Enhancing Preservice Teachers' Observation and Inference Skills

Nurcan CANSIZ
Artvin Çoruh University, Faculty of Education, Department of Mathematics and Science Education

Mustafa CANSIZ
Artvin Çoruh University, Faculty of Education, Department of Mathematics and Science Education

Abstract:

In this study, we aimed to investigate the change in third-grade preservice elementary teachers' observation and inference skills. We also aimed to develop their ability to distinguish observation from inference. A total of 27 preservice elementary teachers participated in the study. Participants' preinstruction and postinstruction observation and inference skills were explored through written statements about three different drawings. An instruction on science process skills within Science Teaching course was provided to the preservice elementary teachers. Analysis of their pre and postinstruction observation and inference statements showed that, at the beginning, preservice elementary teachers were not adequate in observation and mostly confused observation with inference. After participating in classroom discussions and activities, they improved in making observation and inference. They showed better enhancement in making observation than drawing inference. Implications were suggested in terms of elementary teacher education programs and further research.

Keywords: *observation, inference, science process skills, nature of science, science education*

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Öğretmen Adaylarının Gözlem ve Çıkarım Becerilerinin İyileştirilmesi

Nurcan CANSIZ
Artvin Çoruh Üniversitesi, Eğitim Fakültesi, Matematik ve Fen Bilimleri Eğitimi Bölümü

Mustafa CANSIZ
Artvin Çoruh Üniversitesi, Eğitim Fakültesi, Matematik ve Fen Bilimleri Eğitimi Bölümü

Öz

Bu çalışmada, sınıf içi uygulama sonrası sınıf öğretmeni adaylarının gözlem ve çıkarım yapma becerilerindeki değişimin nasıl olduğu araştırılmıştır. Ayrıca, sınıf içi uygulamanın katılımcıların gözlem ile çıkarımı birbirinden ayırt edebilme yetenekleri üzerindeki etkisi de test edilmiştir. Araştırmaya üçüncü sınıfta öğrenim gören 27 öğretmen adayı katılmış olup katılımcıların uygulama öncesi ve sonrası gözlem ve çıkarım becerileri analiz edilmiştir. Sınıf öğretmeni adaylarına Fen Öğretimi dersi kapsamında bilimsel süreç becerileri konusunda sınıf içi uygulama yaptırılmıştır. Uygulama öncesinde öğretmen adaylarının gözlem yapma konusunda eksikliklerinin olduğu ve gözlem ile çıkarımı birbirlerine karıştırdıkları tespit edilmiştir. Öğretmen adaylarının sınıf içi uygulama kapsamında katıldıkları bilimsel tartışma ve etkinliklerden olumlu kazanımlar elde ettikleri ortaya konmuştur. Ayrıca, çıkarım yapma becerileri ile karşılaştırıldığında, katılımcıların gözlem yapma becerilerinde daha yüksek düzeyde bir kazanım elde ettikleri bulunmuştur. Bulgulardan yola çıkarak öğretmen yetiştirme programlarına ve ileride yapılacak olan çalışmalara önerilerde bulunulmuştur.

Anahtar Kelimeler: *gözlem, çıkarım, bilimsel süreç becerileri, bilimin doğası, fen eğitimi*

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INTRODUCTION

Observation and inference are two essential skills for life. How could a baby learn how to dress, wash hands, wear shoes, brush teeth without observing adults? Similarly, observation and inference are cornerstones of scientific investigations. Do you think Copernicus could propose a heliocentric model (an astronomical solar system model in which the Earth and the planets orbit around the Sun) by refuting Aristotle's geocentric model (an outdated astronomical model in which the Sun, Moon, stars, and planets all orbit around the Earth) without observation and inference? Without these skills how could William Harvey defend that heart acts as a pump and advocate that blood is not consumed in the body as it is hypothesized by Galen? Observation and inference are among the important means of producing and developing scientific knowledge. It would indeed be nonsense to contend that all observations are facts but observations form a starting point for scientific knowledge which may be objective or fallible (Chalmers, 1999). Chalmers emphasized that they are objective since anyone can test it and fallible since new technologies can help better observations (e.g. microscope). Observation is defined as making sense of the world through senses or extensions of senses (Lederman, 2007). It is one of the basic science process skills [SPSs] (Burns, Okey, & Wise, 1985). SPSs serve as a way of analytical style of thinking in science. Researchers classified SPSs as basic ones including "observing, measuring, inferring, predicting, classifying, and collecting and recording data" and integrated SPSs covering "interpreting data, controlling variables, defining operationally, formulating hypotheses, and experimenting" (Shaw, 1983, p. 615). In addition to observation, drawing inference is another basic science process skill which scientists utilize frequently. Inference refers to interpretations based on observations. Inferences are not directly available to the senses (Lederman, 2007) and we form inferences based on our observations. Inferences may be in predictive or retrodictive nature (Morrell & Popejoy, 2014). Predictive inference refers to future events while retrodictive one refers to the past events (Morrell & Popejoy, 2014). Some of the other researchers also underlined that retrodictive and predictive inferences differ in time direction "as one goes from the present to the future [predictive] while the other goes from the present to the past [retrodictive]" (Watson, 2006, p. 183). Comprehending the difference between observation and inference is one of the main tenets of nature of science (NoS) as well. Close examination of science education literature indicated that NoS should be one of the basic goals of science education from kindergarten through Grade 12 (American Association for the Advancement of Science [AAAS], 1990, 1993; National Research Council [NRC], 1996). There are different descriptions of NoS in different studies. Such variations are not surprising when the dynamic nature of the construct is taken into consideration (Lederman, 2007). Although there are differences among them, a majority of researcher referred to the epistemological basis of the knowledge by referring to NoS (e.g. Clough, 2006; Lederman & Zeidler, 1986).

There are a number of aspects that individuals are supposed to develop about NoS. One of these aspects points out that scientific knowledge is tentative. In other words, it is subject to change. Lederman, Schwartz, Abd-El-Khalick, and Bell (2001) discussed that a variety of factors make science be subject to change such as currently obtained evidence, high-tech products, an alternative approach to existing data, and change in cultural values. Another aspect emphasizes that scientific knowledge needs to be based on empirical evidence. This aspect proposes that scientific knowledge should be consistent with the evidence as well as rational reasoning (AAAS, 1993). An additional NoS tenet -the role of creativity and imagination in science- defends that science requires scientists' ideas because of the fact that it is a human activity eventually (Lederman, 2007; NRC, 1996). Subjective nature of science underlines that science is deeply affected by scientists' worldviews, attitudes, the area of expertise, cultural possessions as well as their abilities (Lederman, 2007). Moreover, philosophers of science accept that a culture's acceptance of what is good and what is evil, what is right and what is the privilege, what is fair and what is biased, what is moral and what is unethical may be decisive for scientists to judge what's important to study and what is not. This is what researchers called social and cultural embedded NoS. Another tenet of NoS emphasizes that theories and laws have a different purpose in science (Trembath, 1972) and laws do not have a higher level of importance than theories in scientific research (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Theories -contrary to conventional belief- are deep-seated, genuinely confirmed, internally consistent scientific explanations (Suppe, 1977), as are scientific laws. An additional NoS aspect refutes the existence of universal, stepwise and recipe-like method that all scholars follow in doing science (Feyerabend, 1993). Although scientists make observations, draw conclusions, collect evidence, and construct hypothesis -of course, there are much more-, these activities do not follow each other unerringly.

Researchers underlined that (e.g. Chiappetta, Koballa, & Collette, 1998; Lederman et al., 2002) some SPSs and NoS aspects could be conflated with each other. This is much more obvious for observation and inference. As an SPS, observation could be defined as the process of attaining information by carefully inspecting the things using our five senses or devices such as microscopes. Based on Leager's (2008) description, inferences could be defined as the filtration and comparison of observations which are constructed through individuals' background experiences and related assumptions. In a general sense, as SPSs observations and inferences are connected to evidence and deducing rational conclusions considering that evidence (Lederman et al., 2002). As a NoS aspect, understanding the critical distinction between observation and inference is about beliefs and epistemological acceptance underlying these activities (Abd-El-Khalick, Bell, & Lederman, 1998; Abd-El-Khalick, Waters, & Le, 2008; Chiappetta, et al., 1998).

In the literature, there are mixed results on student teachers' observation and inference skills. For example, Karamustafaoğlu (2011) carried out a study with 40 preservice science teachers in Turkey and found that they have adequate observation skills. On the other hand, Karslı, Yaman, and Ayaş (2010) studied with 28 preservice chemistry teachers in Turkey and explored that some of them could not show proficiency in observation skills. In another study, Chan (2002) investigated 30 primary school teachers' confidence in teaching SPSs in Hong Kong. Chan found that teachers were most confident in teaching observation skills to the students. The study of Miles (2008), which was carried out with 24 in-service elementary teachers in USA, showed that although elementary teachers are most familiar with observation, they have the least interest and conceptual knowledge in observation. Akerson, Abd-El-Khalick, and Lederman (2000) investigated 25 undergraduate and 25 graduate preservice elementary teachers' views on some NOS aspects in the context of an elementary science methods course and found that they could not differentiate between observation and inference adequately. In scholarly papers, there is a common acceptance that realizing the critical distinction between observation and inference is important (e.g. Lederman, 2007). In order to teach students to make observations, to draw inferences and to distinguish observation from inference, it is essential that teachers should have the ability to observe, to infer, and to differentiate between the two. In light of this, we aimed to investigate preservice elementary teachers' capacity to make observations on a given case as well as to draw inferences based on their observations. We also aimed to investigate their ability to distinguish observation from inference. More specifically the following research questions were addressed:

1. Does the instruction improve preservice elementary teachers' observation skills?
2. Does the instruction improve preservice elementary teachers' inference skills?
3. Does the instruction improve preservice elementary teachers' ability to distinguish between observation and inference?

Preservice elementary teachers were purposefully selected to participate in this study because they are the first actors in introducing science to the elementary students within an official curriculum framework. Therefore, they need to understand what observation and inference are, and the difference between observation and inference so that they can provide students with opportunities to practice these skills in the classroom as earlier as possible.

METHOD

Research Design and Sample

In order to find answers to the abovementioned research questions, one-group pretest-posttest experimental design (Fraenkel & Wallen, 2006) was conducted. Twenty-seven preservice elementary teachers, who enrolled in a public university in the northeastern region of Turkey, participated in the study voluntarily. They were in their third year of the elementary teacher education program. In the sample, the numbers of females and males were 17 and 10 respectively. It was ensured that any of the participants did not take NoS course before the implementation. They have completed basic science courses (e.g. physics, biology, chemistry) and most of the pedagogical courses (e.g. introduction to teaching, education psychology, material development). Moreover, they took laboratory application in science course which included many opportunities for them to observe, to infer and to practice other science process skills.

The Context of the Study and Data Collection

The participants were taking the Science Teaching course when the data of this study was collected. Before the instruction, preservice elementary teachers (PETs) stated their observations and inferences based on Figure 1. This is called Mystery Footprints, a well-known figure in NoS literature. They were given enough time to think about the picture and write their observations and inferences. During data collection process some PETs asked us some questions such as "Could you please tell what I wrote is an observation?" or "Do you think this is an inference?" but we did not answer their questions to prevent possible clues. Moreover, we prevented them from asking questions to each other during the data collection process to establish the independence of observation. We ensured that their observations or inferences belong to their own ideas. This was necessary to interpret the findings truly.

Figure 1. The picture on which PETs made observations and inferences before the instruction (Adapted from National Academy of Sciences, 1998)

After collecting pre-instruction data, PETs were engaged in teacher-guided whole classroom discussions on SPSs for three weeks. Within the scope of these discussions, they defined SPSs and discussed the characteristics of different SPSs. They also participated in activities (in the form of different scenarios) which include a scenario with a variety of SPSs. PETs were asked to find out the specific skills in the scenario and provide rationales for each of them. An example of the scenarios is given in Table 1.

Table 1
An example of a classroom activity sheet

Direction: *Find out the science process skills in the scenario below and write why you think so.*
Scenario: Mira wonders if the effect of acid rains on plant growth is dramatic or not. She wants to test her idea. She takes two identical indoor plants. She puts them in front of the window so that they receive enough sunlight. For ten days, she watered one of them with tap water and the other with vinegar (substitute for acid rain) and the amount of tap water and vinegar were same. Every other day, she measured the heights of the two plants and recorded it on a table. She also recorded the color change and other visible physical properties. At the end of the tenth day, she made a graph showing the change in the heights of the two plants. She also compared the physical properties of the two plants. Based on what they found, she concluded that the plant watered with tap water is greener, more grown up and seems more alive. On the other hand, the other plant looks more yellowish, faded, and almost decayed. In the end, she concluded that since vinegar harms plants and it is an acidic solution, acid rains may damage the plants in nature too.

	Science Process Skills	*Your explanation*
1.		
2.		
3.		

Such scenarios were discussed in the classroom under the guidance of the instructor. For example, one PET claimed that there is an observation in the scenario. Then, the instructor asked him to explain what made him think so. He responded that Mira recorded the color of the plants every other day which means she looked at them and identified their colors. After completing a number of activities like in Table 1, PETs were required to note their observations and inferences about two different pictures in Figure 2 (known as Boy in the Water) and Figure 3.

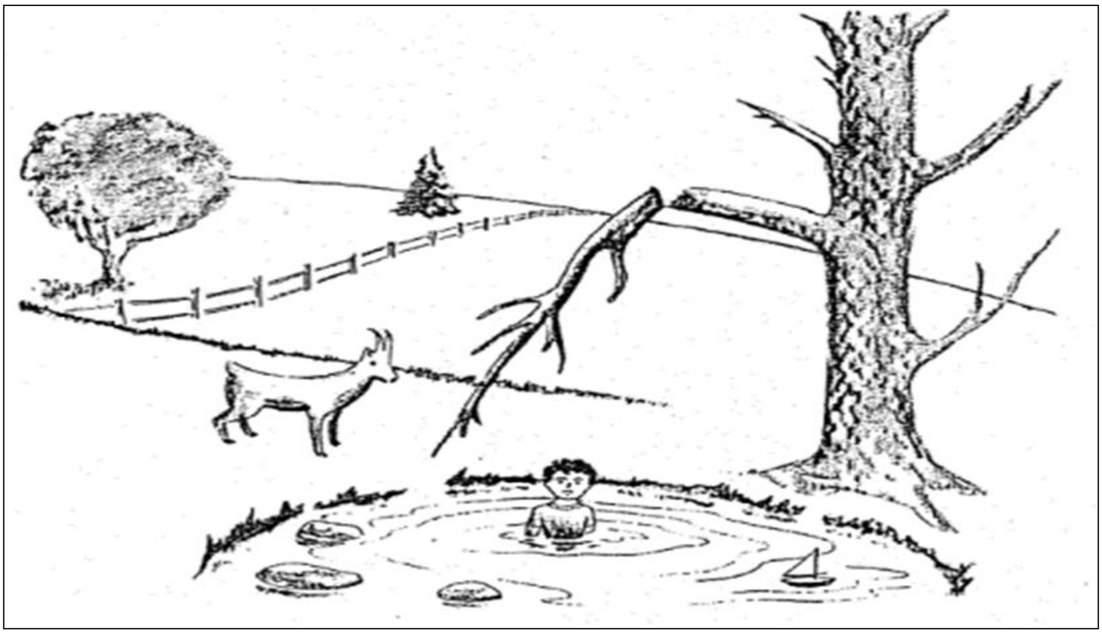

Figure 2. The second drawing on which PETs made observations and inferences after instruction (Adapted from Project Archaeology, n.d.)

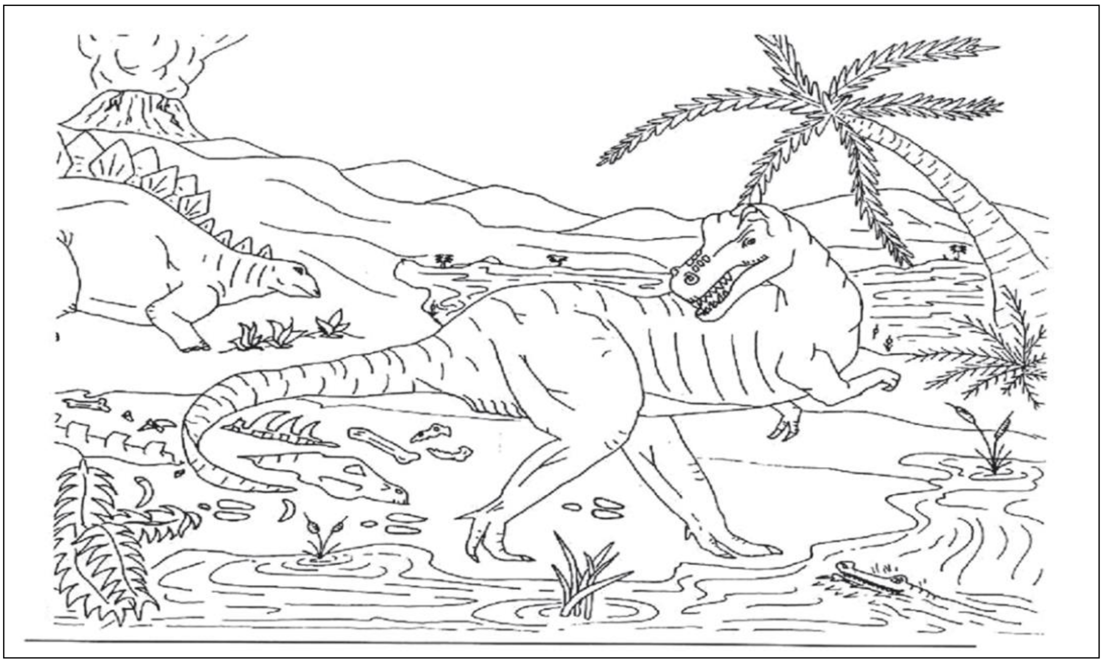

Figure 3. The third drawing on which PETs made observations and inferences after instruction (Adapted from Studylib, n.d.)

Data Analysis

After the completion of the data collection process, they were analyzed by two independent researchers. The researchers tried to form categories to organize the data collected during the study. This part of the analysis enabled the researchers to decide the nature of their observation and inference statements. When two researchers examined all PETs' documents independently, they compared their analyses for the purposes of category refinement and consensus (Miles & Huberman, 1994). After category formation, the researcher discussed categories and this part of data analysis resulted in 11 inconsistencies out of 410 observation and inference statements. The percent agreement among raters was used for interrater-reliability as suggested by McHugh (2012). It was calculated by dividing the number of compromised statements to the total statements. The percent agreement was found to be 97.3%. Then each researcher investigated the inconsistent statements once more and discussed the reason why they think so. After negotiation, the inconsistencies were resolved. The data analysis ended up with six categories for observation and inference as given in Table 2.

Table 2
Emerged categories for observation and inference statements

For Observation	For Inference
No observation	No inference
True observation	True retrodictive inference
Confuse observation with retrodictive inference	True predictive inference
Confuse observation with predictive inference	Confuse inference with observation
False observation	False inference
Confuse observation with expressing an opinion	Confuse inference with expressing an opinion

RESULTS

This section elucidates participants' preinstruction and postinstruction ability to make observations, drawing inferences, and to distinguish between observation and inference.

PETs' Observation Skills

PETs' preinstruction observation skills

Before PETs state their observations and inferences, we asked them whether they know the concepts of observation and inference. All PETs expressed that they are familiar with both of them. However, the analysis of their preinstruction observation statements revealed that out of 81 statements, only 29 of them were true observation statements. That is only slightly more than one-third of the total observation statements (35.80%) were correct. Some examples of true observation statements and their explanations were given below.

The following observation statement was considered correct. Without commenting on it, this participant wrote what he saw in the picture.

> *The figures are collected in the middle of the picture (a true observation statement)*

Another observation statement was as follows. It is evident in his statement that the participant did not interpret the picture instead he just noted what he saw in the picture.

> *There are large and small footprint-like traces (a true observation statement)*.

Another observation statement also reflected the characteristics of observation. That is, it was independent of the participant's views and background knowledge.

> *There is a cluster of figures similar to two different kinds of birds' footprints in the middle of the page (a true observation statement)*.

Before the instruction, most of the PETs confused observation with inference. In fact, out of 81 observation statements, 45 were inference with retrodictive nature. A small percent of the remaining statements was either false (7.41%) or participants did not write any statements (1.23%). The below examples are the observation statements of the participants which are actually retrodictive inference. It can be easily understood that their statements are inferences rather than observation since they all include participants' interpretations of what they see in Figure 1.

> *Those two different bird species are flying in different directions (confused observation with retrodictive inference)*
> *A bipedal animal is coming from the left-hand side (confused observation with retrodictive inference)*
> *A small and a big animal meet in the middle where big one eats the small one (confused observation with retrodictive inference)*.

Since there are no birds or other animals in Figure 1, none of the participants can truly observe birds or other animals by looking at the figure. These are just their interpretations of what they see in the figure.

When participants' observation statements were investigated person by person, we have noticed that there were only four PETs (out of 27) whose all observations were true. The more striking finding was that 11 of the total participants could not express any true observation statements before the instruction.

PETs' postinstruction observation skills

The analysis of PETs' postinstruction observation statements indicated that 79.64 % of the observation statements (262 observation statements out of 329) were true. Some examples of PETs' observation statements about Figure 2 were as follows. These participants did not add their interpretations to their statements as expected.

> *There is a tree with a broken branch (a true observation statement, Figure 2)*.
> *There are waves in the pond (a true observation statement, Figure 2)*.
> *There is a dinosaur (a true observation statement, Figure 3).*
> *There are pieces of bones (a true observation statement, Figure 3)*.

Table 3

Descriptive statistics for PETs' pre and postinstruction observation statements

Category	Before implementation Frequency (Percent)	After implementation Frequency (Percent)
No observation	1 (1.23)	0 (0.00)
True observation	29 (35.80)	262 (79.64)
Confuse observation with retrodictive inference	45 (55.56)	54 (16.41)
Confuse observation with predictive inference	0 (0.00)	3 (0.91)
False observation	6 (7.41)	9 (2.74)
Confuse observation with expressing an opinion	0 (0.00)	1 (0.00)
Total	81 (100)	329 (100)

Although PETs obtained significant gains in terms of making true observations after instruction, there are still some participants confusing observation with retrodictive or predictive inference. Among 329 observation statements, fifty-four (16.41 %) reflected the characteristics of retrodictive inference and only three statements (0.93%) were predictive inference. The statements below are some of them.

> *The broken branch may fall and hurt the child playing under it (confused observation with predictive inference, Figure 2)*.
> *There is smoke coming out of a volcano (confused observation with retrodictive inference, Figure 3)*.

At first glance, it may be seen us as smoke but it could also be a cloud or may be something else. The PET making a judgment about what he saw. Moreover, the branch may not fall at all. This is what the PET thinks when she saw the broken branch and this interpretation is for the future so it is predictive inference.
After the instruction, 20 participants stated observation with at least 75% accuracy. Moreover, there were no PETs who reported a false observation. The frequencies related to PETs' observation skills before and after the instruction are given in Table 3.

Statistical Comparison of Pre and Postinstruction Observation Skills

In order to test the statistical significance between participants' pre and post observation skills, McNemar's Tests were performed. The results indicated that the proportion of participants who could make true observations increased significantly after instruction when compared to participants' prior observation skills, $\chi^2 = 139.11$, $p < .001$. The magnitude of the effect of instruction was found to be medium (Cramer's V = .39).

PETs' inference skills

PETs' preinstruction inference skills

Before instruction, out of 81 inference statements, 57 were true inferences. That is 70.37% of the inference statements were either retrodictive inference or predictive inference. Some representative examples of true inference statements about Figure 1 were provided below.

> *In the middle of the page, big animals might eat small ones because smaller footprint-like shapes disappear (a true retrodictive inference)*.

A pair of footprints is webbed so they could belong to a duck (a true retrodictive inference).
Small footprint can belong to a chick I have seen a chick footprint before (a true retrodictive inference).
Two animals (prey-predator relation) might fight and one might hunt the other (a true retrodictive inference).
The animal with big footprint seems to continue to its way (a true retrodictive inference).

The above inference statements go beyond what can be seen from the picture. They are participants' interpretations of what they see. In other words, no participants observed that a big animal is eating a small one in the middle of the picture. However, the pattern in which only bigger prints seem to continue to the down of the page made them think a prey-predator relationship. The participant who expressed that the small footprints can belong to a chick is again her/his interpretation based on what s/he observed from the picture.

Although plenty of inferences are true, there were some inferences which were not an inference at all. Some examples are as follows:

An abstract concept resembles a concrete concept (a false inference).
This does not give certain results (a false inference).
There can be a cycle (a false inference).

PETs' preinstruction inference skills found to be better than their observation skills. For example, based on Figure 1, all inference statements of 14 PETs' were true. Only three PETs could not make any true inferences.

PETs' postinstruction inference skills

The examination of PETs' postinstruction inference statements indicated that 74 % of the inference statements (158 observation statements out of 215) were true. On the other hand, 9 % of all statements (20 out of 215) were confused with observation. Some examples of PETs' true inferences about Figure 2 and 3 were as follows. These participants added their interpretations to their observations.

Since the tree died its branch was broken (a true retrodictive inference, Figure 2).
The child might think swamp as a pond and fell into it while trying to float his ship (a true retrodictive inference, Figure 2).
Smoke seems to come out of a volcano, it is about to erupt (a true predictive inference, Figure 3).
The dinosaur in the front looks like to have eaten an animal since there are pieces of bones in the ground (a true retrodictive inference, Figure 3).
There are mountains (confused inference with observation, Figure 3).
There are three trees and a goat (confused inference with observation, Figure 2).

A complete list of frequencies related to PETs inference skills before and after the instruction is given in Table 4.

Table 4
Descriptive statistics for PETs' pre and postinstruction inference statements

Category	Before implementation Frequency (Percent)	After implementation Frequency (Percent)
No inference	9 (11.11)	2 (0.93)
True retrodictive inference	56 (69.14)	141 (65.58)
True predictive inference	1 (1.23)	17 (7.91)
Confuse inference with observation	0 (0.00)	20 (9.30)
False inference	13 (16.05)	7 (3.26)
Confuse inference with expressing an opinion	2 (2.47)	28 (13.02)
Total	81 (100)	215 (100)

Statistical Comparison of Pre and Postinstruction Inference Skills

In order to statistically compare participants' pre and post inference skills, a McNemar's Test was performed. The results indicated that the proportion of participants who could make true inferences increased significantly after instruction when compared to participants' prior inference skills, χ^2 = 97.12, p< .001. But the magnitude of this effect was small, Cramer's V = .03.

DISCUSSION

This study aimed to enhance preservice elementary teachers' skills in making observation and inference. Being aware of the fact that science is introduced to students for the first time in third grade, science process skills become more important. However, preservice elementary teachers do not have an adequate understanding of science process skills (Downing, & Filer, 1999). Elementary teachers who are responsible for the science teaching in elementary level should be investigated in terms of their competency in science process skills because they would teach these skills only if they have already mastered them (Funk, Fiel, Okey, Jaus, & Sprague, 1985). On the other hand, elementary teachers who do not have science process skills usually avoid teaching science and science process skills (Tilgner, 1990). Moreover, it is suggested that if teachers are provided with opportunities to master science process skills, then they will feel more confident to teach them (Tilgner, 1990). As a result, in this study, the researchers aimed to help preservice elementary teachers practice two basic science process skills (observation and inference) so that they can teach them in their future science classrooms.

An important finding of this study was that participants in this study were familiar with observation and inference as a term, but they could not demonstrate a high level of ability in making observations. This result was consistent with the findings of other research as well (e.g. Akerson, et al., 2000; Karslı et al., 2010; Leager, 2008; Miles, 2008). The preservice elementary teachers in this study confused observation with inference to an important extent before the implementation. This result was confirmed by the number of true observations participants made before they were involved in the instruction. The statements they wrote as observation were actually inference. A similar result was reported by Akerson et al. (2000) who showed that more than half of the participants in their studies were not successful in differentiating observation from inference. Similarly, Leager (2008) reported that when students are asked to share their observations, they also included their feelings and thoughts. This is what the preservice elementary teachers did in this study. When we asked them to write their observations before the implementation, they mostly shared their thoughts about the pictures we provided to them. However, an observation refers to the statements that is based on individuals' five senses rather than what they feel or think (Lederman, et al., 2002). As suggested by Lederman et al. (2002), students should be able to make the distinction between observation and inference to understand the world around them. Moreover, teachers should be able to make this distinction due to the fact that they will teach it in their future classrooms. However, after the instruction on observation and inference, participants in this study were able to understand the nature of these two science process skills and made true observation and inference statements.

The second important finding of the study was that the change in participants' observation skills from pre-implementation to post-implementation was found to be significant using McNemar's Test in favor of post-implementation. PETs also attained important gains regarding inference skills after participating in the instruction. This result indicated that classroom discussions and activities on observation and inference were effective in enhancing these skills. Their gains were not the same for observation and inference. PETs made relatively more gains in observation than inference. The gains were more in observation because participants confused observation with inference at the beginning of the study. However, they resolved this confusion during the implementation and the number of confused observation statements decreased meaningfully after the implementation. The implementation in this study included classroom discussions on science process skills with the guidance of the instructor. Preservice elementary teachers did not only learn the characteristics of these skills but also understood the differences between them. Moreover, they practiced science process skills through investigating scenarios in which different science process skills were integrated. This finding is consistent with what the literature revealed before (e.g. Akerson et al., 2000). Akerson et al. also found that participants showed more improvement in understanding the difference between observation and inference aspect of NoS through explicit-reflective activity-based approach. Within the context of this study participants were also engaged in observation and inference activities explicitly and they were asked to reflect on their ideas.

CONCLUSION and IMPLICATIONS

In conclusion, this study has shown that observation and inference skills can be enhanced through classroom discussions and activities. Especially the scenarios including science process skills to be investigated can be helpful. Analyzing the case in these scenarios in terms of science process skills may force participants to think, discuss, and reach more accurate decision. Therefore, such activities should be included more in preparing preservice teachers to teach science process skills. This is necessary because they should first master these skills before teaching them to their students. Harlen (2000) also identified one of the teacher's roles as to help students develop skills which they will use to test their ideas scientifically. Investing more time to address observation and inference skills in elementary teacher education programs may be feasible to develop their skills. As a result, they can accomplish their roles as a teacher better. Elementary student teachers are the key to the students' formal early science education. The fact that students will develop skills for doing scientific inquiries is dependent on how their first science teachers organize science teaching in the classroom. Giving opportunities to the students to observe, experiment, or collect data is based on how proficient their teachers on these skills. Teachers who are competent at these skills will definitely guide their students to develop the same skills. This will result in the fact that elementary students will be engaged in the scientific inquiries actively and will develop positive attitudes and interest in science. Therefore, we believe that since teacher education programs is also responsible for preservice teachers' development of science process skills, teacher educators should first explore whether their undergraduates have those skills and act accordingly. The precautions should be taken before they graduate from teacher education programs. Otherwise, their future elementary students may not be involved in scientific activities in which they make observations, form hypotheses, draw inferences, conduct experiments or collect data.

The results of this study have some suggestions for further research as well. First of all, if policymakers expect teachers to educate their students as scientifically literate as possible, teacher training programs should be improved in many aspects. An important aspect is science process skills which is one of the core elements of scientific literacy. Researchers can investigate teacher education programs in terms of their effectiveness in teaching science process skills. Then it is better to follow preservice elementary teachers and investigate how they teach science in elementary schools. By this way, long-term effects of the training in teacher education programs can be better revealed. Another line of research may focus on self-efficacy for teaching science process skills. As mentioned in the introduction, Chan (2002) investigated teachers' confidence to integrate science process skills into their classes. This is crucial since, as Bandura (1977) suggested, if teachers do not have efficacy in teaching science process skills, they most probably avoid such classroom activities. Researchers should develop implementations in which preservice elementary teachers not only learn observation and inference skills but also learn how to teach them. PETs should be provided with many opportunities so that they can practice those skills and gain experience. The more experience they gain, the more self-confident they become and the more they include science process skills in their future classrooms. Therefore, there is a need for further studies in Turkey investigating the effect of providing sources of self-efficacy -mastery experience, verbal persuasion, vicarious experience- to the PETs on their teaching science process skills.

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İletişim/Correspondence
Assist. Prof. Dr. Nurcan CANSIZ
nurcansiz7911@gmail.com