Interdisciplinary Journal of Environmental and Science Education, 2011, 6(1), P. 23-37
Published: Jan. 10, 2011

Pre-service teachers' views on practical work with inquiry orientation in textbook-oriented science classrooms

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Abstract

Despite inquiry-based teaching was introduced and encouraged as significant tool to develop students' scientific knowledge and habits of mind, its implementation has not been well established in science classrooms in Korea. To understand the challenges and difficulties of the practice of inquiry practical work, this study particularly aims to understand how pre-service teachers' understandings of inquiry and practical work have been shaped in educational and social contexts in Korea and later how their views and willingness could be developed through redesigning and practicing textbook activities. 25 third-year students in an elementary science methods course in Korea participated in the study. Mixed methods including questionnaires and reflective discussion and writing were employed for data collection. The pre-service teachers expressed their ideas and difficulties of inquiry approach in their everyday classroom conditions and social situation and thus unwillingness to attempt its practice. Throughout the study, they gradually overcame their resistance and reluctance toward inquiry and practical work and develop willingness and motivation to practice in everyday science classrooms. This study further suggests need for thorough examination on teachers' situated contexts for developing ways of inquiry-based practical work.

Keywords: elementary preservice teachers, perception and willingness of teaching inquiry, practical work

Introduction

To overcome the pitfalls of theory-focused and test-oriented science curricula such as lecturebased teaching and memorization of fragmented concepts, science as a process has been used to encourage students to think about science as inquiring and knowing about the world. Getting students involved in authentic experiences of inquiry-based learning, such as problem solving and investigations, can help them develop scientific knowledge, creativity, and habits of mind to question and learn about the life-world phenomena around them (Haigh, 2007). Given that the importance of inquiry-based teaching has been internationally recognized by science education communities (e.g., Abd-El-Khalick, Boujaoude, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust, & Tuan, 2004), the emphasis of inquiry orientation is recently brought into the science curriculum in Korea as one of the objectives of science education (Ministry of Education and Human Resources, Korea, 2007). However, the ideas of inquiry-based approach are new to majority of science teachers in schools where the ways of teaching and assessing students' knowl- edge and settings of classroom environment are still traditional and outcome-based. Therefore, its practice is even bigger struggle in their everyday teaching.

There are a significant number of studies that discuss the difficulties of scientific inquiry in elementary science classrooms in other countries. For instance, Chin, Goh, Chia, Lee, and Soh (1994) and Lee, Tan, Coh, Chia, and Chin (2000) in Singapore contexts found that elementary science teachers encountered external (constraints with time, curriculum, students' abilities and classroom structure) and internal (lack of knowledge, beliefs and attitudes) difficulties in using the problem-solving teaching approach. Research in western countries also stated that many elementary science teachers lack the necessary background and experiences to teach science, and thus lack confidence in teaching the subject (Appleton, 2002; Appleton & Kindt, 1999; Gustafson, Guilbert, & MacDonald, 2002; Howitt, 2007; Palmer, 2006; Rowell & Gustafson, 1993). Even for science teachers with science background knowledge, the implementation of inquiry teaching is challenging for various reasons, such as lack of administrative support (Zion, Cohen & Amir, 2007) and conflicts of personal experiences and beliefs in scientific inquiry (Crawford, 1999, 2007; Trumbull, Scarano, & Bonney, 2006). Certainly, without external support of time, materials and laboratory

assistance, conducting practical work and inquiry-based learning can be difficult and challenging. Another issue is that science is not a priority subject for elementary school teachers (Appleton & Kindt, 1999). Teachers strive to find a balance among various subject areas and from their perspective, practical work may not seem to be the most efficient way to teach science (Appleton, 2003). Conducting practical work is challenging and cultivating students' inquiry skills through practical work can also be difficult to attain in elementary science classrooms.

Although these concerns are relevant to many countries, there are certain social contexts in Korea that further hinder the implementation of inquiry-based teaching and learning. For example, pre-service and beginning teachers tend to depend heavily on curriculum materials such as textbooks and teachers' guidebooks (Rowell & Ebbers, 2004; Schwarz, Gunckel, Smith, Enfield, & Tsumsaki, 2008). In Korea, this situation is more pronounced. This is because there is one authorized science textbook based on a centralized science curriculum and conventionally, teachers are expected by students, as well as parents, to teach all the content in the textbooks. In addition, national and local examinations and competitions are based on the curriculum and many teachers rely on the content of textbooks as a base for teaching (Yoon, 2008). With a focus on the textbook content and materials, science teaching becomes univocal and less creative since there is not much flexibility. Also, due to the highly competitive examination systems throughout the school years, many children study the subject matter content at private institutions, such as tutoring and cram schools, prior to school science classes (Lee, 2005). That means that they already know what the correct results are and they are expected to achieve these results in their practical work (Yoon, 2008).

Because of content-oriented curriculum and assessment, science teachers tend to focus on concepts, even in practical work, rather than on an understanding of the development of scientific knowledge, scientific process and enterprise, and the culture of laboratories practiced by scientists (Haigh, France, & Forret, 2005). Whereas scientists experiment, communicate, validate, and develop scientific knowledge through practical work, school practical work tends to test textbook knowledge, i.e., "recipe practical" (Haigh, et al., 2005, p. 221). In this study, practical work in classrooms refers to students' hands-on experiments and this could be practiced in two ways. One is there are no certain, known answers to questions to students and they strive to find out results of their practical work

and the other is teachers use practical work to teach textbook knowledge, thus students need to get correct answers through experiments. The latter practice is rather recipebased practical work whereas the former encompasses an inquiry orientation. The latter is the common practice of practical work at schools since the teaching has been content knowledge- oriented. With this nature of recipe-based practical work is not sufficient to develop students' habits of mind. When it is recipe-based approach, teachers tend to give children step-by-step instruction to reach the certain knowledge. There is not much questioning and thinking involved in the process. When children already know the outcomes or they must get the right answers from the work, they may find it uninteresting and discouraging when they do not get right results and some teachers find practical work ineffective and dilemmatic to teach scientific knowledge (Yoon & Kim, 2009). In this case, practical work cannot bring into much development of inquiry process in children's learning. In this regard, practical work with inquiry orientation seems such a challenging task in elementary science classrooms in Korea. It is not simply "doing" but requires "thinking through doing." Following instructions in the textbook activities is not sufficient to enhance inquiry skills and minds. There needs more thorough attention to conducting practical work with inquiry focus.

For this regard, this study attempts to encourage pre-service teachers to understand the need of inquiry orientation in practical work. Since science teaching heavily depends on textbooks in Korea, the practical work practiced in this study was based on Grade 3-6 science textbooks in Korea. While pre-service was practicing inquiry-oriented practical work throughout the study, their views of inquiry were also questioned and interpreted in order to design their practice of practical work effectively. To summarize, the purpose of this study is to understand 1) how Korean pre-service teachers view inquiry orientation in everyday classroom teaching and 2) how practice of textbook practical work with an inquiry focus would help their views - perception and willingness toward inquiry-based teaching.

Research Contexts

The participants

This study was conducted in an elementary science methods course, Science Education II, in a university teacher education

programme. The participants were 25 third-year students majoring in Physical education. There were 11 male and 15 female students. Before this class, the participants (pre-service teachers) had taken two science courses, an introductory science methods course (Science Education I), and Science curriculum and learning theory. Science Education II consisted of 15-week classes, including a two-week practicum in the Week 10-11. During the course, the pre-service teachers were required to prepare two sets of practical work from the primary science textbooks, as well as activity sheets for each set. They worked in groups and carried out five practical activities each class. Each class lasted 3.5 hours. After each activity, they wrote their ideas and concerns about the activities and compiled their own portfolios with lesson plans and reflection notes.

Research design: science education II course

Teachers in Korea tend to depend on textbooks heavily since they are authorized based on the national science curriculum. Teachers feel responsible to teach contents and activities in the textbooks, therefore, it was important for this study not to discard the local context. Thus, Science Education II was designed to provide pre-service teachers to get familiarized to textbook practical work (hands-on experiments) and further encourage them to bring forth inquiry orientation into the practical work in innovative ways. In this case, teachers can still deliver textbook activities and practice inquiry teaching in the activities, thus, the approach can be more practicable to teachers' social and pedagogical contexts in Korea. If the pre-service teachers were familiar and felt comfortable with the repertoire of activities in the textbooks, the chances of their conducting practical work via an inquiry approach would be higher (Appleton, 2002).

Another challenge that teachers encounter is that many children already know the right results of practical work from pre-study in institutions and look for the answers through their experiments in school classrooms. This would hinder teachers conduct practical work to be inquiry oriented (Kim & Tan, in press). To provide the pre-service teachers with opportunities for carrying out textbook activities with an inquiry emphasis, as well as to respond to the concerns of social and classroom contexts that elementary teachers encounter, it was essential to design and restructure the course in certain ways. In this regard, this course required the pre-service teachers to modify textbook materials and activities which children

would not have already-known answers to the practical work. The details of this focus are as follows (also see Figure 1).

	Children's doing	preparing textbook Practical work	Children's thinking	Targeted inquiry skills and process
The 1st round	Grade 3-4 textbook activities	-What is happening and why? -What do you predict will happen and why?	-Children come up with their own ideas and explanation.	Individual inquiry "skills" (e.g. observing, classifying)
	Linking children's doing and thinking through scaffolding			
	Linking individual skills into inquiry process			
The 2nd round	Grade 5-6 textbook activities	-How would you test your prediction or hypothesis? -What is your conclusion? -What will happen if we add/change this part of practical work?	-Children understand the process of problem solving. -Children get challenged by questions, materials, or variables that are not shown in the textbooks.	Investigative inquiry "process"

Figure 1. Developing practical work with inquiry orientation

In the first round of practical work practice, the pre-service teachers carried out practical work based on individual inquiry skills (e.g., observing, classifying). In the second round, they were required to modify practical work to bring more complex levels of thinking such as investigative process. By shifting the focus of practical work from individual skills to integrated process, the course encouraged the pre-service teachers to think of teaching strategies which can develop the connection between practical skills and concepts of evidence during process (Gott & Duggan, 1996). For example, a group of pre-service teachers prepared a lesson on electric circuits from the Grade 4 textbook in the first round. They explicitly focused on developing children's observing and predicting skills through different electric circuits. In the second round, they prepared a practical activity on electromagnets from the Grade 6 textbook which involved the complex process of observing, hypothesizing, designing, experimenting and making conclusions. In their lesson plan, they asked children to hypothesize how they could make electromag
nets stronger. They provided a series of questions for the children to think of, involving variables such as the number of wraps of the enamel copper wire, the length/thickness of the iron nail, the

number of batteries, and the connections of the batteries and asked them to test their hypotheses. Some of these materials and steps were not introduced in the textbook. Later, they added another questions and process which were not shown in the textbook to arouse children's curiosity. They raised a question of how children could make electromagnets with any other materials instead of the iron nail. Letting children think of variables on their own, they also planned to provide possible materials such as wood, plastic, glass and stainless steel sticks. Adding more questions and steps which were not shown in the textbook, the pre-service teacher made the work more intriguing and challenging and transformed it into more of an inquiry-based approach.

For acquiring a set of knowledge and skills in practical work, the pre-service teachers also searched for background information, possible questions and answers, and teaching strategies related to practical work. For instance, for the activity on electromagnets, the pre-service teachers searched for information on electromagnetism and the roles of iron nails in the activity. They explained why glass, plastic or wood were not appropriate in making an electromagnet, explaining the difficulty of aligning atoms in those materials. They shared with their peers, the details of making electromagnets and some instructional tips and discretions based on their experiences during the preparation and practice. The pre-service teachers made this kind of efforts throughout the course in this study.

Data collection and analysis

To investigate the pre-service teachers' views of practical work and inquiry, the study used data from two main sources: survey questionnaires and reflection (discussion and writing). The details of data collection are as follows.

Survey questionnaires: The questionnaires were conducted as pre and post survey. It was to find out what the pre-service teachers' views of practical work and inquiry science teaching are and how their practice of textbook practical work throughout the course help them with their views, especially perceptions and willingness toward teaching scientific inquiry and practical work. The questionnaires consisted of 70 questions in the categories of perceptions on science inquiry and practical work and willingness of teaching inquiry science and practical work. Examples of items on perceptions were "inquiry process means students come up with their own questions and seek for answer by themselves," "getting students involved in

practical work is doing inquiry," and "inquiry-based teaching is possible through practical work". Examples of items pertaining to willingness were "I can make my lesson more inquiry-oriented," "conducting practical work is difficult to me, considering school lab situation" or "practical work requires much effort to conduct than other teaching." The questionnaires were based on a five-point Likert scale and pre-post comparisons were made using the t-test in SPSS. Cronbach's alpha (a) for the pretest and post-test was 0.84 and 0.85 respectively—this gave a measure of the reliability of the questionnaires. A limitation of this t-test was the small sample size of 25 students. With this concern in mind, we considerably looked into the qualitative data through reflective discussions and writing to support the quantitative data.

Reflective discussions and writings: Classroom discussions took place three times during the course. One was carried out at the beginning, the second was after their practician, and the last one was on the last day of the course. The pre-service teachers reflected on their experiences and concerns associated with practical work and inquiry-based teaching. Semi-structured small group discussions were also carried out two weeks after the course finished. Four students (one male and three female) volunteered to participate in the interview to reflect on their experiences of the course and ideas of inquiry-based learning. The conversation lasted 40 minutes. The con

versations were videotaped and transcribed for data analysis. Throughout the course, the pre- service teachers also wrote their reflections on their activities and interaction among themselves in relation to teaching inquiry and practical work. These were collected as written data. No specific instructions were given for reflective writing except that the pre-service teachers were asked to include their views on the difficulties they encountered during the activities.

To understand what could lead the results in the questionnaires, we looked into the qualitative data. We attempted to understand what could hinder and help the pre-service teachers' perception and willingness in inquiry-based practical work. All verbal and written data were examined several times and interpreted to look for emergent themes (van Manen, 1997). The themes were integrated by the similarities of the data from multiple sources. The data and interpretation were shared with two science educators to get more stable understandings of themes. During this peer checking, the researcher (first author) shared and discussed tentative interpretation with colleagues until meanings and themes could be

agreeable and stable. The questioning and discussion process among them helped to increase the depth and reliability of the data analysis and interpretation.

Research Findings

In this section, we present findings in this study. To answer the two research questions, we will explain them in two subsections; one is the findings of pre-service teachers' views on teaching science inquiry and practical work and other is the findings of the effect of practicing textbook practical work with inquiry orientation on their perceptions and willingness toward science inquiry and practical work. The subsection of the Findings I includes two and Findings II highlights three main ideas that we found from the analysis and interpretation of quantitative and qualitative data.

Findings I: Pre-service Teachers’ Views

Inquiry only as open, student-centred process

Many of the pre-service teachers in the beginning of the study explained that scientific inquiry was entirely student-led, open-ended process with no teachers' interference. In their reflection on what inquiry was, 88% of them expressed that scientific inquiry is the process of students' seeking for knowledge and this needs to be led by students themselves. 80% of them expressed that inquiry questions should come from students and the questions needed to be unique and interesting so that students could carry out their own investigation to find answers. They regarded inquiry as an open process, comprising student-initiated questions and investigating process. They also expressed that inquiry could take place only among gifted children on special occasions such as extra curricula lessons and school science clubs. Because of their perceptions on inquiry as a student-led problem-solving process, they felt that inquiry teaching seemed almost impossible to achieve in normal, everyday classroom settings. The following excerpts were taken from their reflective writing and class discussions in the first week of the course.

> I think it (inquiry) is to find new scientific concept or aspect, including the process and the result, through practical work. It will occur in very special cases (Lee, reflective writing).

> How can students follow all those processes of inquiry? Making hypothesis, designing and doing an experiment, finding results and conclusion on their own? It is too much to do in one class (Kyung, during discussion).
>
> Scientific inquiry is not easy to teach in normal science classrooms. You can do inquiry learning with gifted students, but not your students in normal everyday classrooms (Shin, during discussion).

The pre-service teachers said that in their previous courses, they had learned about inquiry as models of problem solving and hypothesis-based investigation. The examples of inquiry they were exposed to were types of authentic open inquiry process as Kyung shared during discussion. These learning experiences might have led them to believe in an idealized practice of inquiry which they felt was difficult and impractical to implement in their everyday science classrooms. Another aspect which gave the pre-service teachers the impression that scientific inquiry had to be pitched at a high level might be related to their perception of how scientific inquiry is associated with gifted students (e.g., Shin's reflection above). Lee also explained later that special cases shared in his reflective writing above meant gifted students whose level of experience, knowledge and skills of science were high enough to carry out inquiry process. There are several science-specialized high schools and many special science programmes for the gifted in Korea. Students who excel in science enter the schools and have opportunities to learn science at advanced levels. Most of the participants and winners in science competitions are from science-specialized schools or schools for the gifted. These social phenomena might have led them to associate scientific inquiry with gifted students in science.

This perception of idealized inquiry discouraged pre-service teachers to implement inquiry teaching. Instead, it resulted in an indifference and resistance to implementing inquiry in normal classroom settings. This suggests that we may need to reconsider how we encourage teachers to look into their own contexts of school and students and take ownership of their decision making over the level of inquiry accordingly. Before we emphasize authentic open inquiry as a valid model, we need to thoughtfully question if the emphasis on this approach has misled our students to understand it as the only way of inquiry-based teaching. We need to discuss what the diverse dimensions of inquiry are and how they can be used in local contexts.

Resistance to practical work with unexpected results

Most of the pre-service teachers mentioned that practical work was an effective way of teaching inquiry minds. However, they were concerned about the effectiveness of practical work in terms of learning since they had encountered several cases where their experiments did not turn out the way that they expected. Some said they enjoyed practical work as students, but as teachers, they felt responsible in teaching correct knowledge and thus, having their students to obtain the "right" results in practical work. They perceived that not getting correct answers was a failure of teaching. It was something that they, as teachers, wanted to avoid. Their responses included:

> When there are unexpected outcomes or wrong results, practical work only confuses students (Seol, reflective writing).
>
> Practical work does not always work. We often fail in an experiment. It is not a good way of teaching science if it does not turn out well (Ae, reflective writing).
>
> I did not like practical work in school. We always needed to manipulate our experimental results to get the right answers in science classes (Jeong, reflective writing in the second round).

Seol and Ae were not very convinced that practical work could teach children correct knowledge in science classrooms when it does not bring the right results. In this case, it does not seem an effective way of teaching science to them. Their avoidance of practical work could have stemmed from their understanding of the purpose of practical work. For them, the ultimate purpose of practical work was to get the right knowledge as learning outcomes, and not as learning skills or processes. Science teachers often conduct practical work to teach the correct knowledge on textbooks as Jeong shared in the reflection on her school experiences. Many assumed practical work was to test or show how scientific knowledge works in real situations, and not as a way of learning inquiry skills and processes. For these pre-service teachers, practical work becomes a tool to teach content knowledge based on recipe-based instruction, and inquiry learning was out of their reach once again.

Findings II: the effect of practicing practical work

Positive changes in perceptions and willingness

Through modifying textbook materials and activities during the 10 week course, the pre-service teachers gradually overcame reluctance toward inquiry teaching and practical work. The t-test results are on the Table 1 below.

The t-test results of the questionnaires showed that there were significant differences between pre- and post-course test in their perceptions of scientific inquiry (t= -4.665, p <0.01) and the relationships between practical work and inquiry (t= -3.330, p <0.05). The pre-service teachers recognized possible ways of inquiry teaching in everyday classroom situations, which they initially thought it would not be possible. The relationships between practical work and inquiry focused that practical work is to be rethought from simple hands-on to minds-on with thinking and problem solving process which science inquiry aims for. In other words, textbook practical work does not automatically bring forth students' inquiry minds and skills when it is simply a doing activity to get results. It needs careful scaffolding and redesigning. There were also significant changes in willingness toward teaching inquiry-based approach (t= -4.064, p <0.01). Working through the course, they seemed to have developed their comfort and interests in implementing inquiry and their views on the possibilities of inquiry teaching, and the importance of connecting doing to thinking in practical work.

Table 1. Pre-service teachers' perceptions and willingess (t-test)

	Sub-categories	Pre-test		Post-test		t	df
		Means	SD	Means	SD		
Perception	inquiry in everyday classrooms	3.45	.24	3.74	.32	–4.665**	25
Perception	Relationships between practical work and inquiry	3.47	.35	3.72	.37	–3.330*	25
Willingness	Teaching inquiry approach	3.43	.29	3.76	.35	–4.064**	25
Willingness	Teaching practical work	3.19	.33	3.33	.31	–1.870	25

However, there was no significant difference in their feelings toward teaching practical work (t= -1.870, see Table 3). There was only a slight change and not a significant difference in their willingness toward teaching practical work. The items in this category addressed the pre-service teachers' feelings and concerns about preparing and carrying out practical work in science

classrooms. For example, there were items on time constraint in preparation, difficulties with school lab situation, and required effort to conduct it. Even though interest and comfort in practical work somewhat improved as some reflected that the practice of practical work helped them to become more confident in teaching, practical work still remained a challenging task in real classroom situations. That may be because teaching practical work still required much time and effort to prepare and to conduct effectively, unless there were more external support provided such as lab technicians and better lab conditions. These sentiments appeared in their written responses as well. During the course and practician, the pre-service teachers encountered much challenge in practical work in terms of preparation time and unexpected incidents. In their reflection, they expressed:

> It was meaningful to see students working and thinking actively during the activity. But indeed, it took me a lot of time to prepare compared to other lessons. The school lab did not have materials that I needed so I had to bring many things from home too. Was definitely a lot of work! (Jin, during discussion)
>
> I thought practical work in primary science education would be easy. I always thought it could be done easily when I skimmed the textbook. I did not expect I could run into so many problems. The problems can be from materials, students, and my instructions (Sook, reflective writing).
>
> Now I understand the failure of practical work does not necessarily mean the failure of teaching. I can still make it meaningful by discussing why it went wrong… but I think it is better to get it right in the first place. It is hard to get right results in practical work all the time (Hyo, during discussion).

Jin and Sook discussed their concerns of time consuming and unexpected problems during practical work. For Hyo, it was a good opportunity to rethink about the term, failure of practical work in his understanding through this study, however, he is still eager to get the right results from practical work, which is hard for him to achieve all the time. It seems that these issues still remain as challenge in the pre-service teachers' understandings of practical work.

Possibility of classroom inquiry by redesigning textbook activities

In the findings, the pre-service teachers' perceptions and willingness toward inquiry changed more positively. To understand the survey results at a deeper level, we looked at their verbal and written responses to what would encourage them to develop their perception and willingness toward inquiry-oriented science teaching. During the course work, the pre-service teachers developed their ideas on possible ways of enhancing children's inquiring and thinking skills in everyday classroom settings. Hands-on activities were based on textbooks and centralized curriculum, therefore, they acknowledged the need of activities to be practiced in classrooms. Through practicing the textbook activities and discussing how to overcome the constraints of classroom conditions and to bring forth inquiry orientation, the pre-service teachers learned the possible ways of incorporating inquiry skills in everyday classroom settings. They did not have to do entirely different activities to enhance children's curiosity and inquiry skills, but by modifying textbook materials, reorganizing the process of activities or adding stimulating questions, they could develop the opportunities of inquiry-based practical work in classrooms. Excerpts from their reflective writing and discussion after the course showed changes in their understandings and willingness of inquiry-based practical work.

> It was useful to know that inquiry-based teaching does not always have to include the whole process of finding answers by the students themselves (Kang, reflective writing).
>
> I always thought inquiry was too abstract, too big and only for the gifted. But it can be done for everyone (Jong, discussion).
>
> It is still difficult for me, but at least, I came to know it's not impossible in normal classrooms. You need to be attuned to the classroom situation to make it work. I can start at a level appropriate for my class (Shin, discussion).

It was meaningful to question the pre-service teachers' image of inquiry in the beginning of the course which caused unwillingness of inquiry implementation in their everyday classrooms. Manipulating textbook materials from lower to higher levels of inquiry approach,

the pre-service teachers explored the boundaries of their comfort zone in terms of practising inquiry, realizing that classroom inquiry did not always have to be open in nature. They learned the need of teachers' decision-making on scaffolding and guidance in inquiry approach.

Some might critique that this approach is too narrow if the pre-service teachers do not fully use authentic, open inquiry and be concerned that it lacks the depth of scientific inquiry mind. Yet, this study attempted to focus on the possibilities of everyday classroom-based inquiry teaching which could enhance pre-service teachers' willingness of inquiry teaching in everyday classroom situations to enhance children's thinking. We found the approach taken in this study to be feasible and encouraging to the pre-service teachers in their attempt to incorporate inquiry in everyday classrooms.

Confidence by acquiring a set of knowledge and skills

We found out that practice of textbook activities with inquiry orientation encouraged the pre- service teachers to practice inquiry teaching in everyday classroom situations and provided them learning opportunities to acquire a set of certain knowledge and skills in the activities. This seemed to have brought forth much confidence in inquiry-based science teaching. Through practicing textbook activities, the pre-service teachers became familiar with the set of knowledge and skills in the activities. Raising questions, changing materials, and searching for knowledge, they got comfortable and confident in knowledge and activities and in teaching for children's thinking and inquiry minds. Excerpts from their writing indicated that they developed confidence in implementing practical inquiry during the course.

> I found them [experiments in elementary level] difficult to carry out. Practising was critical. I feel more prepared for teaching (Cheol, reflective writing).
>
> Once I know how to do it, I can make it more interesting... Children would not know answers before the class. In this way, I can arouse their curiosity (Min, during discussion).
>
> Doing and writing answers is not all that is involved in practical work. It made me question how I can challenge my students to inquire into the work and how I can complete the process within 40 minutes (Jeong, reflective writing).

> Since we practiced many activities from the science textbooks, I feel more ready to teach in the science classrooms. I could also change things around and it was good practice to restructure things in textbooks (Chang, reflective writing).

The pre-service teachers could make changes to their activities in terms of topics, questions, materials and processes. With the changes, they had to search for information and scientific explanation related to the activity they had prepared. That is because they did not know what results those changes would bring out and they should know why those results took place for classroom discussion later on. In this way, this process provided them valuable opportunities to develop their own content knowledge and skills. Hyung talked about his own efforts on searching for scientific explanation for his activities.

> Every time I made a change, I had to check how it would turn out. Then I had to think about how I explain it to others. I spent much time at the library reading science books. It was challenging but glad when I found out scientific explanations to it (Hyung, discussion).

When developing the activities from the original texts, the pre-service teachers also encountered many cases of unexpected results, which led them to discuss how they could cope with the situations. They found this process to be meaningful in learning about the process of scientific inquiry.

Conclusion and Discussion

This study shows that the pre-service teachers in Korea seem to hold narrow understandings toward inquiry and practical work. Inquiry process was regarded as open process which means students have their own questions and look for answers by themselves. For this reason, inquiry process seems quite impossible to be done in everyday science classrooms because of lack of students' competency, conditions of science classrooms, and content-focused curriculum. Their views on practical work are also related to the contexts that they dwell in. For example, because of emphasis of content knowledge in science teaching, practical work is regarded as a tool to teach scientific knowledge in textbooks, therefore it needs to bring out the right results. When it does not get right results, it is

a failure of teaching for them. Because of these reasons, practical work with inquiry orientation is such a challenging task for them in everyday classroom teaching. They are reluctant to practice its approach in their classrooms.

The course design was to challenge these narrow understandings and to help them develop possible strategies of teaching inquiry-based practical work on textbooks. Through the activities of modifying practical work (i.e., changing materials, reorganizing the process of experiment, adding questions, etc.), they could view possible implications of inquiry approach through practical work in their future classrooms. They also changed their ideas of ‘failure' in teaching practical work with unexpected results and developed more positive attitudes and willingness toward classroom inquiry and practical work. Getting familiar to textbook knowledge and activities and practicing applicable strategies of bringing inquiry orientation in practical work helped them gain
confidence and motivation to teach inquiry-based practical work in their future everyday science classrooms.

However, as shown in the findings, some pre-service teachers still seem to be keen to have the right results in practical work. As Hyo reflected earlier, "but I think it is better to get it right in the first place, ” this idea could be common among beginning elementary teachers when they do not have the skills to cope with unexpected situations such as talking your way through it, rigging and conjuring (Nott & Wellington, 1997). The pre-service teachers will need more time and experience to enhance their skills of coping and developing situated knowledge of teaching practical work.

Many researchers have discussed the issues of elementary teachers' difficulties in inquirybased science teaching (i.e., lack of teachers' knowledge, skills and experiences, lack of time, poor laboratory facilities, and overloaded content in curricula). This study also shows the challenges of pre-teachers' perceptions and local contexts that teachers encounter. In Korea, textbook-dependent science teaching within the centralized science curriculum also constrains teachers' practice of inquiry-based teaching. With a focus on the textbook content and materials, the process of open and authentic inquiry becomes a great challenge in science classrooms. Examination systems in the nation do not encourage teachers to practice inquiry-based teaching either. In this regard, the question is how we can help teachers to overcome the challenges of given situations and to improve inquiry approach in their science teaching practice. Despite these difficulties of inquiry teaching discussed in

previous and this research, teachers are required to practice inquiry science teaching and many of them strive to achieve through practical work.

In this study, we attempt to discuss possible ways of practicing inquiry-based practical work by considering the constraints faced by pre-service elementary teachers in local contexts. Without reflecting on limited aspects of inquiry teaching held by teachers, that is, the idealized characteristics of open inquiry and practical work as tool to teach correct textbook knowledge, their feelings of distance, reluctance, and incompetence would hinder them from its practice. Also, the social contexts of curriculum, culture, school environment, students, and community need to be taken into consideration when it comes to encouraging teachers to develop their own strategies of teaching inquiry-based practical work. With the tendency that teachers depends on textbooks and social expectation that all textbook contents need to be taught, it is important to help them develop pedagogical skills to redesign and reinterpret activities in the textbooks with an inquiry perspective. In this way, they could develop their abilities and ownership as teacher and curriculum designer.

The approach taken in this study was not concerned with renovating school laboratory condition or reforming the curriculum as a way of promoting inquiry-based practical work in elementary science. Rather, it was to set up an explicit focus of inquiry teaching through practical work by understanding the complexity of the pre-service teachers' understanding of inquiry approach and practical work and looking into the context that they live in. By doing so, we attempted to help them develop accessible strategies of implementing it in everyday teaching conditions. Without effort to understand teachers' views and lived contexts, the emphasis and encouragement of inquiry-based practical work would not bring out meaningful practice and outcomes in science classrooms.

We also understand there are limitations in this study. Some could argue that teachers' strategic knowledge and skills achieved through carrying out practical work in textbooks could give pre-service teachers only a limited view of particular knowledge and skills; thus it could be criticized as a technical-rational approach to scientific inquiry. Their argument is valid and well- taken. And yet, considering the limited conditions and constraints that elementary science teachers have been and will continue encountering in Korea, we believe that it is also important to help
them acquire strategies that are applicable to everyday classroom

conditions. Inquiry-based approach needs to be situated in social and educational systems that teachers and students live in. With our living/lived situations, we need to develop alternative feasible discourse and action of science teaching, especially for practical work and inquiry learning in elementary science education. Another limitation is the size of participant group is small, thus the findings cannot be generalized to discuss pre-service teachers' views and attitudes on inquiry teaching and practical work in Korea. Nor can the approach of course design taken in this study be adapted in other teacher education programme elsewhere. As we tried to consider the context of teachers' being and class environment in our study, we believe the context of place, society, culture, and education systems in its own place needs to be taken into account in further research.

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