

# TEACHING NATURE OF SCIENCE THROUGH CONCEPTUAL CHANGE APPROACH: CONCEPTUAL CHANGE TEXTS AND CONCEPT CARTOONS

**Emine Çil**

## Introduction

One of the most important aims of science education is to help students in their comprehension of nature of science (NOS). A set of publications and standards such as *Benchmarks for science literacy* (American Association for the Advancement of Science [AAAS], 1993), *Next Generation Science Standards* (National Research Council [NRC], 2013) emphasise the importance of teaching of NOS. However, many researchers report that science education implemented in schools is inadequate for enabling students to understand contemporary views about NOS (Ibanez-Orcajo & Martinez-Aznar, 2007; Kang, Scharman & Noh, 2005; McComas, 1996; McComas, 2000; Rannikmae, Rannikmae & Holbrook, 2006).

When NOS is inadequately understood, this raises the issue of how to effectively teach this topic. Numerous attempts have been undertaken to enhance students' views of NOS. However, it is identified that the effects of NOS teaching approaches which have been tried so far were limited and yet some of them were not effective in teaching NOS aspects (Akerson, Morrison & McDuffie, 2006; Çelik & Bayrakçeken, 2006; Dagher, Brickhouse, Shipman & Letts, 2004; Khishfe & Abd-El-Khalick, 2002). Some researchers suggested conceptual change approach might be a good way for effective teaching of NOS (Abd-El-Khalick & Lederman, 2000; Abd-El-Khalick & Akerson, 2004; Akerson, Abd-El-Khalick & Lederman, 2000; Khishfe & Abd-El-Khalick, 2002). Several teaching techniques or strategies that promote conceptual change in students have been proposed by researchers in the science education. These strategies can be called as cognitive conflict, analogy, concept map, prediction-observation and explanation, refutational texts, conceptual change texts, concept cartoons and so on. The literature describes various techniques and models of conceptual change that have been tested as ways of teaching NOS (Abd-El-Khalick & Akerson, 2004; Abd-El-Khalick & Akerson, 2009; Bienerca, 2006; Mumba, Carver, Chabalengula & Hunter, 2009). However, benefits of conceptual change texts and concept cartoons in the teaching of NOS have not yet been clarified adequately.



JOURNAL  
OF BALTIC  
SCIENCE  
EDUCATION

ISSN 1648-3898

**Abstract.** *The study investigated the influence of conceptual change approach on elementary students' views of certain aspects of nature of science (NOS). In this study, conditions of conceptual change were provided through the use of conceptual change texts and concept cartoons. In addition, this study compared the influence of the conceptual change approach to that of the explicit reflective inquiry-oriented and implicit instructional approaches in the teaching of NOS. The research was conducted with seventh-grade students (aged 12-13 years) at a school in Turkey's Aegean region. A total of 69 students participated in the study. The students' views of NOS were assessed using a questionnaire, (the Views of Nature of Science Elementary Level Scale) as pre-test and post-test in conjunction with data from semi-structured interviews. This study reveals that the best way to remedy the naïve views of students on NOS is a conceptual change framework.*

**Key words:** *conceptual change text, concept cartoon, explicit reflective approach, implicit approach, nature of science.*

**Emine Çil**  
Mugla Sıtkı Kocman University,  
Mugla, Turkey



### *Theoretical Framework*

#### Nature of Science (NOS)

NOS typically refer to the epistemology of science, to science as a way of knowing, or to values and beliefs inherent to the development of scientific knowledge (Lederman, 1992). Science education documents state that elementary school students should be able to understand the following aspects of NOS: the tentative aspect (science is subject to change), the empirical aspect (science is based on observations of the natural world), the creative aspect (science involves inventive explanations), and the inferential aspect (there are differences between observation and inference). The science curriculum in Turkey emphasizes these four aspects of NOS; therefore, these aspects of NOS were investigated in this study.

#### Implicit Approach in Teaching NOS

The implicit approach states that by doing science, students would understand NOS. This approach advocates the use of hands-on science activities, science-based inquiry and/or scientific process skills instruction-without explicit reference to NOS- to enhance students' views of NOS (Abd-El-Khalick & Lederman, 2000). There is no need to discuss the target NOS aspects explicitly in the classroom. Teachers do not develop special materials to teach NOS aspects. Explicit discussions are not carried out on NOS aspects in the classroom. While students explore various science concepts, principles, theories and/or laws like a scientist, they learn about NOS. This approach does not regard understanding of NOS as a cognitive learning product. Understanding of NOS is more like a secondary by-product in this approach.

#### Explicit Reflective Approach in Teaching NOS

Within this framework, the term explicit is not identical to didactic or direct instruction. It emphasizes that learning about NOS should be planned intentionally for learning science concepts or content and complex science theories. It is possible that teachers can prefer different pedagogical approaches including those that are active, student-centered, collaborative, and/or inquiry-oriented in nature (Abd-El-Khalick & Akerson, 2009). However, inquiry-oriented pedagogy is the most popular way of implementing explicit reflective approach in the NOS literature (Akerson, Hanson & Cullen, 2007; Khishfe & Abd-El Khalick, 2002; Khishfe, 2008). Explicit reflective inquiry-oriented approach engages students in a problematic situation. The students asked, designed investigations, obtained data, determined how to organize and analyze these data, and provided evidence-based answers to their problem situations. They were then engaged in whole-class teacher-led discussion on specific science content and focused on relevant NOS aspects in inquiry activities. This study demonstrated the connections that students were making between the activities undertaken and the target NOS aspects during the discussion (Khishfe & Abd-El-Khalick, 2002).

The "reflective" component of the explicit reflective approach to NOS was designed to encourage the learners to look at their own science learning experiences from the perspective of an epistemological framework (Abd-El-Khalick & Akerson, 2009). Abd-El Khalick and Akerson (2004) categorized this component of the approach into structured and unstructured, and written and oral exercises. Oral reflections are usually assigned during and after explicit instruction. With reflective writing assignments, students are given the opportunity to reflect on their experiences in writing after the explicit instruction (Akerson, et.al, 2000).

#### Conceptual Change Approach in Teaching NOS

In such instruction, students were firstly given questions which were to elicit their views of the target NOS aspects. They then shared responses with their peers. They were next asked to comment on, explain, and identify similarities and differences among the responses. Instructors presented alternative and more informative views of the target NOS aspects. Science instruction would then follow using an approach in which inquiry and other science-based activities are helping students examine their NOS views. The activities should aim to raise the status of some NOS conceptions and lower that of others, and provide students with a NOS framework by introducing



and, in a sense, sensitizing them to the target NOS aspects. Small-group and whole-class discussions follow each activity with the aim of explicitly involving students in meta-conceptual discourse about the target NOS ideas. Students are provided with both unstructured and structured opportunities to reflect, both orally and/or in writing, on various NOS aspects during activities (Abd-El-Khalick & Akerson, 2004). Then, the examination of the conceptual change techniques, concept cartoons, and conceptual change texts would serve as a good candidate to implement this instructional component.

### Concept Cartoons

Concept cartoons are cartoon-style drawings involving visual representations of scientific ideas involved in a certain subject. They include minimal text, in dialogue form, using familiar situations, offering alternative viewpoints on the situation and basing the alternatives on research which identifies common areas of misunderstanding. Students make a choice between these perspectives and explain the reasoning behind their choice (Keogh & Naylor, 1999; Keogh & Naylor, 2000). The concept cartoons are a good tool to probe students' ideas/beliefs (Chin & Teou, 2009; Dabell, 2008; Keogh & Naylor, 1999). Also they are excellent for promoting argumentation (Naylor, Keogh & Downing, 2007). In this study concept cartoon was used to probe students' prior NOS views and spark argumentation on NOS.

### Conceptual Change Texts

Conceptual change text is a text structure that states a common misconception about a natural phenomenon and directly refutes it while providing the scientifically acceptable idea with asking students to make a prediction about the given situation (Alkhaldeh, 2007; Guzzetti, 2000; Hynd, 2001; Özmen, 2007; Roth, 1985; Yürük, 2007). In this study, the author selected conceptual change texts because these texts with the introduction of common misconceptions of science can encourage students to directly challenge their own misconceptions; and then these texts can provide evidence which demonstrate why these misconceptions are not scientific. Also conceptual change texts might include a scientific inquiry. Students are persuaded of the scientific explanations through this scientific inquiry.

### *The Aim of this Study*

The aim of this study is to understand the influences of three different approaches of NOS instruction on elementary students' views of certain aspects of NOS. The guiding research questions were:

- What is the influence of a conceptual change approach using conceptual change texts and concept cartoons on elementary students' views of certain aspects of NOS?
- What is the influence of using an explicit reflective inquiry-oriented approach on elementary students' views of certain aspects of NOS?
- What is the influence of using an implicit approach on elementary students' views of certain aspects of NOS?

### **Methodology of Research**

The study was an interpretive study. Because this study focused on the meanings that students attach to certain aspects of NOS, an interpretive approach was considered appropriate to meet the study objectives (LeCompte & Preissle, 1993).

### *Participants*

Children begin their formal education at the age of six in Turkey. Elementary education lasts for eight years and it is compulsory for all children. Students begin to take science education courses in the third-grade. Seventh-grade students (aged 12-13 years) took part in this study. The study was carried out in an elementary school located in a rural area in the Aegean region in Turkey. The school is a state school attended by children whose families had middle-class socio-economic status. The study was conducted with 69 students. They were randomly divided



into three groups, each group consisting of 23 students. In the first group, NOS was taught with the conceptual change approach. The second group was taught NOS with an explicit reflective inquiry-oriented approach. The third group was taught NOS with an implicit approach. The regular science teachers of the children in each group implemented the teaching materials. Out of the three teachers, two of them were females and one was male. All three teachers had the four-year science teaching certificate and each had ten to fifteen years of teaching experience. The most important reason for choosing this school for this study was that the teachers were willing to take part in the research.

#### *Data Collection*

The students' views of NOS were obtained using the Views of Nature of Science Elementary Level Scale (VNOS-E). The VNOS-E was developed by Lederman and Ko (2004). The questionnaire is one in a series of previously validated instruments (VNOS-A, VNOS-B, VNOS-C, VNOS-D) used to assess the NOS views of both students and teachers. The VNOS-E has been used in various studies in the NOS literature (e.g., Akarsu, 2010; Lederman & Lederman, 2004; Parker, 2010; Walls, 2012). The main reason for choosing the VNOS-E questionnaire in this study was that VNOS-E was developed for elementary students. The VNOS-E was implemented before and at the conclusion of the intervention. Following the questionnaire survey, 25% of the students in each group were randomly chosen and individually interviewed. During the interviews, students were given their survey responses to review, and were orally asked again the questions from the questionnaire. The interviews aimed to clarify participants' responses to the questionnaire items. In the other words, semi-structured individual interviews were used to establish the validity of the questionnaire results (Lederman, Bell, Abd-El-Khalick, & Schwartz, 2002). Each interview took about thirty minutes. The interviews were recorded by laptops and then transcribed. The interviews were conducted and transcribed by the author.

#### *Data Analysis*

The data were coded by the author and another researcher who had published research work on NOS. Inter-rater consistency was 95%; and disagreements were resolved by discussion and consensus.

The views of the students about NOS were analyzed in accordance with the guidance of the coding rubric recommended for the VNOS-E. Their views of the aspects of NOS were classified as naïve, transitional, or informed (for detailed information on the survey and the coding rubric, see Parker, 2010). The author of this paper analysed the pre-instructional questionnaires of the six interviewee students to generate profiles for each participant's views of the tentative, empirical, creative, and inferential aspects of NOS. The other coder conducted a similar analysis using these participants' interview transcripts. The independently generated profiles were compared to ensure that the questionnaire responses accurately reflected students' NOS views. Generally, the two analyses yielded similar conclusions. This process was repeated for analysing data obtained from post-instructional interviews and questionnaire surveys.

Next, both coders independently analyzed all the NOS questionnaire responses of the participants in the conceptual change, explicit, and implicit groups. The response to each questionnaire item was used to generate profiles of participants about the four NOS aspects. There were 10% differences between the two coders' analyses. These few differences were resolved by negotiation. In each group, the percentages of students rated as naïve, transitional, and informed on each aspect of NOS were calculated separately for the initial and final assessments. The changes in students' views from the initial to final assessment were taken as the measure of the change in students' views. To better convey students' views, the author included quotations from responses students gave to the questionnaire and in the interviews.

#### *Teaching Design*

In this study, NOS was taught to students via three different approaches: conceptual change, explicit reflective and implicit approaches. The students learned NOS within the light context, a standard instructional topic in the science curriculum for the participants in this study. The intervention materials for necessary conceptual change and the explicit reflective inquiry-oriented approach transferred into classroom were designed by the author, whereas the implicit approach was implemented using the Ministry of Education textbook.



While the teaching materials were being prepared, firstly NOS concept cartoons were developed according to the major themes which emerged as a result of pre-test implementations of VNOS-E. Since four aspects of NOS (tentative, empirical, creative, and inferential) were being studied, four concept cartoons were designed.

The author designed six NOS conceptual change texts and six inquiry-oriented activities to be implemented throughout the instruction on light. Both the NOS conceptual change texts and the explicit reflective inquiry-oriented activities included the same research questions about light. NOS conceptual change texts were different from NOS inquiry-oriented activities only in that the former made students' aware of their prior views and included presentation of clear misconceptions and scientific explanations about the target NOS aspects. The research questions and the experiments developed by the students to answer them are presented in Table 1.

**Table 1. Topics explored and inquired in both NOS conceptual change text and inquiry-oriented activities.**

Topic	Question investigated	Brief description of students' experiments
Light and colours	Is it possible for an object to be seen in a different colour other than its own?	The students covered the front of the torch with a cellophane paper in different colours such as green, red, and blue. Turning on the torch, they obtained different colours such as red and blue on the white paper. Some groups held the torch covered with red cellophane paper on the yellow construction paper. They observed that the light object was seen in red colour.
Light and colours	What is an object you cannot see?	A group placed the source of light at the back of a piece of glass. They placed another object on the other side of the glass which their peers could not see what it was. When the source of light began to run, they obtained a blue image on the white curtain at the back of the object. They asked the other groups to predict what colour of light the source of light emitted and what the object would be. Some groups suggested that the source of light emitted blue light so the object might be a blue light filter or a piece of blue glass. On the other hand, some other groups made an inference that if it was a blue light filter, the source of light would have to emit white or blue light.
Light and colours	How does rainbow occur?	Most of the groups had the white light pass through a light prism. They observed that after the white light passed through the prism, it separated into red, orange, yellow, green, blue and purple colours. They explained that water drops acted like a light prism when the sun shone after the rain.
Refraction of light	Does medium affect speed of light?	Some groups designed experiments where sand represented the solid state, water represented the liquid state, and the gas state was represented by the sponge pieces (they formed an analogy depending on the gaps between the granules of solid, liquid and gas matters). They put the sponge pieces, sand and water in a transparent cup and they waited until the colour of the mixture became clear. Then, they dropped a marble into the mixture from a height of 5-10 cm. They observed the movement of the marble in pieces of sponge, water, and sand. They built up analogies between the speed of the marble in these three states and the speed of light in air, water and glass media.
Refraction of light	How can you calculate the speed of light in air medium?	Most of the groups determined two farthest points from each other in the class. They tried to calculate the speed of light in the air medium via the distance between these two points and the time the laser beam took to travel the distance between these two points. The students concluded that the speed of dispersion of light was too fast to be calculated with this method and they suggested different experiments to calculate the mathematical value of the speed of light.
Lenses	What are the causes of forest fires?	After a forest fire, the photographs taken by the team of crime scene investigation were shown to the students. The students were asked to determine the causes of the fire. Most of the groups thought that the broken glass bottles would be the cause of the fire. The students compared how the light refracted on the thin- and thick-sided lens with the experiments they conducted. They found that the broken pieces of glass looked like a thin-sided lens. Some groups put a thermometer at the back of a piece of glass and then they held the source of light to the piece of glass. They observed the rise in temperature on the thermometer.

The instruction was completed in 18 lesson-hours (each lesson lasted for 40 minutes) for each of the groups. The author participated in the lessons with all groups as an observer and recorded how the teachers implemented



the educational materials. The researchers and two science educators reviewed observation records and checked the alignment between the planned and the implemented intervention.

#### Teaching NOS Using a Conceptual Change Approach

Firstly, the concept cartoons were shared with the participants, who were asked to determine which idea was correct and discuss them on ideas from the cartoons. About 15 minutes were spent for each of the concept cartoons which were implemented in the first part of the instruction. Through teaching the Light unit, six conceptual change texts were implemented. The conceptual change texts composed of five parts. Each part is represented below:

1. In the first part, one question was designed to make students aware of their prior knowledge about the target NOS aspects. The questions asked in this part aimed at exploring the students' awareness of their own views (Roth, 1985; Khishfe & Abd-El-Khalick, 2002).
2. The second part of the conceptual change text is recorded in the table which shows potential misconceptions that students might have about the NOS aspects being asked and what the reasons for these misconceptions might be. Unhappy facial expressions were used in this table to demarcate unscientific views. Below the table were statements that these ideas were wrong. The first two parts of the conceptual change text serve to make students dissatisfied with their naïve views (Posner, Strike, Hewson & Gertzog, 1982; Khishfe & Abd-El-Khalick, 2002).
3. In the third part, the author provided the contemporary views about the NOS aspects being questioned and explained why this views is scientific. Happy facial expressions were used in this table to demarcate scientific views. When the tables for Parts 2 and 3 are compared, the differences between the explanation that is recognized as a misconception and the scientific views can be seen very clearly. This part of conceptual change text aimed to provide scientific explanations in an intelligible manner (Yürük, 2007).
4. The fourth part of the conceptual change text included a research question on the topic of light. In this part, the students were engaged in processes of inquiry that gave them an opportunity to utilize their scientific processing skills. This part was designed to convince students of contemporary NOS views that were presented in the third part of the conceptual change text via a plausible way (Canpolat, Pınarbaşı, Bayrakçeken & Geban, 2006; Alkhaldeh, 2007; Özmen, 2007; Alkhaldeh & Al Olaimat, 2010).
5. In the last part of the conceptual change text, students were asked questions about the inquiry activities that they had completed in the previous part. These questions focused on both the NOS aspects and the Light unit. The students first answered the questions individually, and then a whole-class discussion followed. In this part of the text, scientific views became useful (Posner et al., 1982). Also, students obtained opportunity to reflect on their NOS views (Khishfe & Abd-El-Khalick, 2002). Teaching with each conceptual change text lasted for 15–20 minutes.

#### Teaching NOS Using Explicit Reflective Inquiry-Oriented Approach

The author designed six explicit reflective inquiry-oriented NOS activities, each of which was composed of three main parts. The first part of the inquiry activities introduced a problem situation about light to the students. In the second part of the activity, students were expected to design an experiment to find an evidence-based answer for the problem. It was possible that the students working in small groups might design different experiments at the second phase of the inquiry-oriented activities. The experiment samples designed and performed by the students are shown in Table 1. In the final stage, a whole-class discussion was carried out on the target NOS aspects and light concept in the inquiry process. Students had opportunities to make connections between their inquiry and scientists' research during this discussion.

Finally, in the last week of teaching, the students were given a reflective writing assignment. The reading text was adapted from the preface of the book *Shadows of the Mind: A Search for the Missing Science of Consciousness* by Penrose (1994; pp: 1–4). A detailed description of this reflective writing task can be found in Akerson et al. (2000).





## Teaching NOS Using the Implicit Approach

In Turkey, science instruction has been based on the constructivist learning theory. There are different models (learning cycle, four-phase model, the 5E or 7E model, etc.) that can be used when transferring constructivist learning principles from theory to practice. In Turkey, science has been taught using the 5E model. The 5E model is composed of five stages: engagement, exploration, explanation, elaboration, and evaluation. These phases and every action carried out in each phase are described in the literature (e.g., Orgil & Thomos, 2007). In the engagement phase of the Ministry of Education textbook, students were engaged in a problem situation. The students generated various suggestions in order to solve the problem. In the exploration phase students tested their suggestions. The students usually designed experiments and performed them. The third phase of the 5E model the students reached conclusions about the problem using the data they obtained in exploration phase. In elaboration, tasks which would usually help the students transfer the new knowledge they obtained to their daily lives were designed. For example, the students who explored how light was refracted with thin and thick lenses transferred this new knowledge to remedy vision problems such as myopia (nearsightedness) and hyperopia (farsightedness). Alternative assessment techniques were used for the evaluation phase of the 5E model. In this group, there were not any activities which focused on the NOS aspects throughout the teaching of the Light unit. Because of this, students in this group learned about NOS via an implicit approach.

## Results of Research

Table 2 shows the percentages of students having naïve, transitional, and informed views on the aspects of NOS within the scope of this study. In the following pages in this paper C symbolizes the group that learned via conceptual change strategy, E symbolizes the group that learned via the explicit reflective approach, and I symbolize the group that learned via the implicit approach. In addition, the students in each group are numbered from 1 to 23.

**Table 2. Pre-test and post-test views of the target NOS aspects for C, E and I group participants.**

Group	NOS aspect	Informed			Transitional			Naïve		
		Pre- test (%)	Post- test (%)	Change (%)	Pre- test (%)	Post- test (%)	Change (%)	Pre- test (%)	Post- test (%)	Change (%)
C	Tentative	10	59	+49	52	36	-16	38	5	-33
	Empirical	14	68	+54	43	27	-16	43	5	-38
	Creative	29	59	+30	57	36	-21	14	5	-9
	Inferential	5	46	+41	57	36	-21	38	18	-20
E	Tentative	5	40	+35	50	55	+5	45	5	-40
	Empirical	20	32	+12	30	41	+11	50	27	-23
	Creative	35	50	+15	55	41	-14	10	9	-1
	Inferential	5	22	+17	50	64	+14	45	14	-31
I	Tentative	14	16	+2	62	53	-9	24	31	+7
	Empirical	9	16	+7	48	37	-11	43	47	+4
	Creative	33	42	+9	52	42	-10	15	16	+1
	Inferential	5	5	0	57	63	+6	38	32	-6

According to the pre-test results, very few students had informed views on the target NOS aspects. As shown in Table 2, between 59% and 68% of students in Group C in the post-test presented informed views on the tentative, empirical, and creative aspects of NOS. After the instruction, the majority of students (46%) in Group C had informed views about the inferential aspect of NOS, however, 36% of the students still retained their transitional views. According to Table 2, half of the students in Group E at the post-test had informed views on the creative



aspect of NOS, however, 41% of the students had transitional views. For tentative (55%), empirical (41%), and inferential aspects (64%), students' views were mainly in the transitional category. As shown in Table 2, more than half of the students in Group I retained their transitional views on the tentative and inferential aspects of NOS after the instruction. Nearly half of the group had naïve views on the empirical aspect of NOS. Group I students were most successful in understanding the creative aspect of NOS. According to 42% of students' views, scientists used creativity in almost all stages of a scientific study. However, another 42% expressed only transitional views (for examples of student views, see Table 3).

**Table 3. Illustrative quotes of participants' naïve, transitional, and informed views of the target NOS aspects.**

NOS aspect	Naïve	Transitional	Informed
Tentative	Facts known for years do not change. This knowledge is reached after lengthy research. Their truth has been proven. If the truth of a certain bit of knowledge has been proven once, it will never change. The change of knowledge reduces the trust in scientists. (C-21; pre-instructional questionnaire)	Today, we have limited information on some topics. As technology advances and more information is gathered, what we consider to be true today could change. For example, as the atom is very small, we do not know much about it. Once an equipment is developed so that we can research an atom in more detail, we might find out the information we have is wrong. (C-16; pre-instructional interview)	Science continually develops and changes. From past to present, many pieces of information have changed, such as the shape of the Earth, number of planets, and the structure of the atom. While we were discussing that scientific knowledge may change in time, one of our classmates mentioned Pluto. Pluto used to be a planet but now it is a dwarf planet. Perhaps in the future, when dinosaur fossils are interpreted differently, it might be understood that they might have a very different appearance than what is believed today. (C-4; post-instructional interview)
Empirical	Weather forecasting reports are not certain facts, rather they are merely predictions. They are usually correct, but they could also be wrong, because weather is something that could change at any moment. (I-8; pre-instructional questionnaire)	Nowadays, technology is fairly advanced. We have enough technology to determine the weather forecast. Scientists know the weather forecast by using satellites placed on the Earth's orbit. (E-1; post-instructional interview)	One of the most important features of science is that it relies on the data obtained as a result of observation and experiment. For example, we tried to calculate the dispersion speed of light in the air in the class. We could not reach a mathematical value in the experiment conducted. But according to the data obtained from this experiment, we interpreted what kind of an experiment we had to do. Scientists gather all the clues and try to get a favourable result from them. Scientists collect and record information such as satellite images, wind speed, and temperature changes throughout the day. They gather all the clues and try to make the best possible guess for the weather. (C-18; post-instructional questionnaire)
Creative	In my opinion, scientists do not reflect their creativity in their studies. If they did, whatever they found would be wrong. In this scenario, they would fool the public. Later on, no one would believe them. If creativity was to be mixed with science, scientists could never reach a common explanation of a result on any subject. (C-17; pre-instructional questionnaire)	Scientists have improved their creativity. With this quality of them, they ask questions which no one else even thinks about, and they plan experiments for these subjects. (I-1; post-instructional questionnaire)	At almost every stage of a scientific study, creativity can be used, from deciding the study subject to designing experiments to be performed and even when data is analyzed. Scientists give meaning to experimental data with their creativity. For example, figuring out what dinosaurs looked like requires creativity. (E-5; post-instructional interview)
Inferential	Scientists are researchers and adventurers. They have researched humans living in the age of dinosaurs and discussed dinosaurs. They have found encyclopaedias of that age and studied them. Perhaps they also used drawings on cave walls. (E-17; pre-instructional interview)	Dinosaur fossils give information about dinosaur's bones and footprints. When the bones of dinosaurs are connected end to end, their appearance emerges. (I-11; post-instructional questionnaire)	Scientists have found some dinosaur fossils such as bones or footprints. By looking at them, they developed logical opinions. For example, they could have thought: "if the eye socket is like this, then the head size could be like that." (E-16; post-instructional questionnaire)





## Discussion

Before the instruction, most of the participants had transitional and/or naïve views on each of the target NOS aspects (see Tables 2). Students start formal science instruction in the third-grade in Turkey. Although the students participating in the study had four years' experience in science instruction, the unsuccessful results of the pre-test could be interpreted as indicating that the current science education curriculum was not effective in enabling students to acquire a contemporary understanding of NOS. Many studies in the literature have reported that the curricula in schools were unsatisfactory in teaching NOS (Buaraphan & Sung-Ong, 2009; Ibanez-Orcajo & Martinez-Aznar, 2007; Kang et al., 2005; Parker et al., 2008).

For the implicit approach, the increase in the students' informed views did not exceed 10% (see Table 2). Many studies in the literature found that implicit approaches provide very little help to students in developing their understanding of NOS (Abd-El-Khalick & Lederman, 2000; Abell, Martini & George, 2001; Khishfe & Abd-El-Khalick, 2002; Lederman, 2006). The explicit reflective inquiry-oriented instruction led to an increase that ranged from 12% to 35% in the number of students who had an informed understanding on the target NOS aspects (see Table 2). These results were similar to claims made in the literature that the explicit reflective instruction is effective in teaching students about some aspects of NOS while having a limited effect on other aspects (Akerson et al., 2006; Celik & Bayrakceken, 2006; Khishfe & Abd-El-Khalick, 2002; Khisfe & Lederman, 2006; Veal, 2004). The instruction in the conceptual change group increased the percentage of informed views for every target NOS aspect by 30% to 60% (see Table 2). These results showed similarities to previous findings of teaching about NOS via various conceptual change strategies (Abd-El Khalick & Akerson, 2004; Biernacka, 2006; Mumba et al., 2009).

Drawing on all these results, it can be stated that the best way to remedy the naïve views of elementary school students on NOS is the conceptual change approach. One of the causes for this positive change in the conceptual change group students' views on NOS might be the concept cartoons. All teaching theories hold that prior knowledge, concepts, and experiences are effective in enabling students to learn new information. Like learning other scientific concepts, students develop their viewpoints about NOS based on their daily life experiences and education they receive at school (Kang et al., 2005; Khishfe & Abd-El-Khalick, 2002). In this study, the concept cartoons introduced different perspectives on NOS and gave students opportunities to discuss these perspectives. They led the students to support their own preconceptions and/or to develop arguments to refute their peers' perspectives (Chin & Teou, 2009; Dabell, 2008; Keogh & Naylor, 2000; Naylor et al., 2001; Naylor et al., 2007). The discussions arising from the concept cartoons might create a cognitive conflict among the students and could have guided them to acquire contemporary perspectives about NOS.

Another reason for the positive results achieved in the class using the conceptual change approach might be the conceptual change texts of NOS. The students in Group C performed similar exploration activities with NOS conceptual change texts like those in Group E who had explicit reflective inquiry-oriented activities; both groups also had similar discussions about NOS. But, conceptual change texts used in Group C included some elements which were different from the inquiry-oriented activities. The first one of these elements was that the conceptual change texts began with a question which revealed the prior knowledge of the students about NOS aspects. The second one was that the unscientific answer to the question and why this question is unscientific were discussed. Finally, the scientific answer to this question and why this answer is scientific were discussed explicitly. Presenting scientific knowledge to students in clear and easily understandable language is not sufficient to transform unscientific views that exist in their minds into scientific ideas (Black, 2006; Hewson, 1992; Guzzetti, 2000; Roth, 1985). When students realize that their prior knowledge is naïve and they become dissatisfied with this prior knowledge, they will take action to change it (Liao & She, 2009; Shepardson, Moje & Kennard-McClelland 1994; Posner et al., 1982). First, the students became aware of their own prior views about the aspects of NOS which they were going to study in the conceptual change texts. Then, they were made to explicitly discuss their unscientific views about the NOS aspects and why these opinions are not scientific. Therefore, cognitive disequilibrium was created, and the students became dissatisfied with their prior knowledge. Then, the topics of discussion were conceptualizations that are accepted as scientifically valid and why these conceptualizations are valid. The explanations of scientific and unscientific understandings and the rationales behind them might have contributed to convincing the students of the inadequacy of their ideas and the validity of scientific explanations (Hewson, 1992; Roth, 1985; Yürük, 2007).



## Conclusion and Recommendations

This study demonstrates that the best way to remedy the naïve views of students on the NOS is the conceptual change approach. The explicit reflective approach has a limited effect on understanding NOS. Science teaching in Turkey does not contribute to students' understanding of NOS. In this study, conditions of conceptual change were provided through the use of conceptual change texts and concept cartoons. Concept cartoons can be used in instruction in the classrooms where NOS is taught via conceptual change approach because concept cartoons seem to be an effective tool to have the students focus on the target NOS aspects. Moreover, concept cartoons present different views to students. On the one hand, students justify their views. On the other hand, they try to refute other views. Concept cartoons are effective in starting a discussion on NOS aspects. In addition, they are used to evaluate the students' views because students explicitly express their views about the target NOS aspects. They also justify why their views are true. During this process, teachers may identify the students' naïve and/or transitional views about NOS and they can also probe where these views result from. The author suggests that conceptual change texts are a good tool to change students' naïve or transitional NOS views to informed views. The most important qualities of NOS conceptual change texts are those that (1) present students' misconceptions about the target NOS aspects, (2) explicitly emphasize that misconceptions are not scientific, and (3) encourage students to make an effort to refute the misconceptions. Students have an opportunity to make comparisons between their views, misconceptions and scientific explanations through conceptual change texts. The author suggests that conceptual change texts have high potential in persuading students to accept informed views about the target NOS aspects. Based on the findings from this study, the author concludes that teachers can be trained to develop NOS concept cartoons and conceptual change texts. By doing this, they will be able to grasp how to embed conceptual change texts and concept cartoons within a NOS instruction. Although only two techniques of conceptual change approach were used in this study, conceptual change approach also includes various other techniques. It is widely accepted that different students learn differently. Combination of other techniques in conceptual change teaching may enable teachers to change students' other naïve views about NOS to informed views.

## References

- AAAS. (1993). *American Association for the Advancement of Science, Project 2061, Benchmarks for Science Literacy*. New York: Oxford University Press.
- Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education, 22*, 665-701.
- Abd-El Khalick, F., & Akerson, V. L. (2004). Learning as conceptual change: Factors mediating the development of preservice elementary teachers' views of the nature of science. *Science Education, 88*, 785-810.
- Abd-El-Khalick, F., & Akerson, V. (2009). The influence of metacognitive training on pre-service elementary teachers' conceptions of nature of science. *International Journal of Science Education, 31* (16), 2161-2184.
- Abell, S., Martini, M., & George, M. (2001). 'That's what scientists have to do': Pre-service elementary teachers' conceptions of the NOS during a moon investigation. *International Journal of Science Education, 23*, 1095-1109.
- Akarsu, B. (2010). The influence of disciplines on the knowledge of science: A study of nature of science. *Bulgarian Journal of Science and Education Policy, 4* (1), 99-118.
- Akerson, V. L., Abd-El-Khalick, F., & Lederman, N.G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching, 37* (4), 295 - 317.
- Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Pre-service elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching, 43*, 194-213.
- Akerson, V. L., Hanson, D. L., & Cullen, T. A. (2007). The influence of guided inquiry and explicit instruction on K-6 teachers' views of nature of science. *Journal of Science Teacher Education, 18*, 751-772.
- Alkhalwaldeh, S. A. (2007). Facilitating conceptual change in ninth grade students' understanding of human circulatory system concepts. *Research in Science & Technological Education, 25*, 371-385.
- Al Khawaldeh, S. A., & Al Olaimat, A. M. (2010). The contribution of conceptual change texts accompanied by concept mapping to eleventh-grade students understanding of cellular respiration concepts. *Journal of Science Education and Technology, 19* (2), 115-125.
- Biernacka, B. (2006). *Developing scientific literacy of grade five students: A teacher-researcher collaborative effort*. Unpublished doctoral dissertation, The University of Manitoba, Manitoba, Canada.
- Black, S. (2006). Is science education failing students? *American School Board Journal*, November 48-50.
- Buaraphan, K., & Sung-Ong, S. (2009). Thai pre-service science teachers' conceptions of the NOS. *Asia-Pacific Forum on Science Learning and Teaching, 10* (1), 1-22.
- Canpolat, N., Pınarbaşı, T., Bayrakçeken, S., & Geban, Ö. (2006). The conceptual change approach to teaching chemical equilibrium. *Research in Science & Technological Education, 24*, 217-235.



- Chin, C., & Teoub, L. Y. (2009). Using concept cartoons in formative assessment: Scaffolding students' argumentation. *International Journal of Science Education*, 31 (10), 1307–1332.
- Çelik, S., & Bayrakçeken, S. (2006). The effect of a 'Science, Technology and Society' course on prospective teachers' conceptions of the nature of science. *Research in Science & Technological Education*, 24, 255–273.
- Dabell, J. (2008). Using concept cartoon. *Mathematics Teaching Incorporating*, 209, 34–36.
- Dagher, Z. R., Brickhouse, N. W., Shipman, H., & Letts, D. W. J. (2004). How some college students represent their understandings of the nature of scientific theories. *International Journal of Science Education*, 26, 735–755.
- Guzzetti, B. J. (2000). Learning counter-intuitive science concepts: What have we learned from over decade of research? *Reading & Writing Quarterly*, 16, 89–98.
- Hewson, P. W. (1992). Conceptual change in science teaching and teacher education. Paper presented at a meeting on "Research and Curriculum Development in Science Teaching," under the auspices of the National Centre for Educational Research, Documentation, and Assessment, Ministry for Education and Science, June, Spain.
- Hynd, C. (2001). Persuasion and its role in meeting educational goals. *Theory into Practice*, 40 (4), 270–277.
- Ibanez-Orcajo, M. T., & Martinez-Aznar, M. M. (2007). Solving problems in genetics, Part III: Change in the view of the NOS. *International Journal of Science Education*, 29, 747–769.
- Kang, S., Scharman, L. C., & Noh, T. (2005). Examining students' views on the nature of science: Result from Korean 6th, 8th and 10th graders. *Science Education*, 89, 314–334.
- Keogh, B., & Naylor, S. (1999). Concept cartoons, teaching and learning in science: An evaluation. *International Journal of Science Education*, 21 (4), 431–446.
- Keogh, B., & Naylor, S. (2000). Teaching & learning in science using concept cartoons: Why Dennis wants to stay in at playtime. *Investigating: Australian Primary & Junior Science Journal*, 16 (3), 10–15.
- Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching*, 39, 551–578.
- Khishfe, R., & Lederman, N. (2006). Teaching nature of science within a controversial topic: Integrated versus nonintegrated. *Journal of Research in Science Teaching*, 43 (4), 395–418.
- Khishfe, R. (2008). The development of seventh graders' views of nature of science. *Journal of Research in Science Education*, 45 (4), 470–496.
- LeCompte, M. D., & Preissle, J. (1993). *Ethnography and qualitative design in educational research* (2nd Ed.) New York: Academic Press.
- Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29 (4) 331–359.
- Lederman, J. S., & Ko, E. K. (2004). Views of nature of science, Form E. Unpublished paper. Illinois Institute of Technology, Chicago.
- Lederman, J. S., & Lederman, N. G. (2004). *Early elementary students' and teachers understandings of nature of science and scientific inquiry: Lessons learned from Project ICAN*. Paper presented at the annual meeting of the National Association for Research in Science Teaching (NARST), Vancouver, British Columbia.
- Lederman, N., Abd-El-Khalick, F., Bell, R., & Schwartz, R. S. (2002). Views of NOS questionnaire: Toward valid and meaningful assessment of learners' conceptions of NOS. *Journal of Research in Science Teaching*, 39, 497–521.
- Lederman, N. G. (2006). Research on nature of science: Reflections on the past, anticipations of the future. *Asia-Pacific Forum on Science Learning and Teaching*, 7 (1), 1–11.
- Liao, Y. W., & She, H. C. (2009). Enhancing eight grade students' scientific conceptual change and scientific reasoning through a web-based learning program. *Educational Technology & Society*, 12 (4), 228–240.
- Mumba, F., Carver, J., Chabalengula, V. M., & Hunter, W. J. F. (2009). Chemistry teaching fellows' understanding of the nature of scientific theories and laws. *Journal of Baltic Science Education*, 8, 15–21.
- McComas, W. (1996). Ten myths of science: Reexamining what we think we know..... *School Science & Mathematics*, 96.
- McComas, W. F. (2000). The principal elements of the nature of science: Dispelling the myths (53–70). In W. F. McComas (Ed.) *The Nature of Science in Science Education, Rationales and Strategies*, Dordrecht, The Netherlands: Kluwer Academi.
- NME (2006). National Ministry of Education, *Science and Technology Curriculum for 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> grade*, Ankara: The National Ministry of Education Press.
- NRC (2013). National Research Council, *The Next Generation Science Standards*. Washington, DC: The National Academies Press.
- Naylor S., Downing, B., & Keogh B. (2001, October). An empirical study of argumentation in primary science, using Concept Cartoons as the stimulus. Paper presented at the *Third International Conference of the European Science Education Research Association (ESERA)*. Thessaloniki, Greece.
- Naylor, S., Keogh, B., & Downing, B. (2007). Argumentation and primary science. *Research in Science Education*, 37, 17–39.
- Orgill, M. K., & Thomas, M. (2007). Analogies and the model suggestions for using analogies in each phase of the 5E model. *Science Teacher*, 74 (1), 40–45.
- Özmen, H. (2007). The effectiveness of conceptual change texts in remediating high school students' alternative conceptions concerning chemical equilibrium. *Asia Pacific Education Review*, 8 (3), 413–425.
- Parker, L. C., Krockover, G. H., Lasher-Trapp, S., & Eichinger, D. C. (2008). Ideas about the NOS held by undergraduate atmospheric science students. *American Meteorological Society*, November, 1681–1688.
- Parker, E. A. (2010). The relationship between nature of science understandings and science self-efficacy beliefs of sixth grade students. *Middle-Secondary Education and Instructional Technology Dissertations*. Paper 66.



- Posner, M. G., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of scientific conception: Toward theory of conceptual change. *Science Education*, 66, 211–227.
- Penrose, R. (1994). *Shadows of the mind: A search for the missing science of consciousness*. New York: Oxford University Press.
- Rannikmae, A., Rannikmae, M., & Holbrook, J. (2006). The nature of science as viewed by nonscience undergraduate students. *Journal of Baltic Science Education*, 2, 77–85.
- Roth, K. J. (1985, April). *Conceptual learning and student processing of science texts*, Paper Presented at the Annual Meeting of the American Educational Research Association, Chicago, Illinois, USA.
- Shepardson, D. P., Moje, E. B., & Kennard-McClelland, A. M. (1994). The impact of a science demonstration on children's understanding of air pressure. *Journal of Research in Science Teaching*, 31 (3), 243–258.
- Veal, W. R. (2004). Neandertals, naivete and the NOS, A preliminary investigation of the impact of historical case-based pedagogy for science teachers. *Curriculum and Teaching Dialogue*, 6, 69–80.
- Walls, L. (2012). Third grade African American students' views of the nature of science. *Journal of Research in Science Teaching*, 49(1), 1–37.
- Yürük, N. (2007). The effect of supplementing instruction with conceptual change texts on students' conceptions of electrochemical cells. *Journal of Science Education & Technology*, 16, 515–523.

Received: January 21, 2014

Accepted: April 05, 2014

**Emine Çil**

PhD., Assistant Professor, Department of Science Education, Faculty of Education, Mugla Sıtkı Kocman University, Mugla, Turkey.  
E-mail: enimeonyedi@hotmail.com

