et al*., 2000), (c) inquiry teaching and assessment (Atkin & Coffey, 2003; Lederman, 1998), and (d) the constructivist learning environment (Fraser, 1998).

Though the six facets of our study reflect what was suggested in the SLE literature, what was not explicitly expressed was the community involvement of students' learning in terms of the goals of clinical experience for future teachers. Our literature review suggests that a generally accepted model of an effective SLE is a learner-centered learning environment that engages students in inquiry-based investigation, in which science teaching and learning is guided by a theory of constructivism. Inquiry-based instruction has been accepted as a methodology to achieve various reforms in science education, including an increase of positive attitudes towards science, content acquisition, process skills, creativity, application ability, and the knowledge of the nature of science (Minner et al., 2010; NRC, 1996). This model bridges our understanding of how students learn science in a meaningful way (Bransford *et al*., 2000). An effective SLE typically offers scientific investigations for students to learn science as what scientists do. In other words, students start investigations to construct conceptual understanding by analyzing patterns in experimental data. Students then develop multiple explanations using hypothetico-deductive reasoning that proves their constructed ideas of predictions (Lawson, 2002). If the results do not match the ideas, they revise their ideas or reconsider the methods used to gather data In an effective science learning environment, students are actively engaged in interactions with peers, in discussing observations, and developing explanations based on evidence, reaching a consensus through constructive discussions and communications (Karelina & Etkina, 2007). A number of national-level reports lend research-based support to the idea of quality science instruction in which students should have opportunities and experiences of inquiry including generating research questions, designing investigations, gathering and analyzing data, proposing explanations and interpretations to answer the research questions, and debating and communicating them (Duschl *et al*., 2007; NRC, 1996; NRC, 2005).

Although some of the descriptions are implicit at best rather than explicit, research has produced six facets of effective science teaching and learning. These, in turn, have been validated by additional research (Tytler *et al*., 2001). For this study, we use the six facets as described in the "Introduction" section of this paper to define the effective science learning environment. In effect, the success of a program might be inferred as a function of some set of these six facets.

Ⅲ. Context of the Clinical Experience Program

Since the term 'clinical experience' might not be used universally across the nations and the countries, this study operationally defined it as a field experience of preservice teachers who are attending a methodology course, which is required during their teacher education program. In this section, we more clearly describe the expectations of the clinical experience and align these expectations with six facets of effective learning environments. Preservice teachers who are in the clinical experience would basically be offered opportunities to practice school-related work including teaching, participation in extra curricula activities, building relationships with the community, and management of classrooms as well as administrative responsibilities in an assigned school so that they gradually build up their confidence in carrying out teaching-related responsibilities. During the clinical experience, preservice teachers are encouraged to actively engage in school activities with the expressed ideas and initiatives that help to manage teaching and classroom management (F1). They are also challenged to develop skills and lived knowledge through multiple interactions with a diverse population of students to find out individual learners' needs and interests (F2). During the clinical experience, preservice teachers are required to do a project of school improvement by linking students' lives and interests to the broader community which usually involves school staff members and community people (F3). They are also asked to assess the science learning strategy used in science lessons (F4), and blending and science into other subject areas and everyday life events (F5). Preservice teachers in the clinical experience are required to heavily use learning technologies in teaching science (F6). The above described six facets represent what the Korean and U.S. teacher education institutions, in this study, share as purposes of their clinical experiences. The intent of the clinical experience is to provide opportunity for preservice teachers to increase their sense of confidence to perform as effective teachers and to develop effective learning environments.

Korean preservice teachers in the elementary education program (1) have a 3-week long experience for their clinical called Comprehensive Clinical Experience (CCE) in which preservice teachers' practice teaching and administration skills. (2) During the CCE, preservice teachers are required to plan and teach at least one science lesson and to work with teachers all day. The majority of the preservice teachers are placed at schools near the university, which is homogeneous in socioeconomic status and ethnicity. (3) Each student's placement in classrooms is made by collaboration among three parties including the university, supervisor in each school district, and school principals. (4) In Korea, this particular 3-week long CCE occurs in their senior years. (5) Every day, preservice teachers are required to write a reflection about things including content taught, relationship between what was observed in classrooms and was taught in university courses, discussions about everything with cooperating teachers, classroom managements, teaching reflections, etc. In the U.S., on the other hand, the elementary teacher education program in this study currently requires a senior year 'clinical experience' during the semester prior to 'student teaching' that generally takes out an entire semester. The clinical experience is (1) an intensive 3-week pull-out experience in which preservice teachers are assigned to various classrooms within commuting distance of the campus. (2) During the clinical experience, preservice teachers work with teachers in classrooms all day and are expected to prepare and teach at least one science lesson. (3) During the clinical experience, preservice teachers write a reflection about their teaching, classroom management, and issues and concerns that they face. (4) When the preservice teachers return to their university class after the clinical experience, they reflect and discuss about the issues and concerns that they faced in the classrooms. The classrooms for these clinical placements are determined by collaboration between the Teacher Education Center and school principals.

Research Questions

Within the above described context, the following research questions guided this study:

Research Question 1: How effective, as measured by the six facets, is the science learning environment as experienced in the preservice elementary teachers' clinical experience program in Korea and the U.S.?

Research Question 2: What kinds of science teaching and learning practices, as defined by the six facets, did preservice teachers observe during their clinical experiences in Korea and the U.S.?

Little information has been reported as to how preservice teachers perceive effective science learning environments during their clinical experiences. To better understand how our students are interpreting the science learning environments they experience during their clinical, we developed a new survey to gather information from preservice students. The results of the survey might inform our clinical programs and perhaps be used by other institutions to better understand the science learning environments their preservice teachers are experiencing during their clinical. Thus, this group was tainted with science classroom environments in one way or the other. It is not intact group.

Ⅳ. Methodology

The study was designed using a deductive method in which optimized indicator six facets of science learning environments (SLE) were determined after exploitation and investigation of related literature. Once the six facets were determined and explicitly described, the experiences of clinical interns (preservice teachers) over three weeks were investigated and analyzed in terms of the six facets. This method of study is expected to provide the desirable goals of teacher education program aligned with a number of relevant contemporary learning theories especially in SLE, which may well be suitable for assessing the clinical experiences that preservice teachers have in schools. The study was conducted with a mixed-method approach where both quantitative (pre- and post- data collection of surveys) and qualitative (semi-structured focus group interviews) methodologies were used to enhance the consistency of the findings and internal validity of the study (Greene *et al.*, 1989).

1. Sample

A group of 97 Korean (89 females) and 112 U.S.

teacher candidates (104 females) participated in the study. This was a nonrandom convenient sample because they are willing and available to partake in the study (Cohen *et al.*, 2007). Both groups of participants were enrolled in the science methods course on their senior year block that included the 3-week field experience in their senior year as described above. There was no one who had a pre-teaching experience before in both groups although U.S group of participants were exposed to classroom environments including science class in which they were required to have 100 hours of classroom observations in their first year of the program whereas Korean group has 1 week of classroom observations.

2. Development of Survey Instrument

The study utilized the framework described by Tytler *et al.* (2001) for the definition of an effective science learning environment. Due to lack of literature in this field, we developed additional survey questions to specifically investigate what preservice teachers observed regarding the elementary science learning environment.

3. Pilot test and Reliability

The instrument was pilot tested with 107 U.S. preservice teachers (102 females) in order to establish the reliability of the survey. The participants were in the same block senior year in elementary teacher education program in Midwest region of the U.S. The Cronbach's Alpha for the reliability of the pilot survey was 0.89. After the pilot test, some items were rephrased and changed slightly to make it fit into the context of the sample of this study. The reliability of the instrument for the administration after the field experience was 0.98.

The survey questionnaire consisted of 18 statements related to the six facets of effective science learning environments and an additional question about the number of times science lessons were observed (Appendix A). Using a Likert-scale, each statement required one of five different responses: strongly agree (1 point), agree (2 points), neither agree nor disagree (3 points), moderately disagree (4 points), strongly disagree (5 points). Table 1 presents six facets and the statements that relate to each facet.

4. Data Collection and Analysis

1) Survey: The survey data were gathered by administering the survey to the participants after their 3-week long field experience in both institutions that have coincidently the same time length of 3 weeks. For Korean preservice

Table 1

Characteristics of the physics test for eleventh graders

Category Statement Number	
F1. Encouraging active engagement with ideas and evidence	1, 2, 3, 4.
F2. Challenging students to develop meaningful understanding by catering students' individual learning needs and preferences	5, 6, 7, 9
F3. Linking students' lives and interests and the broader community	8, 15
F4. Assessing the science learning strategy	10, 11
F5. Representing science in many areas	12, 13, 14
F6. Exploiting learning technologies	16, 17, 18

teachers, the survey was translated into Korean and proofread by one science educator and one Ph.D. candidate in English who are all native speakers. Two groups in two countries were placed into schools in the different time period due to their own clinical time schedule. However, the survey was administered in the same year. The survey data were analyzed with t-test to compare the means of each facet and tested at the level of 0.01 for any statistical significance. To find out whether the teacher candidates' answers were skewed or not, the distribution of each facet was analyzed using a statistical skewedness, which is typically important in find out their clear answers in a Likert scale investigation.

2) Interview: After the post survey was completed, volunteers of 4 U.S. and 3 Korean preservice teachers were chosen for a semi-structured interview for their insights and in-depth stories of experience about each item of the survey. Interviews were conducted in a focus group in Korea and individually in the U.S. The interview data were all transcribed in which Korean interview data were transcribed into Korean first and then into English later, which provided details as to their perceptions and interpretations of clinical experience. Interview data were analyzed to find out whether teacher candidates comments, as a group, aligned to a theme that emerged from their answers to 'facet-embedded interview questions' developed out of the survey items in each facet, using constant comparative methodology (Glaser & Strauss, 1967, pp. 28-52). Once we found themes or patterns, we asked two science educators to check if there were any discrepancies or biases between our findings of patterns and the original interview scripts thus minimizing potential discrepancies and biases (Erickson, 1986).

5. Our assumption and limitations

Due to being conducted in different countries with different science curricula and sociocultural differences, some assumptions and limitations were necessary in this study. First of all, in contrasting the science curriculums in the two countries that participating preservice teachers experienced during this study, we assumed that the science curriculums were different, as were the teacher knowledge defined as the content knowledge, pedagogical content knowledge, and pedagogical knowledge (Carlsen, 1999; Shulman, 1987). While the specific science content being taught by the teachers during clinicals would vary, the researchers, both in Korea and the US, did expect that the preservice teachers would have the opportunity to observe exemplary science teaching practices during their teaching practicum. Second, due to a different curriculum and different placement of the preservice teachers within and between the two countries, we could not control for the specific science content nor could we ensure that all the teachers our preservice teachers would be observing would be exemplary science teachers. Therefore, this study was descriptive in nature to determine what facets of effective science learning environments were experienced by the preservice teachers in each country. Third, we used nonrandom convenience sampling for both surveys and interviews, as the preservice students were close at hand, willing, and available to participate in the study (Cohen et al., 2007). Therefore, because of non-systematic sampling methodology, we assumed that there might be a difference of sampling error that might impact the result of study.

V. Results

Of the 112 U. S. participants, only 57% (64) had a chance to observe science lessons taught by the cooperating teachers. The rest of 43% participants never had a chance to observe any science lessons during their entire 3-week clinical experience. On the other hand, all of the Korean preservice teachers (100%) had a chance to observe science lessons, 3.8 times on average, during their three week field experience. Table 2 shows the number of preservice teachers who observed and those who did not observe science lessons being taught while they were in science classrooms.

1. Results of Survey

Table 3 shows the preservice teachers' average response scores, organized by the six facets (F1–F6) of an effective science learning environment on a scale of 1 being strongly agree to 5 being strongly disagree. For the Korean group, the means of the points in three facets ranged from 3.01 to 3.03 while the other three facets were under 3.00. These means revealed that the preservice teachers answered toward an "agree" response to most questions. In addition to the skewed distribution of facets F1 and F3, the data demonstrated a fairly strong "peaked" distribution at the center, specifically in facet F6, by having a positive skew (0.13, left-skewed) and a positive Kurtosis (1.32) that presents more of an "agree" dominant response. On the other hand, for the U.S. group, the means of the points in all six facets were above 3, ranging from 3.09 to 3.82. The means indicate that most of the preservice teachers answered toward "disagree" to each question. All six facets were negatively skewed (right skewed, long left tail) with a negative Kurtosis in distribution. Especially facets F2, F3, F4, and F6 had a fairly strong fatter tail on the left in the distribution. In other words, the U.S. preservice teachers' responses tended toward more "disagree" dominant responses rather than the "agree" responses.

Regarding F1, F2, and F4, there was no statistically significant difference between U.S. and Korean preservice teachers (see Table 3). However, on three facets, F3, F5, and F6,

Table 2

Number of Preservice Teachers who Observed Science Lessons

Type	Science Lessons				Total (%)	
	Observed – N*(%)		Never Observed – N* (%)			
	Korea	U.S.A.	Korea	U.S.A.	Korea	U.S.A.
Preservice Teachers	97 (100)	64 (57.14)	0(0)	48 (42.86)	97 (100)	112 (100)

**N is the number of preservice teachers who observed at least one science lesson.*

Table 3

Korean (N=97) and U.S. (N=64) Preservice Teachers' Science Teaching Observation Responses

Facets	Mean[a]		Std. Deviation		*t (p–value) (2–tailed)*
	Korea	U.S.	Korea	U.S.	
F1	2.95	3.09	0.65	1.14	–.86 (.342)
F2	3.01	3.21	0.64	1.14	–1.48 (.142)
F3	2.92	3.51	0.69	1.17	–3.56 (.000)*
F4	3.02	3.33	0.77	1.30	–1.88 (.062)
F5	3.03	3.46	0.70	1.09	–2.77 (.007)*
F6	2.79	3.82	0.63	1.07	–6.88 (.000)*

[a] 1 (Strongly Agree) ––– 5 (Strongly Disagree)

* $p < .01$

preservice teachers in both countries demonstrated a significant difference in regard to what they experienced in the science learning environment during their practicum. More than half of the U.S. preservice teachers rated low in F3 (e.g., 52.31% disagree), in F5 (e.g., 55.21% disagree), and in F6 (e.g., 63% disagree), meaning that they had few opportunities to observe classes in which students' interests and curiosities were related to the larger community or in which technology was being used to advance science learning. However, Korean preservice teachers responded with a low rate of disagree 30.93% in F3, 36.43% in F5, and 22.68% in F6, meaning that they frequently observed science classes in which students' interests were taken into consideration in linking science learning to the broader community and in which learning technologies were being used.

Overall, these results reflect that U.S. science classrooms, observed by the preservice elementary teachers, showed little evidence of effective science learning environments during their clinical experience. Seldom did they see teachers encouraging active student engagement with ideas and evidence leading to meaningful understanding, nor did they see teachers capitalizing on students' interests or learning technologies to make science more relevant for the students. On the other hand, preservice teachers in Korea were having a chance to observe all of the six facets of science teaching that reflect effective science learning environments to some extent. A specifically interesting finding is that Korean preservice teachers were perceived as not challenged to develop meaningful understanding of the concept that they learned in class and were not often considering individual learning needs and preferences (F2). One Korean preservice teacher from a follow-up interview reported that, "Children were challenged with divergent and higher order thinking questions in classes that I have observed. But the children' answers were all very much similar because they copied them from a reference book that they all possessed as a so-called 'Answer Textbook', which is a commercial one." Korean children had a hard time in developing higher order and divergent thinking skills because they were interested in the 'right answer' rather than their own ideas and reasoning. Instead, they tend to look in the answer textbook.

2. Results of Interview

The follow-up interviews revealed that many of the science lessons the prospective teachers observed were being taught as confirmatory or verification science. One U.S. preservice teacher who observed in a second grade classroom reported as follows (F1):

> The little science instruction I observed was very teacher directed, with little personal involvement by the students. Typically, the teacher provided about ten minutes of instruction followed by an opportunity for students to agree or disagree with statements about the topic before completing a worksheet.

Perhaps the worst case was the student whose cooperating teacher informed her that she was burned out and didn't even like the students in her class. Most of the time in this classroom was spent on discipline, with no commitment to teaching science. The student referred to this classroom as "unmanaged and dysfunctional." On the other hand, two Korean preservice teachers reported that teachers often encouraged children to express their ideas about science in most classes (F1).

> Teachers that I observed encouraged kids to ask questions all the time. These teachers started a lesson naturally by asking kids' experience and stories from their daily life and moved next to the unit of the day. Kids were freely talking their ideas. Some of the high achievers asked a lot about what they saw on

> internet and newspapers. But others just focused on the unit of the day.
> …. Two units that I have observed were 'Function of a Tree Leaf" and 'Travel of Water.' Teachers asked kids to connect their experience about water and phenomena, cloud types and characteristics, and why clouds became dark and how it rains, which stimulated kids' curiosity.

However, one Korean preservice teacher reported the opposite case. "I witnessed one case that a student asked a question in the middle of class, "What percentage of nitrogen is in the air?" The teacher replied with no answer. Instead, she said "Be quiet!" Later the child reluctantly continued asking. This type of thing happens once in a while." Although this type of teacher's attitude occurred rarely, this may be part of teaching practice that Korean preservice teachers experienced as a barrier to their training to make a better science learning environment for their future classroom.

Interviews indicated that Korean students in science classes were taught to develop meaningful understanding (F2) as follows:

> The other day, I observed a class that was doing an experiment that produced dew. A beaker with hot water inside was covered with a sheet of aluminum foil. A piece of ice was put on the foil. Kids watched when a couple of dew droplets were produced underneath the foil. They were so excited and thought it was mysterious. They automatically began to think why it happened based on their observations.
> … Most teachers that I have observed used wait time and encouraged kids to develop their explanations even if their answers were out of context.

Korean preservice teachers observed that elementary students were challenged to develop deep understanding of major science ideas through hands-on activities, i.e., making a dew droplet as shown in the above interview. Also, teachers were sensitive to students' varying abilities, learning needs and preferences by allowing students to explain their ideas even if they were out of focus.

Preservice elementary science teachers had a chance to observe 'Representing science in many areas' in Korean science lessons as follows (F5):

> Students were very active about investigative processes including making hypotheses through discussions and including the opinions of each member in group, designing, and discussing about the experimental result.
> … I often observed
> that teachers taught with inquiry process.
> … Some students were excellent in presenting their scientific knowledge. So science class promoted a higher level of scientific knowledge that kids should know. But the class often ended up with teaching scientific concepts, not developing into job-related professions.

Although the Korean science learning environment seemingly reflected the investigative processes of science, the lessons did not often continue to address science, industry, and science-related professions. While Korean preservice teachers had a chance to witness that their cooperating teachers were making the science environment more amenable and safe for children to freely express their ideas, U.S. preservice teachers reported differently. Confirmatory scientific content knowledge in science classes might hinder children to further inquire about that in which they are interested or curious. One preservice teacher in a sixth grade classroom reported as follows, which showed this hindrance (F5):

The teacher used a lot of open-ended questions and paid attention to students' interest, but there was no inquiry focus and everything was presented as verification science, focusing entirely on the content goals.

Exploiting learning technologies was highly reflected in the Korean science learning environment (F6).

> Internet and multimedia technologies for science class were frequently used. ... Teachers used a variety of technologies, not just doing an experiment. For instance, they showed a video clip related to the concept and used information technologies. I have seen that kids loved multimedia technology.
> … Many classes that I have observed were doing an experiment using different equipment. I liked the discussions about the result that were done in a cooperative learning group. However, I saw some kids just sitting there not participating in a discussion and copied the results from their peers in the group.

Overall, Korean preservice teachers experienced a variety of science learning environments, some were not so desirable. The areas that need to be improved should be the focus of a future study. Yet, we are certain that these types of clinical opportunities provide our future Korean teachers with a great deal of information about how to improve the science learning environment and how to deal with classroom management issues in their future classrooms. Clearly, both Korean and US science learning environments, at least those observed by our preservice teachers, have considerable room for growth and improvement to better serve as models for our preservice teachers.

Ⅵ. Discussion and Implications

Observation Opportunity of Science Learning Environment: The results of the study revealed that the 64 U.S. elementary classrooms that served as clinical settings for U.S. preservice teachers rarely modeled effective science learning environments. But forty-eight preservice teachers did not observe science at all. In other words, the current system of field experience with this particular U.S. sample group did not seem to be working well. We believe this is, in part, because the choice of field experience partners is a random process of asking school districts if they have teachers willing to supervise a brief field experience. Usually, placement for the field experience follows some guide lines from the state. For instance, preservice teachers should experience diverse learners in school settings. Unfortunately, this often means the placements are in schools with low financial means, low scoring schools in which no science program is offered until the 3rd grade or science teaching takes third place in importance behind reading and math. On the other hand, while 100% of Korean preservice teachers were given an opportunity to observe science teaching 3.8 times on average, this leaves considerable room for improvement. Seeing science taught less than 4 times during a 3-4 week clinical is still not a good model for preservice teachers. Unlike the U.S. elementary curriculum operation, Korean teachers are mandated by policy to teach science 3 periods (40 min per period) weekly (Korean Ministry of Education, Science and Technology, 2007). Thus Korean preservice teachers were able to observe their cooperating teachers' science teachings on a weekly basis during their clinical. In addition, with a national curriculum, Korean schools consistently teach science. In contrast, the U.S. elementary schools do not teach science as frequently as Korean teachers do. The U.S.-based teacher education program for this study clearly indicated that all the preservice teachers ought to teach a minimum of one lesson in each of the subject areas including science, social science, and language arts during the 3-week long clinical period. However, the survey results revealed that about half of U.S. preservice teachers did not have an opportunity to observe their teachers' science teaching during the entire clinical period. The reason is, in part, that school science teachers tend not to teach science due to a lack of resources and science background (Moore & Watson, 1999). In addition, the No Child Left Behind Act has significantly impacted the instructional time of science. A national survey reported that elementary schools spent more time, weekly, on mathematics and language arts than on science (CEP, 2007). The information we learned from this difference between the two countries implies that preservice teachers' opportunities to observe an effective science learning environment (SLE) may depend on the existence and implementation of effective education policy.

The U.S. preservice teachers' field experience program described here has many difficulties. More than a dozen school districts participate in the program and preservice teacher placement is often in the hands of district personnel who may, or may not, share our teacher education goals. Sometimes the sheer number of preservice teachers in the program makes the quality of the placement less important than finding the placement. There is no single process in place to improve the current program, however, there are some alternative clinical experiences now being field tested, in hopes of providing improved science learning environments for teacher candidates.

Quality of Observation in Six Facets: Given the fact that there was a significant difference of preservice teachers' clinical experience between Korea and the U.S., the six facets of SLE helped us to better understand what types of experience they had. A comparison of F3, F5, and F6 between the two countries showed a significant difference about the effective science learning environments while F1, F2, and F4 showed no significant difference. The U.S. and Korean preservice teachers witnessed that the elementary science learning environment was actively engaging students with ideas and evidence (F1), challenging students to develop deep understanding (F2), and assessing science learning strategies (F4). Indeed, we noticed that one thing in common among F1, F2, and F4 was the characteristics of science teaching and learning which came from the concerted efforts to implement the reform documents at a state and national level, that is, "scientific inquiry ability and skills" (NRC, 1996). However, a significant difference was found with regard to F3, F5, and F6. Regarding Facet 3 linking students' lives and interests and the broader community, the U.S preservice teachers experienced very little of it while Korean preservice teachers had ample opportunities to experience about F3. This same pattern applied to both F5 Representing science in many areas and F6 Exploiting learning technologies. In other words, Korean preservice teachers agreed that they experienced Facet 5 and Facet 6 in the classrooms while the majority of U.S preservice teachers experienced significantly less of it during the clinical period. The reason may be that U.S. teachers often taught "verification science, focusing entirely on the content goals" (see interview quotes) rather than expending the science knowledge in other areas. Regarding use of learning technologies (F6), Korean preservice teachers observed their teachers using technologies frequently as stated in interview, "Internet and multimedia technologies for science class were frequently used. ... Teachers used a variety of technologies, not just doing an experiment" whereas the U.S preservice teachers did not have many opportunities to observe its use in science classes. The U.S. teacher education program emphasizes the use of learning technologies in teaching science and mathematics to meet the needs of students and a fast-changing society (ISBE, 2008; NETS, 2008). For example, "Explain how technology is used in science for a variety of purpose (13.B.2a) … Analyze challenges created by international competition for increases in scientific knowledge and technological capabilities (13..B. 5a) … Describe how occupations use scientific and technological knowledge and skills (13.B.3c)" (ISBE, 2008). In addition, many states adopted the recommendations of National Educational Technology Standards including an example, "Develop technology-enriched learning environments that enable all students to pursue their individual curiosities and become active participants in setting their own educational goals, managing their own learning, and assessing their own progress" (NETS, 2008, p.1). Even though U.S. programs and standards recommend use of technology in science teaching and learning, it seems U.S. teachers often teach no science in elementary schools and seldom use technology when teaching it, whereas Korean teachers are mandated to teach as the national curriculum recommends.

After examining our data it is obvious to us that the current U.S. on-campus system is not working to provide preservice teachers with models of effective science teaching and learning. Indeed, the data suggest that preservice teachers enrolled in this program may experience a lower-quality experience compared to preservice teachers in Korean teacher education programs. The task now becomes: How do we provide a quality experience for all preservice teachers enrolled in one of the largest elementary teacher education programs in the country? How do Korean schools of education better prepare their teachers to promote divergent and higher order thinking skills and problem solving? The answer will require more resources, further study, and perhaps working more closely with some of our partnership schools. One alternative model would be the placement of two teacher candidates in each classroom during the clinical experience. This would require half the number of classrooms needed for the experience so that the quality of the teacher and an improved learning environment may begin to enter the equation. One argument we have heard against a two-preservice teachers-per-classroom model is that it provides less time during the clinical for each candidate to have direct experiences with children. We believe this argument confuses the purpose of the clinical experience. Many seem to believe the clinical experience is a "mini-student-teaching experience" or simply meeting some pre-student teaching hour requirement. We believe the clinical experience to be an opportunity to observe and implement ideas learned in the associated methods courses. If so, then we should provide, to the degree possible, a clinical experience in classrooms with teachers who share the educational philosophy espoused by the program. Our U.S. data indicate that the current system is not reflecting the philosophy of the teacher education program and we must work to improve this situation for both Korea and the U.S.

Since this study was conducted, some changes have already taken place in hopes of improving the clinical experience for our preservice teachers and discussions are taking place for additional changes in the future that may help to assure our students experience better science learning environments during their clinical placements. We would hope that other teacher education institutions might also use the survey developed for this student to inform and improve the clinical experiences within their teacher preparation programs.

Ⅶ. Concluding Remarks

Based on conversations with science teacher educators across the country, providing effective science-focused clinical experiences is a common challenge in teacher education programs. Some believe that the emphasis placed on reading and mathematics due to several years of the influence of NCLB (USDoE, 2002), has taken the focus away from science and technology, thus little time is spent on science instruction in the elementary classroom. This is not only a challenge to teacher education programs, but to the education of our future workforce. Though the results of this study do not represent or generalize the preservice teacher's field experience of a country due to a small sample size, perhaps this study will encourage other teacher education programs to focus on the science learning environments that their teacher candidates are experiencing during their teacher education programs. Such data may prompt closer collaboration between schools of education and their partnership schools, perhaps focusing on professional development in science teaching and learning. As measured by the six facets of SLE in this study, the U.S preservice teachers experienced less encouraging science learning environment by having the low number of observation opportunities than the Korean preservice teachers did. In addition, the U.S. preservice elementary teachers observed little evidence of effective science learning environments during their clinical experience: neither very often encouraged students' active engagement with ideas and evidence, nor linked students to develop meaningful understanding, nor catered to students' individual learning needs and preferences, nor linked science to students' lives and interests, and promoted students' learning technologies. On the other hand, the Korean preservice teachers had an opportunity of observing all of the six facets of science teaching that demonstrated effective science learning environments although some cases were not encouraging.

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Appendix A. Perceptions of the Science Learning Environment

Please Read: The following statements refer to your perceptions of the science learning environment experienced in your clinical/field settings. **The statements refer only to the science learning environment you observed, not to instances in which you taught.** Please indicate the degree to which you agree or disagree with each statement by filling in the appropriate circle.

Statement	Strongly Agree A	Moderately Agree B	Neither Agree or Disagree C	Moderately Disagree D	Strongly Disagree E
1. The learning environment encouraged students to express their ideas about science.	A	B	C	D	E
2. The learning environment encouraged students to question evidence and raise issues in relation to science topics/concepts.	A	B	C	D	E
3. The learning environment was influenced by student input (questions, ideas, expression of interest) during the course of science lessons.	A	B	C	D	E
4. The learning environment encouraged and supported students to take responsibility for the purpose, design and analysis of science investigations.	A	B	C	D	E
5. The learning environment encouraged students to develop deep understanding of major science ideas.	A	B	C	D	E
6. The learning sequences were structured to encourage students to extend ideas in science.	A	B	C	D	E
7. The learning environment challenged students to develop higher order and divergent thinking to respond to science questions.	A	B	C	D	E
8. Students' interests and concerns (hobbies, media) were reflected in the science learning context, and were regularly used in class to link to science ideas.	A	B	C	D	E
9. The science learning environment was sensitive to students' varying abilities, learning needs and preferences.	A	B	C	D	E

10. Learners were continuously diagnosed and monitored for understandings and perceptions, prior to and during a unit of work in science.	A	B	C	D	E
11. Different assessment tasks were used to reflect different aspects of science and types of understanding.	A	B	C	D	E
12. The learning environment reflected the investigative processes of science.	A	B	C	D	E
13. The learning environment reflected the interplay between science and social and personal issues.	A	B	C	D	E
14. The learning environment addressed science, industry, and science-related professions.	A	B	C	D	E
15. Projects were used to provide science links beyond the classroom (for example, special projects involving the school and/or local community, or science competitions)	A	B	C	D	E
16. Information and Communication Technologies were commonly used to teach science.	A	B	C	D	E
17. Information and Communication Technologies were commonly used to increase students' control over their science learning.	A	B	C	D	E
18. A variety of learning technologies were used in a manner that reflects their use by professional scientists.	A	B	C	D	E
19. Approximately how many science lessons did you observe being taught by a teacher?	NONE (A)	1-3 (B)	4-6 (C)	7-9 (D)	10+ (E)