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The Changes of Five-year-old Children's Understanding about the Nature of Science through the Explicit and Reflective Instruction

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ABSTRACT

This study focused on the changes of five-year-old children’s understanding about the nature of science (NOS) by participating in the explicit and reflective instruction. Participants were 106 five-year-old children. Data sources included participant observation, semi-structured interviews with children by using the questionnaire form of The Views of Nature of Science (VNOS) questionnaires. Before the explicit reflective instruction, the majority of participants held naive views of NOS except 'the empirically based NOS', but after the instruction, the participants improved their perception about the nature of science, especially 'the tentative NOS' and 'imagination and creativity' of NOS. Also, slight improvement was observed in the views of 'the socially and culturally embedded NOS' and 'the relationship between observation and inference' of NOS. Therefore, the teaching and learning activities related to the nature of science can be more effective by the explicit and reflective instruction. It is valuable to design and develop the educational program of providing the experience of the nature of science for five-year-old children.

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I. Introduction

Science is a process of knowledge allows to reach the technological advances that most closely influence on human life (Khishfe & Lederman, 2006; Lederman, 1992). Human society has advanced to the direction of more convenient human life by the development of science and technology. Due to the contribution of scientists, the treatment methods for diseases have been improved (Carey & Smith, 1993) with the development of artificial intelligence robots evolving human life more productive and enriching (Metz, 2004). Now science is considered not as one of the study areas, but as the key to solve the more serious problems of mankind, such as the human life, the human coexistence, and the environmental and energy problems. Therefore, science education is growing in importance for educating the future citizens and scientists who have the scientific literacy in order to creatively solve all the global problems which human beings will be facing in the future (Akerson, Flick & Lederman, 2000; National Science Teachers Association, 2000).

Thus science education program should be constructed for supporting students' curiosity and interests, providing the scientific sensitivity, and showing the task commitment of attempting to experiment in various ways in order to examine their hypothesis (Akerson & Hanuscin, 2007; Clough, 2006; Noh, et al., 2002). For this, experts have argued that science education should teach the nature of science (NOS) in classroom (Akerson & Volrich, 2006; Christidou & Hatzinikita, 2006; Kim, et al., 2008). Science educators have been discussed the sub-categories of the nature of science, and achieved an agreement with the contents which could be included in science curriculum. Those are summarized into the following six sub-categories; (1) the empirically based NOS, (2) the tentative NOS, (3) the socially and culturally embedded NOS, (4) theory and law, (5) imagination and creativity, and (6) observation and inference (Akerson & Donnelly, 2010; Khishfe & Lederman, 2006; Lederman, 1992).

First, the empirically based NOS mean that scientific phenomena or facts must be observed or proved through experiments. Second, the tentative NOS mean that the previous scientific discoveries can be changed whenever new facts have been introduced by the advanced experimental technologies. Third, the socially and culturally embedded NOS mean that the scientific conclusions and theories should be approved by scientific peer review and affected by socio-cultural impact. Fourth, there are the relationships between the scientific theories and laws. Fifth, science is the product of human inference, imagination and creativity. Scientists' imagination and creativity affect the process of the scientific reasoning when they design experiments, set up the hypothesis, and ask scientific questions. Sixth, there is the distinction between observation and inference. The fact that scientists theorize and observe, using the five senses of observation will be published as a scientific fact, but sometimes, the unobservable things are inferred by the scientists. Scientists are exploring the truth in an objective and scientific way in the process of reasoning. However, due to the fact that scientists have not observed directly in the eye, it could be refuted by other scientists. For example, it is with Thompson when he introduced the structure of the atom, many people questioned how he found out the interior of atoms which cannot be seen by the human eye. No one in the earth went inside the atom and observed the structure, but scientists have inferred and explained the structure of the atom through the electromagnetism. Therefore, science is about the observable facts and phenomena that can be observed, but sometimes scientists draw conclusions and make inferences without observation. So, the NOS includes the notion that the scientific interpretation by a scientist is affected by the scientists' creativity in this reasoning process, socio-cultural influences, or the existing previous studies which fellow scientists have described previously. Thus, when we understand the nature of science properly, science is not the absolute truth that you must memorize and learn, but the field of challenges where you can find a variety of studies by access to new ideas.

Based on the above-mentioned six elements of the NOS, various studies have been carried out in relation to the "nature of science", in particular, the research on teaching and learning how to educate the nature of science to K-12 students(Akerson & Donnelly, 2010; Akerson & Hanuscin, 2007; Carey & Smith, 1993; Meichtry, 1992), the research about how the students understand the concepts of the NOS(Akerson *et al.*, 2000; Christidou & Hatzinikita, 2006), the research about the pre-service and in-service teachers' perceptions on the NOS(Kim, 2012; Lee, 2006), the studies about the effects of understanding of NOS on the teachers' teaching practices(Akerson & Volrich, 2006; Clough, 2006; Metz, 2004) have been mainly conducted for adult, school aged, or gifted education.

However, the NOS related studies in early childhood science education are scares, and domestic research has mainly dealt with pre-service or in-service teachers' teaching of the NOS in education settings (Kim, 2012; Lee, 2006). International studies have also dealt with teachers' perspectives rather than young children's thinking and understanding (Akerson & Volrich, 2006; Clough, 2006; Metz, 2004), a handful of studies have been around a wide audience from kindergarten to elementary school students in public elementary schools (Akerson & Donnelly, 2010). Therefore, research on children's thinking about the NOS, on children's ability of understanding the NOS, and on what kinds of teaching and learning strategies are effective and efficient for young children's perception about the NOS has been few.

In addition, there have been many opinions on that to teach the NOS to young children is not suitable in terms of their development (Piaget, 1974; Wolfolk, 2006). According to the views of these scholars, it was almost impossible for young children to understand the NOS which implied the comprehensive concept when we consider young children's ability of cognitive development. But, due to the methodological developments of recent studies about infants, different findings from previous research have been revealed. For example, Piaget (1974) proposed that infants under 9 months do not have the concept of object permanence while Baillargeon (1993) protested that infants around 3 months and a half are capable to understand object permanence. Prior research has concluded that infant was capable of understanding the concept if infant answered the researchers question by using a verbal language. Yet, study conducted through new research methods may represent that infants have already had their inner thought. Even though they cannot express their thinking verbally, researchers can assume that infant's ability of thinking and understanding about certain concepts by interpreting their gestures and eye gazes. Likewise, the development of research methods has made it possible to discover the capability of young children, and which was recognized as an impossible ability of children in previous research. It revealed that young children's cognitive ability develops much earlier than Piaget previously claimed.

Moreover, according to Piaget (1974)'s study, young children are difficult to understand the cause of a natural phenomenon, especially when they understand a certain fact, they tend to judge and to conclude the results based on the externally visible phenomena. Young children firstly understand the natural phenomena on magical stages, and gradually advance to the animistic stages. They finally become to figure out the causal relationship at around 7-8 years old, However, according to the recent research, the very young children can have the ability to infer the physical cause-and-effect relationship, and can explain the scientific causal relationship about the natural phenomena even before arriving at the stage of development that have the exact mechanism for this reasoning (Cho & Kim, 2009; Christidou & Hatzinikita, 2006).

Cho & Kim (2009) have studied the process of scientific inquiry of 2 years old children and reported that infants aged 2 performs high-level scientific inquiry skills such as prediction, inference, variable recognition, and hypothesis, as well as observation, comparison, classification, and measurement. Based on Kim & Lee (2009)'s study, it is concluded that the very young children, who has scientific misconception in certain facts, try to gain the correct understanding about the facts based on their prediction and inference on the relationship between the existing theory and the newly discovered evidence, when presented the material which is inconsistent with this misconception.

Abd-E1-Khalick, et al. (2001) said that young children's development about the concept of the NOS is more effective after participating the explicit teaching and learning activities rather than the exploratory learning activities. Above all, various studies have found that pre-service and in-service teachers' teaching of the NOS has a positive impact on young children's development about the concept of the NOS (Akerson, Flick, & Lederman, 2000; Akerson & Hanuscin, 2007; Akerson & Volrich, 2006). Akerson &

Donnelly (2010) reported that young children were ready to understand the NOS and became to think of the scientific concepts related to the NOS more deeply after participating in the explicit teaching and learning activities of the NOS. The categories of the NOS which young children could develop after the participation of the explicit learning experience were observation and inference, imagination and creativity, the tentative NOS, and the empirically based NOS, but, the concept of subjectivity of science was a little improved. Therefore, the research studies for exploring the solution of the questions, such as how young children think of the NOS, how explicit teaching and learning activities for very young children can have a positive effect on children's understanding the NOS, what kinds of scientific experience young children have when participating in the explicit teaching and learning activities, were very small.

Science education should be made up to foster scientific curiosity which includes a scientific sensitivity and interest in scientific phenomena, not only from the reassurance and understanding of the theories and concepts discovered and established so far. Science education is an important discipline of providing a substantial and developmental influence on human life by converging with creative ideas. When we consider the creative aspects of science education, young children's scientific literacy skills can be built up by the quality scientific experience for young children.

The present study explored the contents and the meanings of young children's experience of the NOS while participating in the explicit and reflective teaching and learning activities related to the NOS in early childhood education settings. The research questions pursued through the present inquiry were as follows; firstly, what had 5-year-old children experienced about science during the explicit and reflective teaching and learning activities related to the NOS? and secondly, what was the meaning of the scientific experience of 5-year-old children during the explicit and reflective teaching and learning activities related to the NOS?

The results of this study will find out the meaning of young children's thinking about science during the participation of the explicit and reflective teaching and learning activities, and provide the early childhood science education specialists with the educationally meaningful ideas about how to design and develop the program of science education for 5-year-old children.

II. Methodology

A. Research Participants

Research participants were 106 preschoolers, who were fifty-four boys and fifty-two girls, and 3 teachers in 5-year-old classrooms at a kindergarten attached to D public elementary school located in Seoul, South Korea. The researcher sent the forms of the consent of research participation to parents of 120 preschoolers in that classroom, and received the signed forms from 106 parents. Research participants' names were treated to ensure anonymity. All the participants were from the middle or the upper-middle classes and lived in the surrounding apartment complex, therefore, the social economic status (SES) of parents was similar. Twenty children out of one hundred six children were observed and interviewed by a researcher for 5 months. They were in one classroom where a researcher had observed more closely. This kindergarten has three 5-year-old classes, two 4-year-old classes, and two 3-year-old classes. Each homeroom teacher had 5~6 years of teaching experience and graduated from a four-year-course college majoring in early childhood education at the school of education in university. Two of these teachers were students at graduate school of education while participating in this study. One of these teachers was very interested in the science area, and decided to enter the graduate school of education in order to study more about how to provide the meaningful scientific experience to young children in that area and how to integrate the science area with other interest areas in developmentally appropriate ways. All twenty participants who played in the science area during free choice activity time were observed by a researcher. Sometimes, if the child voluntarily participated in activities taking place in small groups with a teacher in a science area, it has been observed by a researcher, too. In this way, the researcher tried to include young children's natural play patterns as it was in the regular classroom situations as much as possible.

<Table 1> Research participants

no.	**name**	**sex**	**age (mos.)**	**participant's characteristic observed at pre-test**
1	Kim, Jiae	F	71	not interested in science area, but participate in that area as a small group with a teacher
2	Kim, Jungwon	M	74	interested in minicars to play with at block area, fond of taking care of animals and plants at science area
3	Kim, Sanghyun	M	72	try to focus on puzzles for a long time at manipulative area, and visit science area for playing with new materials once or twice a week

4	Na, Yeji	F	70	mainly play at language area, especially like storybook reading, and rarely work in science
5	Mun, Jiwoo	F	68	very interested in turtles raised in her classroom, feed and observe them very closely
6	Park, Bumjun	M	67	mainly play at art area and block area, but also actively participate in small group activities at science area
7	Park, Hyeree	F	69	drawing activities at art area, role-playing with peers at dramatic area, but not interested in science activities
8	Song, Jihoo	M	71	mainly play at block area rather than science area, show interests in small group science activities but do not participate in them
9	Shin, Minsoo	M	63	raising beetles at home, very interested in insects enjoying talking about animals
10	Shin, Yeoju	F	70	play quietly at art area or manipulative area, and hardly participate in science activities
11	Yun, Sunghun	M	73	enjoy observation journal writing about plants and animals at science area, but not much interested in other materials at science area
12	Yun, Jihwan	M	64	usually play at block area, but sometimes come to art or language area when a teacher calls
13	Yun, Jungyeun	F	69	hardly play at science area, but interested in magnifying glasses and scales, mainly play at dramatic area
14	Jang, Minjun	M	70	not showing any response to researcher's question, just experiencing the observation of leaves or shells at science area
15	Jang, Seoyoung	F	70	observing goofy for a long time, but not participate in other activities at science area
16	Cho, Munsung	M	63	very interested in materials and books at science area, bring a strange bottle called "monster liquid" and introduce it to friends for sharing interesting ideas
17	Ji, Hyunjun	M	74	actively participate in small group activities at science area, and usually enjoy playing at block area
18	Choi, Hyunkyung	F	73	mainly reading story books at language area
19	Ha. Isul	F	69	hardly interested in science activities, but enjoy observing newly introduced pets in class
20	Hong, Minkyu	M	72	usually play at science area, and especially actively participate in child-directed activities, such as classifying materials

* Participants' names are all anonymous.

B. Data Collection and Analysis

1. Data collection

In order to figure out the understanding of the NOS, The Views of Nature of Science Questionnaires (VNOS) had been translated and revised to be suitable for surveying the young children. Items made an agreement among scholars that the information might deal about the nature of science in education were included in the VNOS. The items were theory and law, the relationship between observation and inference, the empirically based NOS, the tentative NOS, subjectivity, imagination and creativity, the socially and culturally embedded NOS. Among these, theory and law, which is beyond 5-year-olds to understand, had been foreclosed (Akerson & Donnelly, 2010). Subjectivity was also excepted because it is information that can be included in the area of observation and inference or imagination and creativity. The face validity of the revised questionnaire had been verified from two early childhood education experts and one science education expert. In addition, we recruited five 5-year-olds, who were not the present research participants, for the preliminary test in order to check out any difficult or misunderstandable terms are used, and finally modified with easy-to-understand terms according to the feedback. This questionnaire included five aspects of the NOS, which are the empirically based NOS, the tentative NOS, the relationship between observation and inference, imagination and creativity, and the socially and culturally embedded NOS. The in-depth interviews utilizing this questionnaire before and after the explicit and reflective instruction about the NOS were conducted. The researcher audio-recorded and translated all the contents of research participants' response to the questions. The recorded amount was the total of 12 tapes with 30 minutes of each tape.

2. The explicit and reflective instruction about the Nature of Science

The explicit and reflective instruction about the NOS focusing on 5-year-old children was done over a period of 5 weeks, mainly conducted at science area in a classroom, but if necessary, linked with art area, language area, or block area. For the extension of the activities observed from the outside, taking advantage of the recording feature of digital cameras, exciting activities, which have been conducted by some of the children outside to play with the whole infants, were also planned. Video recording was in progress while the activities were going on. The video recording amounts collected through twenty-one of participant observation was a total of 28 tapes, and which were 60 minutes of running time each tape. Field notes written through participant observation were a total of two books, and which were 80 sheets of A4 sized paper each notebook.

The explicit and reflective instruction related to the NOS followed the framework of the teaching strategies that Akerson & Donnelly (2010) designed. Detailed information was modified according to Korean kindergarten classroom situation, and then, verified by two early childhood education experts. The explicit and reflective instruction was constructed by the following five contents; first, introducing the NOS though the non-contextual activities, second, participating in the NOS activities related to scientific contents through contextual activities, third, utilizing children's story books, fourth, summarizing the activity results and evaluating the NOS, and fifth, participating in the exploratory science classes via teacher-guided or child-directed activities.

3. Data analysis

The data collected in this study were the video recorded tapes related to the explicit and reflective instruction, the memory chips of the digital camera including the outdoor play activities, the field notes, and in-depth interviews with young children. The explicit and reflective instruction about the NOS carried out for this study was prepared to set the basic framework based on previous studies, but while the research was in progress, a teacher tried to link children's interests to the NOS activities, and to deal with the topics child-initiated activities.

The collected data were translated on the observed day, and the translated data were re-read several times. While re-reading, emerging themes were categorized and analyzed according to the research questions (Miles & Huberman, 1994). While repeating the review of the categories of analyzed data several times, a new concept was added or integrated into the existing conceptual categories, and the constructed categories were modified and supplemented throughout the process. Two early childhood education experts, who had experience of qualitative research, reviewed and advised, and discrepancies between researchers and reviewers that occurred during the review process was modified through discussion in order to increase the accuracy of the data analysis.

II. Results

A. Preconceptions about the NOS

Looking at the science-related preconceptions of 5-year-old children and their understanding of the NOS concepts after participating in the explicit and reflective instruction, we could find out that young children increased the level of understanding the NOS in all five areas. 5-year-old children thought that science is what scientists have discovered through observation and experimentation, and therefore, children's preconception about the empirically based NOS scored higher than in other areas (M=2.01, SD=.23). But they had inadequate thought about other areas such as the tentative NOS (M=1.05, SD=.54), the socially and culturally embedded NOS (M=1.02, SD=.91), imagination and creativity (M=1.00, SD=.32), the relationship between observation and inference (M=1.14, SD=.29). Moreover, they thought that the aspects of imagination and creativity were against science.

<Table 2> 5-year-old children's understanding of the NOS(N=106)

the aspects of the NOS	pre-test		post-test	
	M	SD	M	SD
the empirically based NOS	2.01	.23	2.85	.25
the tentative NOS	1.05	.54	2.63	.31
the socially and culturally embedded NOS	1.02	.91	1.47	.73
imagination and creativity	1.00	.32	2.78	.11
the relationship between observation and inference	1.14	.29	1.85	.13

However, after participating in the explicit and reflective instruction, the empirically based NOS (M=2.85, SD=.25), the tentative NOS (M=2.63, SD=.31), and the imagination and creativity (M=2.78, SD=.11) had greatly improved, while the socially and culturally embedded NOS (M=1.47, SD=.73), the relationship between observation and inference (M=1.85, SD=.13) had slightly advanced.

1. Young children's preconception: science as absolute truth which exists outside

We found that 5-year-old children had already had objectivity of truth prior to their preconception about the NOS. This was apparently internalized in engagement with the subject of science because children strongly believed that science is the absolute truth that exists outside and scientists are trying to find the truth through observation or experimentation. Children thought that only scientists were scientifically knowledgeable enough to find out the absolute truth through scientific inquiry which is processed based on their vast scientific knowledge.

> (Scientists are supposed to) know much about science...If they don't know (science) well, they cannot do science. Scientists can experiment because they know a lot.
>
> (R child, in-depth interview, 10/01/2015)

> My uncle is a scientist...Scientist studies hard, and knows a lot about nature and things...He (my uncle) said scientist can make(invent) something convenient for human lives.
>
> (K child, interview, 9/14/2015)

During a discussion of the empirically based NOS with young children, it was found that they thought scientists discovered the scientific truth which existed as an absolute truth through the method of direct experiment. Therefore, external absolute truth is unchanging and the purpose of science is to find that absolute truth which makes human lives more convenient.

2. Young children's preconception: unclear and ambiguous concept

Young children had a vague and unclear preconception in the aspects of the socially and culturally embedded NOS and the relationship between observation and inference.

Understanding of the impact of the society and culture which are the expanded concept of relationship to very young children can still be difficult. Considering their developmental stages, information observed is understandable through five senses, but the process of reasoning is difficult for them to fully understand and express verbally. Comparing the socio-cultural influence on science, which means scientist ask questions and do experiments based on his socio-cultural background, with the influence of socio-cultural foundation of scientists whether they accept a certain scientific fact found by a certain scientist in a certain time, young children have a confusion of their social knowledge related to foreign greetings, foods, and customs with the scientific facts.

> Like each country has different languages, different wardrobes and different foods?.....but, the fact science pursue to find out cannot be different...science should be understood by everybody...that is science..... such as where rolling balls go, and how mixing colors become another color...all the same in India and also in Korea.
>
> (J child, interview, 9/26/2015)

> All the scientists cannot experiment and observe all the things.....sometimes scientists cannot see something...which is invisible or too deep to see...because dinosaurs had lived before human beings lived.....Nobody truly saw dinosaurs with his naked eyes.....even scientists...so scientists find out dinosaur bones or fossils while investigating caves...after finding out fossil fractures, scientists figure out that a dinosaur looks like this...if he saw the fossils, is that an observation?
>
> (H child, interview, 9/06/2015)

In addition, when having an interview about observation and inference, young children tried to talk confidently about observation. But while talking, they finally became to confuse the concept of observation and inference. It was possible to describe the concept of observation that was already well understood, but in the part of explaining reasoning, the ambiguity of two concepts, observation and inference, caused the disconnection of message delivery.

3. Young children's preconception: science as unchangeable truth

Young children had a preconception of considering science as unchangeable truth. Scientific fact is the absolute truth existing outside. If a different experimental result was found by a different scientist, one of which is true and the other must be false. If another scientist found out different experimental results on something one scientist had already found out and concluded, one of them might be right, and then, the other might not be right. In this case, young children tend to believe that the second experimenter might be wrong because the scientific fact which was originally found should be true and unchangeable.

> Science is not changed....the earth is in the universe and the moon is in the universe, too. This fact is not changed...that is a science.
>
> (A child, interview, 9/14/2015)

> Scientists...(with experimental instruments)...can experiment very well.....what scientists have already presented cannot be changed.....after repeating experiments several times, the results should always be same.
>
> (C child, interview, 9/22/2015)

> Like sun sets in Africa, sun does in America and in Korea.....in any countries, science is not changed.....to earthians or to aliens...science cannot be varied.
>
> (D child, interview, 9/17/2015)

Young children thought that science is an unchangeable truth, such as the universe and the sun exist all the time without any error. They believe that science should share the same experimental results all the time because it is an absolute truth. They tend to confuse between the natural phenomenon, such as the sun sets, and the tentative NOS. Therefore, 5-year-old children tried to understand the tentative NOS related to the natural phenomenon, after finding out the scientific fact, they thought that it should be accepted and learned as an outside absolute truth.

4. Young children's preconception: distinguish science from art

Asked about scientists' imagination and creativity, young children considered science is exclusive to imagination. Differing from art which made from imagination and creativity, science is related to the fact and the experimentation. If scientists think creatively, he does not do the science any more. The most important aspects of science are to experiment objectively, to observe rationally, and to maintain objectivity through obtaining pre-discovered scientific knowledge.

> Imagination is not allowed.....If imagine, not a scientist, but a character in story books.....Scientists must not say what they imagine, they must tell something found from books or experiments.....or directly found in a cave.....so people trust scientists' reports.
>
> (H child, interview, 9/26/2015)

> But it's wrong when scientists make something like artists do.....That isn't science but art.....because...art area is different from science area in a classroom.
>
> (K child, interview, 10/04/2015)

To scientists, obtaining a scientific idea, designing experiments with new ideas, and deriving the results by using the experimental apparatus in a new way are very important. Young children thought that imagination or creativity should go with arts or crafts. Science should maintain the scientific objectivity based on the discovery through experiments and observation which people might trust.

5. Young children's preconception: the importance of scientific knowledge, experimentation, and observation

Young children thought that scientists have a lot of scientific knowledge, they have studied a lot and know all the pre-discovered scientific facts clearly. According to young children's answers, the process of scientific inquiry includes the experiment based on the scientific knowledge and the verification through observation of the discovered facts. If not, that is not a science but a fiction or a fairy tale.

> Science is about something happened in this world. Scientists always find out the fact through experiment.....If not found through experiment, that is not a science. It's a fairy tale. Sometimes scientists discover something, but mainly do the experiment or find out dinosaur's bones directly.
>
> (H child, interview, 9/30/2015)

> Cause we can see apples fall from trees.....then we can know...something heavy falls down......as Newton said.....But many things we cannot see exists..... We cannot see inside human body, so we try to see it through endoscope or X-ray.....but using endoscope or X-ray is up to scientists...scientists use them.
>
> (B child, interview, 10/09/2015)

When explaining the relationship between observation and inference, young children thought that observation is very important in science because all the scientific proofs should be observed or experimented. If it is unobservable, various high-tech equipments can be used in order to investigate scientific truth, and so, the importance of observation is perceived even by young children. However, young children's clear understanding related to inference was insufficient.

B. Area-specific understanding of the NOS

1. The empirically based NOS

Most of children understood the empirically based NOS. Young children's understanding of the tendency of empirical science gained high points at both of pre-test and post-test because they thought that a scientific result should be obtained by a precise experiment. The characteristics of the tendency of empirical science which very young children recognize are as follows.

> Scientists can experiment pretty well. Science is what scientists discovered by experiments. Without experiment?...we must experiment that.
>
> (I child, interview, 10/08/2015)

> If other scientists conduct the same experiments, the results must be same. When we (young children) do (experiment) at science area, always the results are exactly same.
>
> (P child, interview, 9/17/2015)

Young children perceived that the scientific result or knowledge proved by scientists is objective and empirical. Whenever the experiment is repeated, they thought that the results should be identical, and so, the reliability and validity were already proved enough to get the same results. Moreover, some children considered science equal to experiment. Even though experimentation in science is so important, experiment is not equal to science. Science education in preschool or kindergarten should expand the experience of the real scientific inquiry process, rather than just writing an observation journal or only observing and experimenting as teachers showed.

2. The tentative NOS

The tentative NOS means the interim of the scientific knowledge, in other words, the application of new experimental methods and new interpretation can change previous scientific theory. In order to help young children to understand the concept of the tentativeness, a researcher prepared various materials which will be used the experiment of "floating or sinking" at science area. After placing a variety of materials, such as various shapes, colors, or types, a researcher asked young children to assume in order to classify something floating on water or something sinking in water. At first, young children were asked to group them, as they guess, with pencils and notes prepared at science area. But for children who are illiterate yet, tiny picture cards of prepared materials were ready for them to participate in the classification activity. Besides the provided materials, young children were able to draw any materials they think in order to include for putting in the classification box. Young children were allowed to use any concepts they want, such as "smaller thing", or "thin thing." After two days of random classification based on young children's guess, young children were asked to talk about or write down the characteristics of classified materials in certain category. They wrote down "yellow," "big," or "thin" on the below of each box. Next day, two water tanks filled with water were provided for them to explore if their guess was right or not. On the bottom of each boxes, young children could categorize floating things or sinking things according to their new experiments.

> At first, I thought small thing might float on water... but this wooden boat which is bigger than that small one floated....it was wield...and I have to correct it (small thing floats, and big thing sinks) now. (Q child revised the classification boxes on the wall)
>
> (Q child, recording log, 9/28/2015)

> More important if it is a wood or an iron.....rather than big or small.....Styrofoam floats easily among any other things.
>
> (M child, recording log, 9/27/2015)

> During my experiments, yellow things all floated. But the color does not make it float......But all the floating things in the box are yellow.
>
> (H child, in-depth interview, 9/26/2015)

> I can revise it whenever new things are discovered......at first, I thought so (small things float).....but now I think.....iron is heavier than wood.....so even small things can sink....right, iron sinks, wood floats, now I need to move it. (revising the classification boxes)
>
> (R child, field note, 9/29/2015)

Unlike young children's original categorization, the color or size did not affect the phenomenon of floating or sinking. The items they expected first should be modified after the actual activity. A teacher tried to discuss with young children during this process by asking if the scientific knowledge scientists originally thought might be always correct, or if it can be changed whenever new experiment results or facts are discovered by other scientists.

> (A researcher asked, if a scientist find out that he is wrong, then what should he do?) He should experiment again and again.....but if the first thinking was wrong, then he can revise it.....like me, I revised.....but for revising, he should experiment many times. Just one time and then revise it...that is not good.
>
> (O child, in-depth interview, 9/25/2015)

> (A researcher asked, if a scientist find out new facts with high-tech experimental equipments, then what should he do?) If new equipment comes out, the results can be changed. Without microscopes, we could not see microorganism.....now with it, we can see what we couldn't.
>
> (L child, in-depth interview, 9/29/2015)

While participating in the classification activity of floating or sinking, young children have had an opportunity of thinking and discussing about the tentative NOS. They have not thought about it before, but new possibilities of discovering new scientific facts by using high-tech or new ways of experimental equipments are opened. Now young children became to understand the very important scientific inquiry process, that the scientific knowledge can be changed after convincing the validity and reliability through repeated experimentations. In addition, even though the scientific knowledge was changed, the hasty conclusion, which the previous knowledge is wrong and the newly discovered fact is right, should be avoided. Science is about explaining a certain natural phenomenon, so sometimes, each scientist has different ways of explanation on that condition, but it is not about right or wrong, it is about how to explain the natural phenomena in certain conditions. However, as compared with young children's preconception of the science as an absolute truth, young children became to understand the tentative NOS, which mean that scientists' new ways of approach bring new interpretation and new discovery, after participating in the explicit and reflective instruction.

3. The socially and culturally embedded NOS

Young children have had a difficulty of understanding the socially and culturally embedded NOS because socio-cultural area is much broader than individual and family relationship areas. A researcher has planned to read story books so that young children can understand the socially and culturally embedded perspective. The title of the fairy tale, 'Galileo Galilei' helped young children to think about that, even the newly discovered theory was right, the scientific community could not accept the fact because the geocentric theory was prevailed at that time. The Copernican theory proposed by Galileo Galilei was not accepted even though it was truly right.

> Galileo Galilei said...but people said he was wrong.....for a very long time, people thought the sun moves, so people cannot change their thinking.....the earth moves around the sun. It was right, but people were reluctant to accept it.
>
> (E child, recording log, 10/15/2015)

> Galileo Galilei was one, but other people were many.....Many people said the sun moves...suddenly one man said the earth moves.....everybody said that's not true...difficult to fight with many people....Galileo Galilei was just one. Truly Galileo Galilei was right, but he was sad because everybody said he was wrong.
>
> (C child, in-depth interview, 9/28/2015)

> Scientists experiment alone.....if he discovered something, it is a science...but other scientists are there.....they are supposed to say your result is right.
>
> (F child, interview, 9/27/2015)

In order to deal with the socially and culturally embedded NOS, a teacher and young children read story books and discussed together. While reading and discussing, young children could think of the topic freely and express their thinking on their own ways. When this new discovery challenges for the already agreed-upon approach by the members of society, the members are trying to find a compromise. But if the majority of scientific phenomena are explained by conventional wisdom, the members cannot accept and acknowledge new scientific knowledge by rejecting the previous one. Therefore, science is not something that can be defined by factorial knowledge and results. Young children showed a tendency to think of the topic based on the good and bad people positions, such as the main character, Galileo Galilei must be good and others might be bad rather than thinking in light of a cultural consensus about the newly discovered fact. A teacher tried to let children think about this from the perspective of Galileo Galilei, and also from the perspective of other scientists. Young children are helped to focus on the scientific perspectives based on socio-cultural backgrounds rather than the idea of good and evil. However, young children have gradually figured out that the study results and findings by scientists are not achieved by one scientist's individual working, but accomplished based on the relationship of social and cultural impact of other scientists in the discipline.

4. Imagination and creativity

Before participating in the explicit and reflective instruction, young children did not reach the appropriate level of understanding of the NOS, especially imagination and creativity, which means 'science is created and imagined, and a scientist's inference is sometimes necessary.' They thought that scientific knowledge is discovered through experiment or observation. According to young children's perception, if science is composed of imagination, then it is not a science any more.

> ...no imagination allowed....an experiment is necessary for science to be a science....scientists do not make it as they want with imagination.
>
> (L child, in-depth interview, 10/08/2015)

While young children played outside, three boys played with sand. Among them, a boy brought water and unceasingly poured it at one side of sand area. Another two boys tried to block water flooding and built a high fence in order to construct ants' village. A teacher video-recorded the situation with a digital camera for bridging with 'the caring science' (Cho, Kim, & Kim, 2011). Later, at the time of large group discussion in classroom, they played the video clip and talked about how to help ants to keep their village from floods.

Young children said that, in order to protect the ant's town from flooding, they must create a town on higher ground and build a high fence around the village for protecting water from coming in, and then, they actually made it at outdoor play area and also pouring water in it to pretend of flooding. A teacher asked if ants in that village can live happily without worrying about floods. They answered yes and said that water will be necessary for ants to live on. A teacher played a previously prepared video dealing with the 'straw of life,' one of video clips about 'caring science' to the class. The teacher's question related to the video clip was as follows. When someone who made this straw, first saw African children who had drank muddy water, what might he think? Young children thought about the idea of scientists, new ideas, imagination and this new invention. Through these activities, children expressed their thoughts and different opinions, and broadened their understanding of imagination and creativity of the nature of science.

> pitiful...wanted to help them...so a scientist thought and thought.....again and again. One day he saw someone drinking a juice with a straw by chance, his idea suddenly came up.....(A researcher asked if that is a scientist's imagination?)...not an imagination, it was an idea. Good idea came up whenever we think a lot.
>
> (B child, in-depth interview, 9/30/2015)

> He imagined.....African children's smiling face of drinking clean water.....the imagination of helping poor children.....(imagination is) not ok when experimenting, but (it is) ok when caring.
>
> (C child, interview, 10/02/2015)

Young children's perception of science has been changed from that scientists should not imagine at all, to that imagination and creativity influence in certain ways in science. But it was so difficult for young children to understand that a science is influenced by a scientist's imagination, creativity and inference. The reason might be that the notion of the imagination and creativity of the NOS seems to be the most opposed to the idea that science is objective fact. Through the imagination, scientists can help and care others which is very meaningful works for scientists. In addition, during the large group discussion, young children became to recognize the imagination and creativity as the NOS. However, some children strongly believed that the imagination and creativity are not allowed to scientists during the experiment and observation, as time goes on while participating in the explicit and reflective instruction, children thought that imagination is allowed in the case of caring science, but not generalize to other areas of science. Nevertheless, during the ongoing science-related activities, even very young children frequently used to say that a scientist can imagine, and showed to expand their thoughts on the notion of imagination and creativity of NOS.

5. Observation and inference

In terms of the observation and inference of the NOS, scientific knowledge can be constructed by deducing results through observation, but beyond the observation, scientists use the inference based on the results and the previous studies, and also, invisible parts of phenomena should be inferred by scientists. For helping to understand if what we observe is always right or not, the activities of Black box (Akerson & Volrich, 2006) and magnet picking activities were used. Young children were asked to think of what was inside by putting hands into the black box and touch anything in it. Infants were to look at only touched by hand in the black box containing the object thought to whether certain things in it and say. Infants have different ideas and answers for the same object. They had different ideas and answers toward the same material. They had various ideas and thoughts about the question of how scientists study something invisible, which means that a scientist's observation is not possible. Young children did not mention a scientific term, the inference, in this case, but became to think of the process of finding out scientific facts through reasoning.

C child: Nobody saw dinosaurs, but they saw dinosaur's bones.
J child: Because of finding dinosaur bones, (scientists) know about dinosaurs.
Teacher: Scientists only discovered bones, but how could they know dinosaur's eyes or skin colors?
A child: Then, dinosaurs now (the present images of dinosaurs) are fake?
Teacher: Well, how did they know its eyes or skin colors?
C child: Scientists always think and think while setting bones.
R child: Dinosaur's bones were set, and skin colors were thought (inferred) by scientists.
A child: So, if we find new bones, dinosaurs might change?
N child: No new bones have discovered yet.
Teacher: So scientists try to find something new and study more and more. Even though finding out answers is not possible, keep asking questions. Is

there any new discoveries? Are the images of the present dinosaurs true? Then, you will find the answer someday.

(a teacher and children, recording log, 10/06/2015)

K child: I haven't been the universe before, but I have heard about it from an astronaut.
A child: Right,... not going to the universe, we can see it through a telescope.
M child: I don't have a telescope...so I can look stars with my eyes.
A child: Stars can be seen at night without a telescope...but with a telescope, we can see the universe more clearly.
L child: A telescope makes us to see new things.

(children, recording log, 10/11/2015)

It is very important to think of the role of inference in science at the experimental situations which observation is not possible. Scientists become to discover new facts through the scientific inquiry process of the observation and inference. Having thought about scientists' inquiry process of knowledge, young children will have a scientific attitude while asking the scientific questions continuously, such as why? or Is it true?, rather than simply absorbing in a passive attitude and only thinking that a scientist might be a very smart and unusual person whom they cannot be special. Science is not a sacred area of unusual scientists, but a general area of anybody, even infants, can try to ask new questions and open to new attempt. Magnets picking activities are ones that are aware of the limitation of observation by looking at the difference between materials that cannot be attached to the actual content, and the magnets that can be attached after the classification based on the observation.

S child: Iron attaches (to magnets), so let's pick up iron.
F child: This is iron..... is this iron, too?
A child: Silver things are all iron.
B child: No way, silver things cannot always be iron.
A child: No, silver stuffs are iron. That is iron. (classifying a plastic stick of silver color to the blank of 'substances that stick to a magnet')

(children, recording log, 10/08/2015)

As one would know that what children classified through the observations was sometimes not right, and needs to be modified, we have talked about the observation and inference of the NOS. As scientists' observation is not always right, during the explicit and reflective instruction, it was dealt with that the inference and reasoning should go together for confirming if it is true or not.

> Seeing is important. (A teacher asked, we thought it was iron, but it wasn't. If wrong, what should we do?)... experiment it...(If we cannot experiment, such as dinosaurs, the universe, or underground?) If we can't see, we must think. (the concept of inference).... (How can we use inference?).....reading books a lot, and talking with other scientists.
>
> (R child, in-depth interview, 9/31/2015)

Since observation activities were performed through seeing, hearing, tasting, or smelling with direct experience, young children were able to understand the concept of observation. However, understanding the concept of inference was little improved by children because the level of inference was difficult, even replace the expression to 'reasoning.'

IV. Conclusion

The present study explored young children's understanding about the NOS, and the change of their perception about the NOS after participating in the explicit and reflective instruction. The results of this study will provide a basis of developing the science education program dealing with the NOS for young children.

The summary and discussion about the key findings are as follows. First, introducing the nature of science to young children is important and meaningful. Young children at first thought that science was an absolute truth which was discovered by an experiment or an observation. But as time goes on, through the various activities and large group discussion, they became to perceive that science is the process of asking new questions, thinking differently, and discovering new facts. Before participating in the explicit and reflective instruction, young children thought that science is difficult or scientists should be smart. They got this idea from their relatives or neighbors who are doing science. But after participating in this instruction, they became approach to science more closely by broadening the concept of science which anybody can ask a scientific question and start to experiment for finding out new discovery.

Second, there have not been science education related to the nature of science targeting young children before, but the program making young children to participate in scientific activities has a possibility of changing young children's preconception and making them to fully understand the NOS. Young children have the ability to understand the nature of scientific in developmentally appropriate ways (Akerson & Donnelly, 2010; Baillargeon, 1993). So, the science education program for early childhood has to expand the thinking through various activities and participate more in the direction of observation and experiment (Khishfe & Lederman, 2006; Meichtry, 1992).

Third, the aspects of the empirically NOS, the tentative NOS, and the imagination and creativity were easily understood by very young children, but young children had difficulties of fully understanding the socially and culturally embedded NOS and the observation and inference. This is because very young children haven't developed to establish an expanded concept of society and culture (Clough, 2006), and also, the concept of inference can be difficult for them because of abstractness (Cho, Kim & Kim, 2011; Metz, 2004). Through a variety of situations, such as, discussion, storytelling, or reading related books, young children are able to think of the concept of inference, for example, "Who brought honey from honey jar?" That is a combination of the given clues through reasoning activities, and an introduction of the notion of inference by drawing conclusions.

Finally, the teaching and learning activities related to the nature of science can be effective by the explicit and reflective instruction. Without the explicit and reflective instruction, even though a variety of objects were provided, there was a limitation for young children to understand the NOS aspects through the activities of young children's self-exploration (Kim, et al., 2008; Akerson & Donnelly, 2010). However, it could be made up through the active interaction with teachers and the explicit and reflective instruction. Science activities and experiments, as well as a way for them to realize the concept of the NOS aspects through participation in activities that cause imbalance in science stories and preconceptions were effective.

Limitations of this study were as follows. First, it is difficult to generalize results because the research participants were only 106 children. Second, the present study has only conducted for five weeks, and therefore, it has not included the effectiveness through long-term studies. Third, we have only examined the explicit and reflective instruction about the nature of science, but not included the effects on the implicit instruction or the exploratory science activities.

Therefore, in future studies, we need to perform a study of the scientific understanding of the nature of science with large subjects, and the substantial research about how to provide educationally meaningful program for supporting young children's proper understanding of the nature of science. In addition, further studies are required to explore how to design and develop a science education program for opening up the possibility of making young children understand the nature of science, and for interacting with very young children in developmentally appropriate ways.

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