Early childhood pre-service teachers' self-images of science teaching in constructivism science education courses

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Contents

Abstract

The purpose of this study is two-fold. First, it investigates the self-images of science teaching held by early childhood pre-service teachers who took constructivism early childhood science education courses. Second, it analyzes what aspects of those courses influenced these images. The participants were eight

pre-service teachers who took these courses during the spring semester of 2013 at universities in Korea and the United States. A Draw a Science Teacher Test Checklist (DASTT-C), questionnaires, individual interviews, researchers' field notes, and participants' documents were collected. The results showed that four participants who displayed teacher-centered images before taking the courses changed to child-centered images after the courses. The factors that influenced those images were changed perspectives of a teacher's role and experiences of constructivism-based science teaching for young children. The other four pre-service teachers who held child-centered images before the course solidified child-centered images after the course. The influences on those images were learner-centered learning experiences and experiences with constructivism-based science teaching for young children. This result implies that early childhood science education should provide opportunities for pre-service teachers to reconstruct their own views about science teaching in order to learn and teach based on constructivism.

Keywords: self-images of science teaching, DASTT-C, early childhood pre-service teachers, constructivism early childhood science education courses

Introduction

The field of science education puts the constructivist approach into practice. Current efforts to realize constructivism in science education have focused on many aspects such as the purpose of science education, theories and methods of teaching and learning, and processes and assessment of education (Cho & Go, 2006a; Luxton-Reilly, & Denny, 2010; Sadhana, Stylianous, & Goldstein, 2012; Yeung, Lee, & Lam, 2012). To realize changes toward constructivism in science education, teachers should develop their professionalism in teaching science-based constructivism, including beliefs about science teaching; learners' knowledge, processes, and strategies of science education; and their evaluation of science (Cho & Ko, 2008; Lee & Cho, 2010).

In particular, teachers' beliefs have received considerable attention because those beliefs are mental work that influences science teaching behaviors (Markic & Eilks, 2008). They also can be a foundation for developing teaching materials and methods as well as defining the roles of teachers and learners in science education (Cho & Go, 2006b; Sadhana et al., 2012; Thomas, Pederson, & Finson,

2001). Teachers' beliefs about science teaching have two perspectives: traditional and constructivist. Traditional beliefs toward science teaching emphasize teachers' active roles in delivering scientific information or facts to learners and students' passive roles in consuming the information. Constructivist beliefs place emphasis on learners' ability to construct scientific knowledge by themselves—along with a teacher's facilitation—while participating in the process of inquiry (Haney & McArthurs, 2002; Ogan-Bekiroglu & Akkoc, 2009; Woolley, Benjamin, & Woolley, 2004). In spite of the importance of constructing teachers' beliefs about constructivist science education, a body of research describes that in-service teachers have more traditional perspectives about science teaching than constructivist perspectives. The studies also reported that teacher education can change the teachers' beliefs toward constructivism, but it was difficult to alter their long-believed perspectives about science education that were developed through their teaching experiences (Lumpe, Czerniak, Haney, & Beltyukova, 2012; Go, 2005). Thus, teachers must build the beliefs of constructivist science education before they actually serve in a class. College courses about science education should provide opportunities to consider and reconstruct pre-service teachers' own beliefs about science teaching.

Current studies emphasize that science education courses can help pre-service teachers develop constructive beliefs (El-Deghaidy, 2006; Elmas, Demirodöğen, & Geban, 2011; Go, 2013; Kang et al., 2007; Koh & Choi, 2013; Ucar, 2012; You et al., 2010). They used activities such as drawing images and doing narrative writing about teaching science as means for exploring teachers' beliefs about science education (Thomas et al., 2001). Drawing enables many people to express their inner thoughts, which they often cannot do through written or narrative texts (Markic & Eilks, 2008). By using the images and narratives, these studies showed that pre-service teachers changed their beliefs about science teaching from traditional to constructivist views due to the influence of opportunities to watch and discuss videos of in-service teachers' lessons, to develop the lessons in their own ways, and to learn about constructivist theories of teaching. However, these studies focused mostly on elementary and secondary pre- or in-service teachers; little research has been conducted on early childhood pre-service teachers. Unlike secondary education, which focuses on academic subjects, early childhood education has long emphasized child-centered education based on play, having accepted constructivist education under the name of interactionism.

This difference in educational context would result in early childhood pre-service teachers having different images of science teaching than those held by elementary and secondary teachers. In addition, most of this research has focused on those who changed their images of science teaching from teacher-centered to child-centered; none of them investigated those who were child-centered before even taking courses nor did they examine what aspects of courses contributed to their solidifying those previous child-centered images. Moreover, teachers' beliefs about science education have been influenced not only by individual experiences and knowledge but also by sociocultural factors related to science or school curricula for science education (Markic & Eilks, 2008; Markic, Eilks, & Valanides, 2008). Even when titled as a science education course, course content and teaching methods depend on instructors (Koh & Choi, 2013). That is, course contexts could influence pre-service teachers' different perspectives of science teaching and learning.

Therefore, this study aims to examine how early childhood pre-service teachers who took science education courses changed or solidified their images of science teaching. Both reviewed courses were based on constructivist science education, but they showed differences in content and teaching methods. In one course, science was taught jointly with mathematics and technology. This course emphasized providing opportunities for pre-service teachers to be in actual kindergarten classes for observing the teachers' teaching science and having teaching experiences for young children. Another class addressed only the subject of science and placed emphasis on thinking critically about teachers' perspectives of science teaching, executing a team project about science, and performing and discussing a simulated lesson of science. The study about the two different course settings can help to suggest effective ways to improve the quality of programs for pre-service teachers so that they may develop constructivist views with regard to science education. Thus, the purpose of this study is two-fold. First, it investigates the images of early childhood pre-service teachers after they took early childhood science education courses based on constructivism. Second, it aims to determine the factors that influence the development of those images.

Methodology

Early Childhood Science Education Courses

The classes in the study were titled "Early Childhood Science Education (ECSE)" in Korea and "Math, Science, Technology in Early Childhood Education (MST in ECE)" in the United States. Both classes were aimed at promoting constructivist views of science teaching. Moreover, both classes included learning about theories of constructivism and experiences as a constructivist learner as well as a teacher. Table 1 shows the main content and types of instructional activities in the two courses.

Table 1. Contents and types of instructional activities

Course Content		Types	
ECSE	**MST in ECE**	**ECSE**	**MST in ECE**
1. Constructivism and constructivist science education		Lecture; Discussion; Journal writing	Discussion; Journal writing
• Experiences with science and science education and attitudes toward these • Perspectives on science and early childhood science education • Children's attitudes toward and concepts of science • Contents and methods of early childhood science education • Practice of science activities for young children	• Constructivism, inquiry for science • Perspectives on science and early childhood science education		
2. Curriculum		Lecture; Discussion	Lecture; Discussion
Scientific inquiry addressed in the Korean National Curriculum	National science curriculum standards and curriculum standards of the state of Illinois		
3. Science activities for pre-service teachers		Discussion; Presentation; Journal writing	Discussion; Performance; Presentation; Journal writing
• Selecting one subject per small group along with 4–5 sub-subjects • Planning, performing, and analyzing the chosen lessons	• Participation in science activities provided by the class instructor • Technologies by the outside instructor • Science activities prepared by groups of the pre-service teachers or		

	individually		
4. Planning, performing, and analyzing science activities for children			
• Analyzing examples of lessons performed in real classrooms (provided by an instructor) • Planning, performance of small-group activities for early childhood science activities (in simulated situations)	• Analysis of examples of lessons performed in real classrooms (provided by an instructor) • Planning, performance of small-group activities for early childhood science activities (STEM classes)	Discussion; Simulated instruction; Presentation; Journal writing	Discussion; Practice in the STEM class; Presentation; Journal writing

ECSE. The course "Early Childhood Science Education (ECSE)" met for 16 weeks for three hours per week (see Table 1). The focus of this course was to promote pre-service teachers' reflective thinking in various ways. First, the course included reviewing their own views of science teaching and eventually reestablishing constructivist perspectives. In doing so, the pre-service teachers kept journals about their views of science activities and learned about various examples of science activities based on constructivism. Second, the pre-service teachers conducted a team project of science throughout the semester. The teams were comprised of a group of five to six members, and the team planned a project to investigate a subject that they wanted to understand. Later, they performed an investigation and evaluated their own work with the class. They also made subject-based science lessons for young children in a simulated setting. They formed another small group, and they selected one lesson and performed it as a simulated lesson. In the simulated lesson, one group member pretended to be a teacher, and the other group members pretended to be children. For example, in a lesson about slope, they planned four activities: cars rolling on slopes with different variables of slopes and cars, slopes with different angles, slopes with different surface textures, and cars with various wheel sizes. The last plan was to roll on the actual slide that children play daily. The groups video-recorded the lessons of one of the activities and evaluated their own teaching. The video recordings and their reflections about the lesson performances were shared in the class.

MST in ECE. The course "Math, Science, Technology in Early Childhood Education (MST in ECE, shortly referred to as MST)" was taught 12 hours a week for five weeks, and students were scheduled for their last student-teaching practicum in March (see Table 1). The focus of this course was for the pre-service teachers to understand inquiry-based science/math activities in various ways. First, in order to address inquiry-based science activities for student-centered learning, the instructor brought science materials such as plants, insects, or tools to the class with which to conduct experiments. The pre-service teachers observed and performed the prepared experiments, and they shared the processes and results with the class. Second, the course provided various examples of science lessons. Teachers watched teaching videos of inquiry-based science activities for young children that the instructor selected, or they visited and observed actual kindergarten classrooms, providing inquiry-based science lessons by a STEM (Science, Technology, Engineering, and Mathematics) program. They also discussed what they observed. Third, groups comprised of three to four students planned inquiry-based science activities. Specifically, they performed three science lessons in the STEM classrooms for kindergarteners and first graders: building bridges, rolling on a slope, and stacking up blocks. Each lesson was a one-time activity; likewise, the lessons were not related or extended to each other. After each lesson, they shared their experiences of teaching science to young children in the class.

Participants

The participants in this study included eight pre-service teachers who took early childhood science education courses during the spring semester of 2013. They were juniors or seniors with a major in early childhood education at four-year universities in Korea and the United States.

The participants were four seniors who took the MST course at a university located in mid-Eastern America during the spring semester of 2013. Five of 14 pre-service teachers volunteered to participate in the study, but one of them later withdrew. The four pre-service teachers (A1, A2, A3, and A4) ultimately participated in the study. The first author worked at this university as a visiting scholar from March 2012 to February 2013. The second author was a doctoral student who had supervised these students during their student-teaching practicums in the previous year, including junior practicum and senior student teaching. The participants took foundational college science courses such as biology or chemistry before enrolling in this course.

The participants included four juniors (K1, K2, K3, and K4) who took the ECSC course, and the first author was an instructor at a university located in the Chungnam, Korea during the spring semester of 2013. Thirty of them volunteered and participated in all data collection procedures. To compare and contrast, the researchers discussed and selected four students whose images displayed characteristics similar to those of the MST students (see questionnaires on images about science education in the Data Collection section of this paper). The pre-service teachers had experience observing in preschools but did not have student-teaching experience; instead, their experience consisted of teaching simulated lessons during their college courses. They did not take any college science courses prior to enrolling in this early childhood science education course.

Data Collection

The main data resources included DASTT-C (the Draw-a-Science-Teacher- Test Checklist, Thomas et al. 2001) questionnaires examining the influences on those images after taking the courses, conducting interviews, observing classes, and performing document collection. Pre-service early childhood teachers were asked to draw an image of themselves teaching a science activity as an early childhood teacher in the classroom and write brief answers to the following questions: What is the teacher doing and saying? What are the students doing and saying? Factors that influenced images of science teaching focused on the reasons for drawing a self-image of a specific science activity. The instrument included one question regarding reasons for drawing the image of a science activity. In MST, the first survey was distributed to the participants during the third week of January 2013; in ECSC, it was distributed during the first week of March 2013. The second survey examining images and influences after taking the respective course was completed in the United States during the third week of February 2013 and in ECSC during the third week of June 2013.

Interviews. Follow-up interviews were conducted to ask additional questions and clarify unclear answers that were found in the process of analyzing the drawings and written responses from the questionnaires, specifically about the roles of the teacher and children represented in the images of science teaching. The interview questions were typically stated as follows: "Please describe in detail what you drew…" or "You wrote _. Please tell us more specifically why you thought that." Individual interviews were conducted face-to-face or by email, whichever was more convenient for a given participant. The interviews were conducted in the week following the

completion of each survey. In MST, the first interviews before taking the course were conducted on January 4, 2013; in ECSC, they were conducted during the second week of March 2013. The second interviews after taking the course were performed in the United States during the fourth week of February 2013, and in ECSC, they were conducted during the third week of June 2013.

Observation. The first author observed the course in MST and took field notes in each class (12 hours per week). She was also the instructor for the course in ECSC. Moreover, she observed her own classroom while teaching her class and wrote reflective journal entries immediately after each class. The researcher focused on observing three aspects of the courses: (a) the nature of the course environment, (b) the contents and methods of each lesson, and (c) the roles of the pre-service teachers in the course. In all, the researcher collected 36 written research journals.

Document collection. The pre-service teachers in both settings created various documents as part of their class assignments. The researchers collected the copies of those documents which included their reflective journals and portfolios of the team project on science teaching. These documents helped the researchers better understand the pre-service teachers' thoughts about their images of science teaching.

Data Analysis

To perform this analysis, the data from the DASTT-C and individual interviews were combined. The integrated data were coded according to the 13-point checklist (Thomas et al., 2001) in three areas: teacher (i.e., teacher's activity and position), student (i.e., student's activity and position), and environment (e.g., desk arrangement; lab organization; symbols of teaching, such as a blackboard; or symbols of science knowledge). Each of the 13 attributes was scored with a 1 or a 0, representing the presence or absence of the respective attribute. Total scores ranged from 0 to 13. The total scores between 0-4 indicated a fairly student-centered approach to teaching, and those scores between 7 and 13 suggested a fairly teacher-centered teaching approach. Meanwhile, for scores of 5 or 6, no decision could be concluded. Unclear information about the images was checked through interviews. The Crobach' α between the researchers was 0.85 before the courses and 0.86 after the courses.

To discover the factors that influenced the self-images of science teaching after the courses concluded, the data from questionnaires about factors, individual interviews, observations, and documents that the participants completed were analyzed. The researchers first coded the data from the transcribed interviews and typed surveys about factors and established categories. Then, the codes from typed field notes were added to the previous coding sheet followed by the codes from other documents. By reading the coding sheet repeatedly, the researchers developed themes to tell the whole story of the study topic. To validate the analysis, the researchers did a member check with two early childhood education professors and the participants.

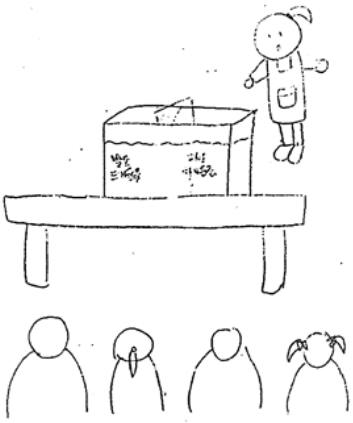
Results and Discussion

Before taking the course, the average score that this group (K1, K2, A1, and A2) earned was 11 out of 13 points, which showed high teacher-centered tendencies. After the courses, they all showed child-centered images, and the average score dropped dramatically to 2.8 points. The four pre-service teachers (K3, K4, A3, and A4) displayed the child-centered images (i.e., topics, teaching methods, and environments) even before taking the courses and moved more toward child-centered images and solidified them after the courses. The average scores of the images in this group were 2.1, and such scores fell slightly to 2.0 after the courses. Although the number change did not show much difference, we found that the content of the after-course images showed that they moved more toward the child-centered approach, particularly in the roles of teachers and children.

Before Taking the Courses

The following images and excerpts display the pre-service teachers' images of science teaching before taking the course. K1, K2, A1, and A2 displayed teacher-centered images, and K3, K4, A3, and A4 showed child-centered images. Figure 1 reveals the teacher-centered views of the pre-service teachers before the course commenced.

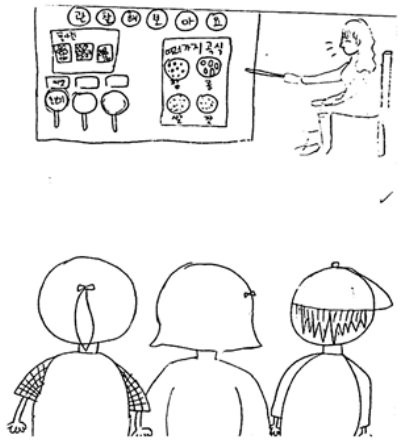
K1



Teacher (T) : "I already poured the red hot water and the blue cold water in a container separately. I am going to take the middle part out. Then, what is going to happen?" I am asking to children and then I'm about to do as I said.

Children (Cs): They are answering the teacher's question, "the colors will mix," or "nothing will happen."

K2



T: I am showing various kinds of flower seeds and grains that I prepared so that they can compare the differences between the two. I am explaining the meaning of those two and then telling them we will observe how the seeds will grow to become grains.

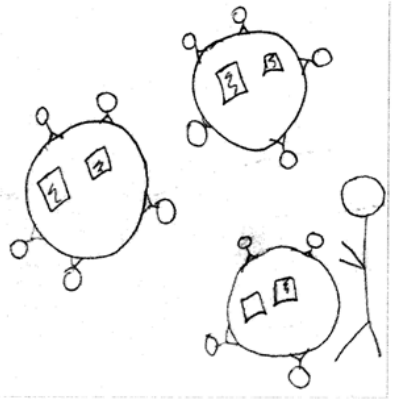
Cs: After they listen the teacher's explanation or answer her question, they will observe the grains and seeds as the teacher guides.

A1

T: The teacher has her students gathered around a demonstration table. She has assigned Jane to pour in one color of water into a bin and Michael to pour another. Before her demonstration, she discussed with her students what they thought would happen. Afterwards, she explains to her students what they will be mixing their own colors.

Cs: The students are sharing their predictions about what will happen when the two colors mix. Others are (hopefully) invested in the demonstration and subsequent activity.

A2



T: The teacher is going around to the various groups and making sure they are on task.

Cs: Having the students work together to complete the activity and ask me questions. The objects that were on desks included textbooks, worksheets, and a pencil.

Figure 1. Teacher-centered images and descriptions before the course

The pre-service teachers described different activities; some of these activities were child-centered, and others were teacher centered. K1 suggested a "convection of water" activity, which is beyond the children's levels of understanding. K2 and A1 suggested appropriate content for young children - "flowers and grains" and "mixing colors" - that are familiar to children in their daily lives. A2 was not able to specify the described activity even after the follow-up interview. The images by K1 and A2 especially show that pre-service teachers have a lack of understanding about what is an appropriate concept of science for young children. In turn, this lack of understanding results in teachers leading science activities by choosing activities beyond the children's level of development (Cho et al., 2012).

However, with the mixed content, they all described teacher-centered teaching methods and environments. In the image by K1, the teacher explained the names and uses of those tools that she had prepared before the class. She informed the students of the rules with which to experiment, and she then demonstrated the process. Children passively listened to the teacher's explanation and observed her demonstration. The teacher was explaining, and children were sitting and listening to the teacher's explanation. In the image by A1, the teacher set up the experimental equipment on a table in front of the teacher, demonstrated color-mixing experiments, and explained the results. The children were instructed to come up to the front of the class, they were asked to do as the teacher did or just sit and listen to the teacher. A2's image shows that the teacher was standing in front of the class while the children were sitting in a group at their desks, working on textbooks or a worksheet. The children were not displaying active involvement in the activities.

Interestingly, as shown in the study by Herron (2010), the pre-service teachers perceived that small-group learning is an important form of teaching for constructivist learning (Cho et al., 2012; Saunders, 1992). However, this study found that some pre-service teachers displayed children's small-group activities in their teacher-centered images even before the class. This result implies that an important aspect of constructivism science education is not simply a matter of small-group opportunities but rather the actual learning process that occurs within the small groups. That is, science education courses should help pre-service teachers understand the importance of the process of children's scientific inquiries in small groups for constructivist science education.

Figure 2 shows the initial child-centered images of the other four teachers' (K3, K4, A3, and A4) views about teaching science before the course and how they maintained their views after taking the course.

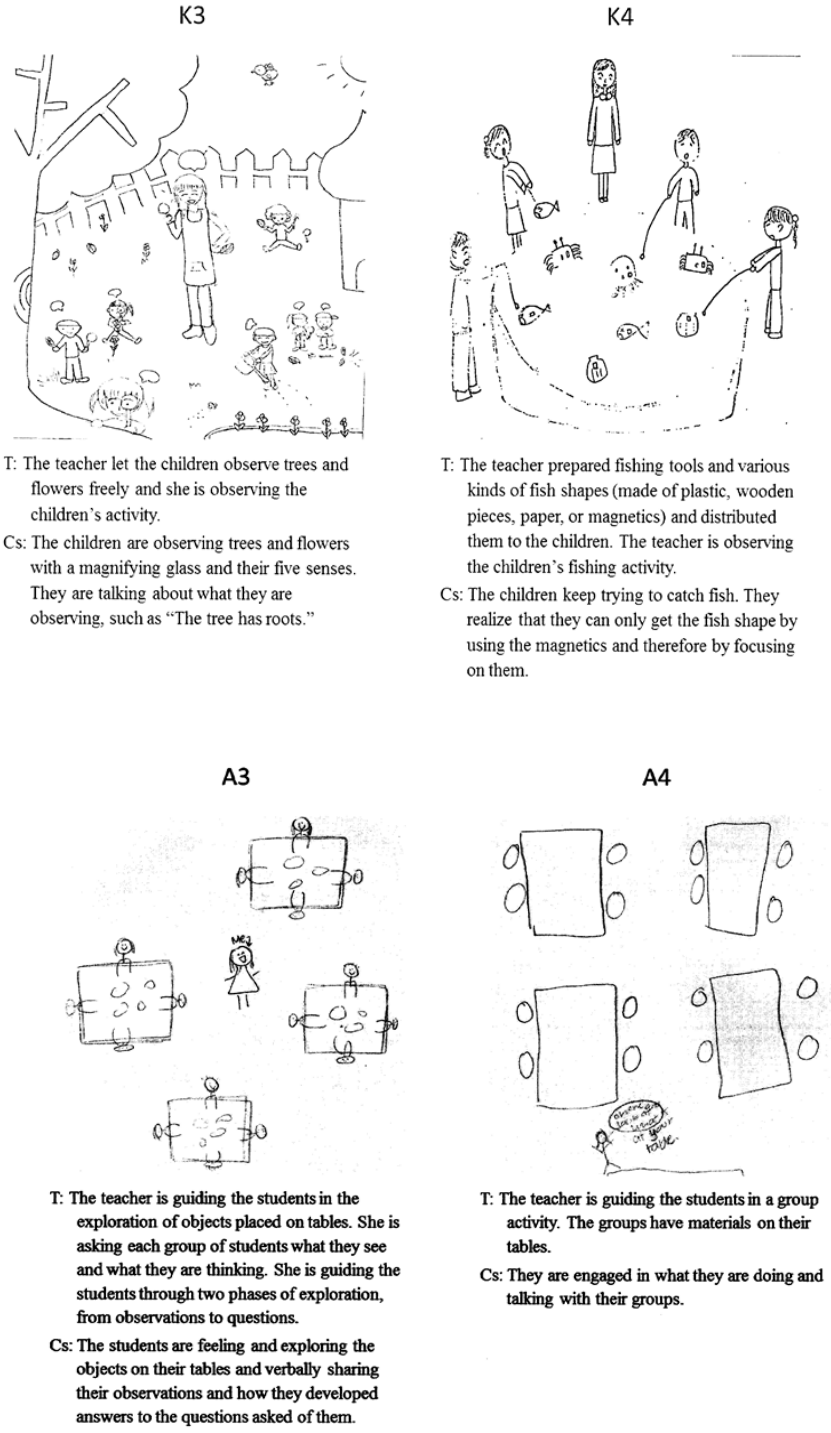


Figure 2. Child-centered images and descriptions before the course

All the teachers suggested activities that are appropriate for young children's level of understanding. The image by K3 shows that the teacher is providing an outdoor activity in which children are observing flowers and trees outside — something that is easy for them to access in their daily lives. Children are using five senses to observe, and the teacher is observing the children's activity. Similarly, in the image of K4, the teacher is providing an indoor science activity in which children are executing an assignment using magnetics —something with which they are familiar in their everyday lives. The children are actively participating in the assignment, and the teacher is observing the children's level of engagement. Initially, A3 and A4 did not suggest a specific activity. In the follow-up interviews, A3 identified the activity as "What is an insect?" Similarly, A4 still was not able to describe concrete content of the image she drew. All the images by these pre-service teachers depicted child-centered teaching methods, emphasizing the process in that the teachers observed children's activities, guided them, and asked questions, while the children were solving the provided activities and discussing what they observed.

After Taking the Courses

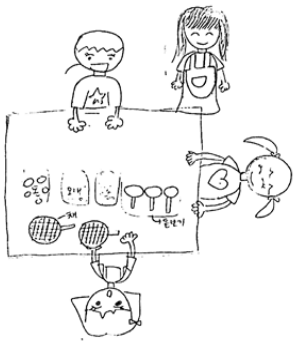
Similar to the findings of previous studies (Go, 2013; Kang et al., 2007; Seung, Park, & Narayan, 2011), this study also shows that science education courses contributed to changing the pre-service teachers' images of science teaching from teacher-centered to child-centered. The following images and excerpts show the pre-service teachers' child-centered images of science teaching after taking the course. Figure 3 shows specific characteristics of the images by K1, K2, A1, and A2. Specifically, these pre-service teachers had displayed teacher-centered images before taking the courses and changed toward becoming child-centered in their teaching approach.

K1

T: The teacher is helping and extending children's exploring activity by watching them explore freely, posing questions to them at the appropriate time.

Cs: The children are freely observing with a magnifying glass and talking with their friends as they observe.

K2



T: The teacher is letting the children explore stones, sand, and soil that they collected while walking outside. The teacher is asking questions of the children, such as, "How do you feel when you touch them?" and "Please try to smell them: how are the smells?"

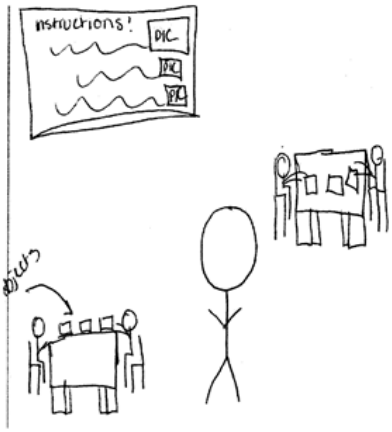
Cs: The children are exploring the objects with five senses and sharing verbally what they observe, such as "Stones give me hard-touching feeling," "Sands are coarse and rough," or "Soils are soft."

A1

T: The teacher is asking her students questions in order to understand the bridge the students are building out of newspaper (e.g., "What shapes did you include in your bridge? Why?" "Does your bridge have a foundation?"). She is also steering in the right direction the groups that require more assistance.

Cs: The students are rolling up newspapers in order to make rods that will become parts of their bridges. The students are working cooperatively to determine how to make a bridge to support the weight of at least three books. Some students are rolling newspaper; others are using tape to put the bridges together.

A2



T: She is going around to the students' tables to make sure they are following directions. She gives students the opportunity to explore.

Cs: The students are working together in the picture to solve the problem. The students need to be active and do their own exploring.

Figure 3. Child-centered images and descriptions after the course

Although the content of the activities that K1 and K2 suggested was different, both showed similar child-centered activities (i.e., "exploring various objects" by K1 and "stones, sand, and soil" by K2) as well as teaching methods. The teaching methods and class environments described by K1 and K2 show the teachers and children working together in the activities with the teachers observing and asking questions and the children exploring and observing.

A1 and A2 drew similar images after taking the course, which described teachers observing and helping children while children participated directly in activities. However, the images and descriptions of these two pre-service teachers also demonstrated some differences. She added an additional thought to the teachers' roles, namely encouraging children to connect their performance to the outcomes, which was not shown in the drawing made prior to the course. The image of children made by A2 after the course was more child-centered in that the children were described as exploring more actively rather than simply working on textbooks or worksheets at their desks. However, A2 was not able to suggest a concrete topic even after a follow-up.

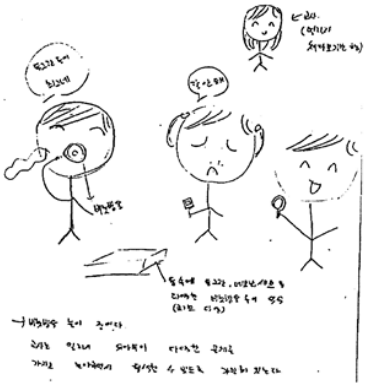
K3, K4, A3, and A4 showed continuation of child-centered images after the course; however, they displayed broadened views in some respects. The most important change in this group was in regard to teachers' roles. Prior to taking the course, these pre-service teachers noted the importance of children's active involvement in assignments rather than the teacher's direct involvement. However, the described teachers' roles were limited to simply asking questions or guiding activities. After participating in the course, both groups expanded their views on teachers' roles to promote children's scientific thinking. This is a constructivist teacher's role, emphasizing children's scientific thinking of connecting their performance with outcomes (Cho et al., 2012; Fosnot, 2005). Figure 4 displays their more child-centered images after taking the course.

K3

T: The teacher asks the children how to change the prepared tomatoes and lets them think about the ways in which to do this.

Cs: The children try their own approaches for changing the tomatoes and talk about their explorations, with such comments as, "I smashed a tomato and water came out."

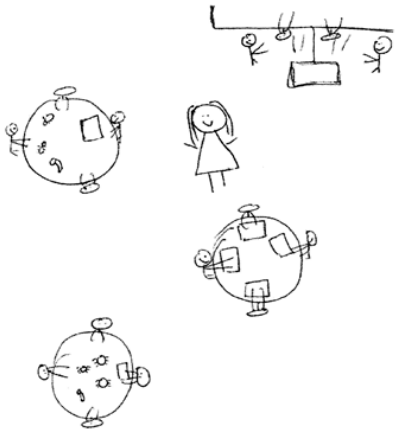
K4



T: The teacher prepares soap bubbles while employing a controlled variable. She lets the children explore various kinds of materials freely so that they can construct their own knowledge about soap bubbles. The teacher is observing the children's explorations.

Cs: The children blow bubbles with a variety of objects (the shapes of circles, squares, and triangles). They think about how to blow bubbles into these shapes and figure out their own methods of doing so.

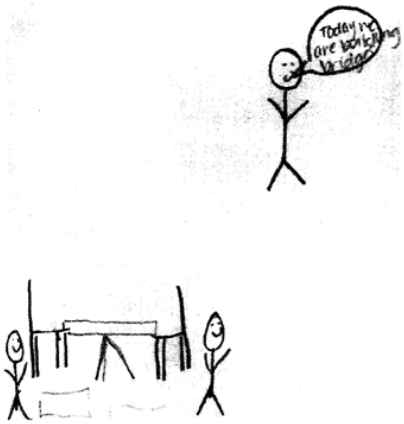
A3



T: The teacher is merely walking around the classroom and asking the students what they are seeing, observing, hypothesizing, and claiming.

Cs: The students are using technology to learn about the difference between bugs and insects.

A4



T: The teacher is guiding the students in how to build a bridge that will support weight. The teacher is letting the students experiment and not intervening too much.

Cs: The students are working together to build bridges. They are asking questions and thinking about shapes in bridges.

Figure 4. Child-centered images and descriptions after the course

In the images by K3 and K4, the teachers' roles were described as observing and watching children's activities before taking the course, but after the course, the teachers added roles to include scientific content such as providing materials with controlled variables or encouraging children's scientific thinking by asking them questions. The roles of children included having the children consider their own methods of approaching the materials and experimenting with such methods. The children could connect their activities to the results, whereas the roles of children described before the class were focused on playing and exploring. Prior to the course, A3 and A4 emphasized a teacher's role as merely guiding children through the activities. However, after the course, A3 described the image depicting a teacher asking questions about children's explorations. Likewise, A4 drew an image of the teacher guiding activities but emphasized the importance of minimizing the teacher's intervention in the activity in order to encourage children's active involvement in the experiments by asking questions and thinking about shapes in bridges, for example. Interestingly, the topics of A3's activities were similar before and after the course. After the course, though, she considered the benefits of using technologies such as a microscope, laptop, and smart board for learners to experience the scientific inquiry process. This result implies that to help pre-service teachers put child-centered perspectives into practice, courses should include an opportunity for them to understand a teacher's role for facilitating children's scientific thinking (Go, 2013; Kang et al., 2007) and diverse up-to-date tools to help learners explore scientific inquiry.

The content of the images created by pre-service teachers in the two courses had some similar aspects but also differences. For example, after the course, all the ECSC pre-service teachers suggested different topics, all of which were familiar to children in their daily lives. Two ECSC pre-service teachers (K2 and K3) suggested familiar activities even before taking the course; their activities after the course became more constructivist. The topic presented by K3, "changes in fruits," is not a one-time activity but does require children's constant scientific thinking as well as the process of scientific inquiry. The pre-service teachers in the United Sates (A1, A2, and A3) showed child-centered images after taking the course; however, they did not display ideas as diverse as those in ECSC. A1 and A4 represented "building a bridge," which they learned from a textbook and taught in the STEM class. A3 mentioned the same topic as the one mentioned prior to the course. A2 remained unable to identify specific topics even after the course occurred. These differences seem to be explained by the different content of the early childhood education

courses in these two countries as shown in Table 1. ECSC consisted of only the single subject of science—to emphasize attitudes toward the process of scientific inquiry as well as specific and broader content for young children to understand such as biology, nature, or earth science. In contrast, MST comprised interdisciplinary subject areas, namely math, science, and technology. The course still focused on the process of scientific inquiry and attitudes toward science, but the content of the course limited information and provided typical topics for science education for young children such as plants, insects, pancake-making, or building bridges. This suggests that early childhood science education courses should include explanation of and information about core concepts as well as varied content that young children should learn. This will help early childhood pre-service teachers understand what to teach in addition to how to appropriately teach science for young children.

Factors to change the images. The factors that the pre-service teachers changed from teacher-centered toward child-centered ones after taking the course included: (a) changed perspectives about a teacher's role (K1), (b) observation of teachers' child-centered instructional practices (A2), (c) learning experiences about constructivist science learning (K3, A3), and (d) teaching experiences of constructivism-based science lessons for children (K2, A1, K4, and A4).

K1 mentioned that before taking the course, a teacher's role was one of providing scientific information to children, but after the course, she changed her perspective to that of a teacher's role as helping children to build their own knowledge base. She mentioned that this changed view was influenced by what she had learned from opportunities throughout the course to constantly review her own perspectives about science teaching.

> Today in the class, I learned about the purpose, content, and ways for constructivism science education for young children; I think I need to change my views of teaching science. I should become a teacher who helps children learn by themselves through inquiry, not just prepares and demonstrates. (K1's journal after the course, April 26th 2012)

Noting that the teachers' own views about science teaching influenced the images is an important result because analyzing their own teaching activities based on their beliefs and self-constructed views about teaching is important for teachers to develop professionalism (Cho & Go, 2006b; Cho et al., 2004; Go, 2013).

The second factor that the pre-service teachers mentioned was that the course provided opportunities for in-service teachers to observe child-centered science lessons. In this context, A2 remarked the following:

> I have seen teachers moving around the classroom to make sure students are on task and working together. . . . The only lesson I truly took away from this course is to make science. . . "hands-on" or to make sure the students are being active with the curriculum. (Interview with A2, after the course, June 28th 2013)

When she visited the STEM class for kindergarteners, A2 observed that children were actively involved in the activities, and the teacher observed children's participation. The opportunities to observe teachers' actual performance of a science activity influenced her views as they changed toward a child-centered perspective.

These experiences in the course influenced them to solidify their previous perspectives on science teaching.

> In this course, I learned about various learning means based on constructivism. While applying this learning to the science project, I [was] reassured that it is important that students should take [an] active part in their own learning with interests. I also learned about [the] importance of children's experiences to draw results through scientific thinking such as "how can I change this?" or "how this is changed?" (Interview with K3 after the course, June 25th 2013)

Similarly, A3 indicated the following:

> After this course, I realized the importance of technology in the classroom. . . . I learned that there are awesome resources students can use and still be engaged and hands-on in what they are learning. (Interview with A3 after the course, February 19th, 2013)

These excerpts show that the two pre-service teachers had confirmed child-centered images after taking the course through experiences as constructivist learners, specifically performing a team project of science (K3) and learning about using technology to observe and experiment with (A3). In particular, K3 considered only children's interests before the course; however, after the course, she included a teacher's role to promote children's scientific thinking based on their interests. The different views of the pre-service teachers from the two settings about influences on their images of science teaching can be explained by the different content and

methods found in each course. Teachers tend to teach as they learned; their experiences as constructivist learners during their school years are important for becoming a teacher who can teach science based on constructivism (Fosnot, 2005; You et al., 2010).

To help early childhood pre-service teachers construct firm images of child-centered science education, the course should provide opportunities for them to consider their views about science education and share their perspectives with others so as to understand various points of view and to learn about science activities that are developed with a basis in constructivism. Lastly, similar to the previous study (Kang et al., 2010 & Go, 2013), the pre-service teachers (K2, A1, K4, and A4) mentioned teaching experiences of child-centered science activities as an influence on their views. K2 and A1 changed their images from teacher-centered to child centered ones. K2 mentioned as an experience to plan and perform a science activity for young children at the simulated lessons. A1 considered the building bridges activity that she performed in the STEM lab as an ideal example of how the science lesson should go because she saw that the children were genuinely interested in the activity that she prepared. They specifically indicated that the teaching experiences helped the pre-service teachers assure themselves that children are able to construct their own knowledge while they explore. This assurance of children's abilities led them to change toward child-centered images. K2 stated, "Today, I learned that without a teacher's explanation, children are unable to understand by themselves." (K2's journal after the course, June 19th 2012). A1 said:

> In the activity, when I asked a question, "How can we make a bridge with newspaper?" they provided various ideas and discussed, then built a newspaper bridge. Then, I [was] assured of [the] importance of child-centered science activity that I learned in the course." (Interview with A1 after the course, February 21st 2013).

K4 and A4, who maintained but solidified their child-centered images, also mentioned opportunities of applying constructivist theories to practice. K4 emphasized children exploring directly for the purpose of constructing for their own knowledge after taking the course. By doing so, she also mentioned that a teacher's role was to provide materials with controlled variables:

> This semester, I learned theory about the purposes, contents, and methods of early childhood science education and actually applied the theories to practice. I came to understand that children,

> rather than a teacher, should take a lead in activities. My drawing shows that children are playing with bubbles, which has controlled variables. (Interview with K4 after the course, June 24th 2013)

A4 mentioned the teaching experiences of a science activity (e.g., building bridges) for young children in the real classroom [STEM lab school]. Her statement regarding the influence of her teaching experience in the STEM lab school matched the researcher observations of the researcher.

> Today, in the STEM lab, A4 taught the first graders "Building Bridges." The main aspect of this activity was how to encourage the students to build strong bridges and try out their ideas with various materials, such as books…. During the discussion in class after the activities, she self-evaluated that her activity was a successful experience. (Observation at STEM class, February 15th 2013)

These excerpts indicate that A4 continued her emphasis on child-centered images after the teaching experiences of young children in the STEM class. Specifically, she evaluated her own teaching of a child-centered activity as successful. This positive teaching experience for young children helped her maintain child-centered images of science teaching.

Implications and Conclusion

The result showed that the science education courses positively influenced the pre-service teachers' images about science teaching. Thus, the previous teacher-centered images were changed toward child-centered ones, and their child-centered images were solidified. This result indicates that the science education courses in the both settings had content and methods of science teaching based on constructivist perspectives. By investigating the specific aspects of the courses that influenced the pre-service teachers' perspectives, the study made some implications for developing early childhood science education courses for pre-service teachers.

Those pre-service teachers who moved their images from the teacher-centered to child-centered were influenced by their changed views on a teacher's role and their observation of in-service teachers' teaching science lessons. This result implies that for those pre-service teachers who displayed teacher-centered views before taking a science education course, it should provide not just theoretical perspectives on

teachers' roles but actual experiences of teachers' roles in science classes, possibly playing a constructivist teacher. It is also noted that observing in-service teachers' teaching influences the pre-service teachers' images. This fact suggests that the course should provide the pre-service teachers with opportunities for observing science lessons based on constructivist perspectives through watching videos of exemplary science lessons or visiting those classes such as STEM as in the American course. To do these observations, research is required to investigate ways to promote constructivist science education in early childhood classrooms.

Those pre-service teachers who solidified their previous child-centered images after the courses revealed that in performing the constructivist science activities, the courses provided influenced their solidification of those images. This result indicates that those pre-service teachers who already showed child-centered images should have learning experiences as a constructivist learner, participating in actual science activities. For example, they can conduct a long-term science project for their own scientific inquiries as ECSE provided. They also can do constructivist science activities for young children as part of the course, which was offered in both the ECSE and MST courses.

The teaching experiences influenced both images that were changed or solidified after the course. The course should provide teaching experiences for young children that should include not just planning and performing activities but also analyzing their own lessons with others. Particularly, those who solidified their previous child-centered images indicated the importance of a teacher's role as an inquirer to promote children's scientific thinking, not merely asking a question to check if children are doing an activity correctly. They mentioned that they learned about this teacher's role in considering their own teaching. While planning a lesson, they developed several activities and discussed how these activities related and extended to each other in a subject. After planning and implementing, they analyzed their own teaching. This result implies that teaching experiences for pre-service teachers should emphasize the teachers' inquiry process about their own teaching and lessons by analyzing and discussing them, not just planning and performing. The teacher as an inquirer is an important part of a constructivist teacher's role to promote children's scientific thinking.

The study concludes that pre-service teachers have previous images on science teaching for young children. An early childhood science education course should

provide them with opportunities to consider their own images before the course. Given that constructivist education emphasizes individually responsive instruction, the course for constructivist science education should include various teaching approaches that emphasize teaching as inquiry and learning opportunities for responding to their prior images of science teaching.

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