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THE EFFECT OF THE COMMON KNOWLEDGE CONSTRUCTION MODEL-ORIENTED EDUCATION ON SIXTH GRADE STUDENTS' VIEWS ON THE NATURE OF SCIENCE

Hasan Bakırcı,
Muammer Çalık,
Salih Çepni

Abstract. *The aim of the present research was to explore the effect of the Common Knowledge Construction Model (CKCM)-oriented education on sixth grade students' views on the Nature of Science (NOS) and to compare it with the existing learning model (5Es learning model). The research was conducted with a total of 76 students (38 by 38--for experimental and control groups) in 2013-2014 school year. Within a quasi-experimental research design, the Views of Nature of Science Questionnaire (VNOS) and the Student Interview on the Nature of Science Aspects (SINOSA) were used for data collection. Quantitative data from the VNOS were exposed to independent t-test while qualitative data from the interview protocol were analyzed using content analysis. Results of pre-test and pre-interview denoted that both groups properly constructed 'empirical' aspect of the NOS while the other aspects of the NOS were naïve and transitional levels. After the intervention, it was found that the control group's views of the NOS, except for the empirical aspect, were transitional level whilst those of the experimental group were informed level. Further, it was elicited that the experimental group performed the highest change in 'imaginary and creative' aspect of the NOS.*

Key words: *CKCM, 5Es learning model, light and sound topic, nature of science, science education.*

Hasan Bakırcı
Yuzuncu Yıl University, Turkey
Muammer Çalık
Karadeniz Technical University, Turkey
Salih Çepni
Uludağ University, Turkey

Introduction

Science education primarily focuses on getting students to acquire scientific literacy and nature of science (NOS) (Khishfe, 2012; Ministry of National Education [MoNE], 2005, 2013; Şardağ, Aydın, Kalender, Tortumlu, Çiftçi, Perihanoğlu, 2014). Hence, scientifically literate individuals not only perceive construction of scientific knowledge but also notice significance of social and personal traits in decision-making. Phrased differently, engaging students in learning the aspects of the NOS directly improves their 'scientific literacy' levels (Aydın, Demirdöğen, Muslu & Hanuscin, 2013; Kaya, Şardağ, Cakmakci, Doğan, İrez & Yalaki, 2016; Khishe, 2012; Köseoğlu, Tümay & Budak, 2008; Lederman, 2004).

The fact that Turkish students' views on the NOS generally fell into 'naïve' level in the international comparison/evaluation reports, i.e. Programme for International Student Assessment (PISA) (Aksu & Güzeller, 2016; Anagun, 2011; Baldi, Jin, Skemer, Green & Herget, 2007), has emerged a critical question on how to integrate the aspects of the NOS into science curriculum. Also, this means that Science and Technology Curriculum released in 2005 was inability to get students to satisfactorily learn the NOS and to enhance their awareness of scientific knowledge (Çil, 2010; Yiğit, Alev, Akşan & Ursavaş, 2010). Given the critical question, Turkish science curriculum released in 2013 created a new separate sub-heading called Science-Technology-Society-Environment (STSE) learning area (involving the NOS, socio-scientific issues and relationship between science and technology). Thereby, the NOS plays a significant role in achieving the vision of Turkish Science Curriculum released in 2013. For this reason, the effectiveness of any teaching model (i.e. the *Common Knowledge Construction Model--CKCM)* serving to accomplish the vision of science curriculum should be investigated.

The CKCM is theoretically underpinned through Marton's *Variation Theory of Learning* and Piagetian conceptual change studies (Ebenezer, Chacko, Kaya, Koya & Ebenezer, 2010). Further, the CKCM incorporates in Vygotsky's

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zone of proximal development and Doll's ideas of curriculum development, e.g. *scientific discourse* (Biernacka, 2006). This means that the CKCM with four phases (Exploring and Categorizing, Constructing and Negotiation, Translating and Extending, Reflecting and Assessing) purposes to socially construct scientific knowledge and involve many different methods in this process (Ebenezer & Connor, 1998).

Because the CKCM explicitly embeds the NOS aspects within its own lesson sequence, students are expected to grasp such the NOS aspects as: (a) The roles of imagination and creativity on constructing scientific knowledge; (b) tentativeness of scientific knowledge that may change over time; (c) the role of experiment on science teaching; (d) the role of social and cultural values (i.e. religion and folks) on decision making; and (e) the effects of observations and inferences on constructing scientific knowledge (Biernacka, 2006; Ebenezer & Connor, 1998).

Few studies have examined the effect(s) of the CKCM on different dependent variable(s) within varied grades and/or subjects. Of these studies, Ebenezer, Chacko and Immanual (2004) reported a classroom teacher's view of the effectiveness of a CKCM-oriented-science education in seventh grade. Biernacka (2006) focused on the effect of a 'weather events' unit accompanied with the CKCM on fifth grade students' scientific literacy level whilst Wood (2012) researched the effect of an 'acids and bases' unit with the CKCM on high school students' conceptual changes and science achievement. Also, İyibil (2011) presented a sample CKCM lesson sequence of 'energy' concept at seventh grade, whereas Vural, Demircioğlu and Demircioğlu (2012) evaluated the CKCM materials of 'acid-base' subject for gifted students from sixth, seventh and eighth grades. Further, Kıryak (2013) explored the effect of the CKCM-oriented instruction of 'water pollution' subject on 7th grade students' conceptual understanding. Moreover, Çepni, Özmen and Bakırcı (2012) illustrated how to teach 'Interaction of Light with Matter and Reflection' subject in sixth grade via the CKCM. Bakırcı and Çepni (2012) also compared similarities and differences between the CKCM and 5Es learning model as well as Bakırcı and Çepni (2014) discussed the applicability of the CKCM given the Turkish Science Curriculum released in 2013. These studies indicated the CKCM's promising outcomes for science education (Biernacka, 2006; Ebenezer et. al., 2004; Kıryak, 2013; Wood, 2012).

Studies found out that students and teachers held many alternative conceptions of 'light and sound' concepts (Atasoy, Tekbıyık & Gülay, 2013; Çalık, Okur & Taylor, 2011; Hrepic, 1998, 2004; Küçüközer, 2009; Linder, 1993; Maurines, 1993; Wittman, Steinberg & Redish, 2003). Common alternative conceptions of the 'light' concept are especially about the definition of the light (Büyükkasap & Samancı, 1998), vision (Şahin, İpek & Ayas, 2008; Toh & Boo, 1999) and plane mirror image (Anıl & Küçüközer, 2010; Osborne, Black, Meadows & Smith, 1993). Similarly, alternative conceptions of the 'sound' concept are concerned with the propagation of sound (Çalık, Okur & Taylor, 2011; Linder, 1993; Hrepic, 2004), production of sound, echo of sound, timbre, sound reflection, sound height and the speed of sound (Çalık et al., 2011; Demirci & Efe, 2007). Moreover, conceptual change studies (i.e. Çalık et al., 2011) revealed that students still had alternative conceptions even after the teaching intervention. Overall, the CKCM intends to shape its lesson sequence by taking students' pre-existing knowledge into consideration. Therefore, given sixth grade students' pre-existing knowledge of the 'Light and Sound' unit, the effect of the CKCM- oriented-science education on their views of the NOS needs to be investigated.

Studies of the NOS point to: (i) The effectiveness of explicit reflective approach vis-à-vis implicit one (Ayvacı, 2007; Çil, 2010; Khishfe & Abd-El-Khalick, 2002); (ii) the importance of pre-service and in-service education (Arı, 2010; Doğan et al., 2011; Erdoğan, 2004; Colagrande, Martorano & Arroio, 2016); (iii) the significance of socio-scientific issues (e.g., global warming, environmental pollution) (Khishfe, 2012; Köseoğlu, Tümay & Budak, 2008); (iv) the role of critical thinking (Khishe, 2012; Sadler et al., 2002); (v) a need to learn the NOS aspects at early ages (Quigley, Pongsanon & Akerson, 2010); and (vi) students' and teachers' poor views of the NOS (Bora, 2005; Çelikdemir, 2006; Gürses et.al., 2005; Küçük, 2006; Lederman & O'Malley, 1990; Lederman, 2004; Özbek, 2013). For this reason, they call for alternative ways/strategies (i.e. CKCM) in science education.

Because the Turkish Science Curriculum revised in 2013 is in a harmony with the CKCM (Biernacka, 2006; Wood, 2012), it is expected that the CKCM- oriented education will result in better improvements in 6th grade students' views of NOS. Thus, the aim of the present research was to explore the effect of the CKCM-oriented education on sixth grade students' views on the nature of science (NOS) and to compare it with the existing learning model (5Es learning model suggested by the Turkish Science curriculum). For this purpose, the following questions guided the present research:

- What was the effect of the CKCM-oriented education on sixth grade students' views of the NOS?
- What was the effect of the 5Es learning model on sixth grade students' views of the NOS?
- Was there any statistically significant difference between the experimental and control groups' post-test mean scores of the NOS?

Methodology of Research

Research Design

Taking such variables as the existing school structure, type of teaching intervention, and random selection and/or classification of students, the present research employed a quasi-experimental research design (Çepni, 2011; Ekiz, 2013; Shadish, Cook & Champbell, 2002).

Sample of Research

The research was conducted with a total of 76 sixth grade students (38 by 38--for experimental and control groups) enrolled to a middle school in the city of Trabzon in 2013-2014 school year. The sample of the research was determined through convenient sampling method that practically reduces official formalities (Yıldırım & Şimşek, 2006). Also, semi-structured interviews were conducted with a total of 18 students (9 by 9 from each group) given their pre-test scores of the Views of Nature of Science Questionnaire (VNOS)--6 interviewees for each NOS level (e.g. 'naïve' level--E10, E16, E28, C2, C14 and C25; transitional level--E24, E31, E37, C6, C12 and C31; and informed level--E5, E12, E18, C8, C21 and C34). In accordance with the research ethics, students' real names were concealed. Therefore, numerical codes were exploited, i.e. E1-E38 codes for the experimental group and C1-C38 codes for the control group.

Data Collection Tools

The Views of Nature of Science Questionnaire (VNOS) with open-ended questions--(originally developed by Lederman and O'Malley (1990) and adapted into Turkish context by Çil (2010)-- and semi-structured interviews, called Student Interview on the Nature of Science Aspects (SINOSA) (improved by the researchers), were employed (Lederman, 2007; Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). However, within the aim of the research, researchers decided to leave the first and the third questions of the VNOS out due to their overlapping features with the previous questions. They also made some minor revisions in the VNOS, e.g. use of the Van earthquake in 2011 instead of Marmara Earthquake in 1999. Then, the final version of the VNOS was sent to a group of science educators to ensure content validity. Afterwards, they confirmed content validity and suggested some minor revisions, i.e. typographical errors and visual typesetting.

The SINOSA consisted of 6 open-ended questions including six aspects of the NOS (i.e. tentativeness, imagination and creativity, subjectivity, empirical, social dimension, observation and inference). To probe interviewees' views of the SINOSA, the daily life and explanatory examples were embedded within the interview questions.

Five science educators examined the SINOSA to confirm its readability and content validity (Merriam, 1988; Yıldırım & Şimşek, 2006). Also, the SINOSA was pilot-tested with 5 sixth grade students, who did not take part in the real research. Such a procedure not only led the researchers to notice some minor revisions but also to enhance their familiarity with the SINOSA. After verbatim transcription of the SINOSA, the interviewees checked their own responses to clarify any misunderstanding and/or unclear issue if necessary (Maxwell, 1996).

The NOS aspects in the VNOS and SINOSA are presented in Table 1.

Table 1. The NOS aspects in the VNOS and SINOSA.

The NOS Aspects	The VNOS	The SINOSA
	Question Number	Question Number
Empirical	1	1
Tentative	2	2
Imaginary and creative	3 and 5	3
Difference between observation and inference	3 and 4	4
Social and cultural	6	5
Subjectivity	7	6

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Teaching Intervention

The teaching interventions in both groups lasted 4 weeks (16 class-hours). While the control group was instructed via the 5Es learning model suggested by the Turkish science curriculum, the experimental group was exposed to the CKCM- oriented education. The subjects '*Interaction of light with matter and reflection*', '*Mirrors and their areas of use*', '*What happens when sound comes together with matter*?' and '*Absorption of the sound and isolation*' in the 'Light and Sound' unit were handled in the teaching intervention.

A 15 year-experienced teacher (selected voluntarily), who participated in a 16-hour in-service education on the use of the CKCM-oriented education, implemented the teaching interventions in both groups. The first researcher of the current research took part in all class hours as an observer and monitored the extent to which the teaching intervention was consistent with the planned one. After each teaching session, he negotiated any unclear issue with the teacher. A sample teaching intervention of the subject '*Interaction of light with matter and reflection*' is illustrated in Table 2.

Table 2. A sample teaching intervention of the subject 'Interaction of light with matter and reflection'.

	Control Group	Experimental Group
Pre-test	The VNOS and SINOSA were administered as pre-tests before the teaching intervention. Each pre-interview session (called SINOSA) lasted nearly 25-30 minutes and was conducted with a total of 9 students. The VNOS took about 40 minutes.	The VNOS and SINOSA were administered as pre-tests before the teaching intervention. Each pre-interview session (called SINOSA) lasted nearly 25-30 minutes and was conducted with a total of 9 students. The VNOS took about 40 minutes.
Teaching Intervention	The control group followed the Science and Technology course book and student workbook recommended by the MoNE in accordance with the 5Es learning model. In '*Engage' phase*, questions of '*Reflection*', '*Regular Reflection*' and '*Diffuse Reflection*' concepts were asked for eliciting the students' pre-conceptions of the related concepts. Then, they were requested to read the text '*The Role of light in the sight of an object*' in the course book. In '*Explore' phase*, the activity '*Light interacts with matter in different ways*' was carried out in order to classify the matters as transmitting, reflecting, partially reflecting and non-transmitting the light. Later, the activity '*Let's discover the route a reflected light will follow*' aimed to discover the relationship between the source direction of the light and the direction of the reflection. Lastly, the activity '*Are there any reflection rules*?' was implemented. In '*Explain' phase*, the teacher created a discussion continuum to stimulate the students' gained experiences in the 'Explore' phase. Hence, he purposed to confirm scientific explanations and disconfirm/refute any unclear mistake/deficiency that needed to be remedied. In '*Elaborate' phase*, the activities '*The modes of interaction of light with matter*' and '*Let's discover the route a reflected light will follow*' drawn from the course book to examine the light transmission, opacity and light reflection of the matter were carried out to elaborate newly generated knowledge. In '*Evaluate' phase*, the activities '*Let's evaluate ourselves*' and '*which is the right exit*?' were conducted to evaluate the extent to which the students had learnt the subject.	The experimental group pursued the CKCM-oriented education developed by the researchers. In '*Exploring and Categorizing' phase*, students were asked to read the story '*Let's get enlightened*!' and to respond 3 open-ended questions in the first part of the worksheet that intended to elicit their prior knowledge. Later, '*Word Association Test'* was hand out to categorize their prior knowledge. Thus, their prior knowledge was deployed to decide the teaching processes/materials. Also, the activity '*Adventure of the Light'* that triggered to their awareness of three NOS aspects (i.e. tentative, social and cultural) was implemented. In '*Constructing and Negotiating' phase*, the prediction–explanation–observation–explanation (PEOE) worksheets '*Regular and diffuse reflection*' and '*Are there any reflection rules*?' were passed the students out to construct their knowledge. Further, they were asked to negotiate their results with the whole class and/or the group members. Such a learning procedure implicitly referred to two NOS aspects (e.g. empirical and subjective). In '*Translating and Extending' phase*, a conceptual change text was employed to overcome their alternative conceptions through the teacher-student and/or the student-student discussions. Later, the teacher passed the worksheet '*Light pollution'* out in order to draw their attention to the socio-scientific issues. Also, the worksheet '*Grandfather and Cedric'* was used to link the subject with the daily life (as a context). Lastly, Edison activity '*Story of the invention of the light bulb'* was conducted to get the students to grasp the 'Social and cultural' and 'Difference between observation and inference' aspects. In '*Reflecting and Assessing' phase*, such complementary assessment and evaluation techniques as '*Word Association Tests'*, '*Structured Grid'* and '*Diagnostic Tree'* were utilized to evaluate the learning's outputs.
Post-Test	The VNOS and SINOSA were re-administered as post-tests after the teaching intervention. Each post-interview session (called SINOSA) lasted nearly 35-40 minutes and was conducted with a total of 9 students. The VNOS took about 40 minutes (a class-hour).	The VNOS and SINOSA were re-administered as post-tests after the teaching intervention. Each post-interview session (called SINOSA) lasted nearly 35-40 minutes and was conducted with a total of 9 students. The VNOS took about 40 minutes (a class-hour).

Data Analysis

In analyzing data from the VNOS questionnaire, the students' responses were labeled under three levels: 'naïve' level (1 point) that disregards the NOS aspects; 'transitional' level (2 points) that includes at least a scientific explanation about the target NOS aspect; and 'informed' level (3 points) that contains convenient NOS aspects under investigation (Khishfe & Lederman, 2006; Khishfe & Abd-El Khalick, 2002). The data were imported into SPSS 15.0™ to run statistical analysis. After checking the parametric analysis requirements, an independent samples t-test appeared for statistical analysis. To make basic comparisons of the VNOS questionnaire, the following mean range was taken into account: 1.00-1.66 (Naïve), 1.67-2.33 (Transitional) and 2.34-3.00 (Informed).

The interview data were exposed to a content analysis that emerges related codes and themes (Çepni, 2011; Ekiz, 2013; Yıldırım & Şimşek, 2006). Three researchers, who were familiar with the NOS studies and/or categorization, independently analyzed the data from the VNOS and the SINOSA. The interrater reliability was found to be 82%. Any disagreement was solved through negotiation. The basic statistical results (i.e. frequency, mean, standard deviation) were presented throughout relevant tables.

Results of Research

The descriptive results of the VNOS are shown in Table 3.

Table 3. Descriptive results of the VNOS.

Question Number	Groups	Pre-test		Post-test	
		Mean	Standard Deviation	Mean	Standard Deviation
1	Experimental	1.97	.82	2.42	.72
	Control	2.15	.82	2.26	.83
2	Experimental	1.79	.84	2.50	.69
	Control	2.00	.90	2.15	.89
3	Experimental	1.68	.81	2.50	.69
	Control	1.84	.92	1.97	.95
4	Experimental	1.79	.84	2.55	.68
	Control	1.84	.89	2.10	.92
5	Experimental	1.92	.85	2.55	.68
	Control	2.05	.87	2.10	.89
6	Experimental	1.63	.79	2.42	.86
	Control	1.68	.87	1.81	.93
7	Experimental	1.76	.82	2.44	.83
	Control	1.74	.90	1.94	.93

Table 3 shows that pre-test mean score of the experimental group's responses to Question 6 fell into 'naïve' level (1.00-1.66) while others were classified under 'transitional' level (1.67-2.33). Furthermore, post-test mean scores of the experimental group's responses to the VNOS were labeled under 'informed' level (2.34-3.00) while those for the control group were categorized under 'transitional' (1.67-2.33) level. Also, the standard deviation values of the experimental group were between 0.79 and 0.85 in pre-test and between 0.68 and 0.86 in post-test. Similarly, the standard deviation values of the control group ranged from 0.82 to 0.92 in pre-test and from 0.83 to 0.95 in post-test

The findings of independent samples t-test between the experimental and control groups' mean scores to the VNOS are indicated in Table 4.

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Table 4. The findings of independent samples t-test results between the experimental and control groups' mean scores to the VNOS (degree of freedom: 74).

Question Number	Tests	Groups	Mean	Standard Deviation	t	p
1	Pre-test	Experimental	1.97	.82	-.977	.33
		Control	2.15	.82		
	Post-test	Experimental	2.42	.72	.886	.378
		Control	2.26	.83		
2	Pre-test	Experimental	1.79	.84	-1.052	.29
		Control	2.00	.90		
	Post-test	Experimental	2.50	.69	1.880	.064
		Control	2.15	.89		
3	Pre-test	Experimental	1.68	.81	-.796	.42
		Control	1.84	.92		
	Post-test	Experimental	2.50	.69	2.397	.019
		Control	1.97	.95		
4	Pre-test	Experimental	1.79	.84	-.265	.79
		Control	1.84	.89		
	Post-test	Experimental	2.55	.68	2.397	.019
		Control	2.10	.92		
5	Pre-test	Experimental	1.92	.85	-.667	.50
		Control	2.05	.87		
	Post-test	Experimental	2.55	.68	2.955	.004
		Control	2.10	.89		
6	Pre-test	Experimental	.79	.79	-.276	.78
		Control	.87	.87		
	Post-test	Experimental	2.42	.86	2.955	.004
		Control	1.81	.93		
7	Pre-test	Experimental	1.76	.82	.134	.89
		Control	1.74	.90		
	Post-test	Experimental	2.44	.83	2.477	.016
		Control	1.94	.93		

The findings indicated that there was no significant difference between the experimental and control groups' pre-test mean scores of the VNOS [$p>0.05$]. This means that both of the groups had almost similar views of the NOS aspects. The results of the independent samples t-test revealed statistically significant differences between the experimental and control groups' post-test mean scores of Questions 3-7 in the VNOS [$p<0.05$] in favor of the experimental group. However, no statistically significant difference occurred between the experimental and control groups' post-test mean scores of Questions 1-2 in the VNOS [$p>0.05$].

The findings of the pre- and post-interviews are displayed in Table 5.

Table 5. The findings of pre- and post-interview.

Themes of the NOS	Codes	Experimental Group		Control Group	
		Pre-interview	Post-interview	Pre-interview	Post-interview
Tentative	Variability	E5, E12, E18	E5, E10, E12, E16, E18 E24	C8, C21, C34	C8, C21, C31, C34
	Situated precision or variability	E16, E24, E37	E31, E37	C6, C12, C14, C31	C6, C12, C14, C25 C31
	Precision	E10, E28, E31	E28	C2, C6, C8, C12 C14, C31	C2, C6, C8, C12, C14
	Scientists' studies	E5, E16, E18 E37	E5, E12, E16, E18, E24, E37	C12, C21, C31, C34	C6, C8, C12, C21, C31 C34
	Technological developments	E5, E12, E37	E5, E12, E18, E24, E37	C8, C21, C34	C8, C21, C25, C34
Creative and Imaginary	Using only creativity	E5, E16, E28	-	C6, C14, C25, C31	C2, C6, C14, C25, C31
	Inability to use imagination	E5, E16, E28	-	C2, C6, C8, C14 C25	C2, C14, C25
	Using creativity at some certain phases	E5, E16, E24	E28, E31, E37	C6, C8, C12, C14 C21, C31, C34	C2, C8, C12, C31
	Using creativity along with imagination	E10, E12, E18, E24, E31, E37	E5, E10, E12, E16, E18, E24, E28, E31, E37	C2, C6, C8, C12 C14, C21, C34	C2, C6, C8, C12, C14, C21, C31, C34
Subjectivity	Personal differences (Imagination, creativity, opinion, point of view)	E24, E37	E5, E10, E12, E16, E18, E24, E31, E37	C8, C12, C21, C34	C8, C12, C21, C34
	Different interpretation of data	E28	E5, E10, E12, E16, E18, E28, E37	C8, C31	C8, C12, C21, C31, C34
	Various tools in measurement	E12, E28	-	C2, C14, C25	C2, C14
	Multi-dimensional nature of phenomena	E18, E31	-	C6, C14, C25	-
	No idea	E12, E18, E31	-	C2, C6, C12, C14	C14, C25
Empirical	Convenient empirical scaffold of science	E5, E10, E16	E5, E10, E12, E16, E24, E28, E31, E37	C6, C14, C21, C34	C2, C6, C8, C12, C14, C21, C31, C34
	Facilitating conceptual (permanent) learning	E12, E18, E24, E31	E5, E10, E12, E16, E18, E24, E28, E31, E37	C8, C12, C21, C34,	C2, C6, C8, C12, C21, C25, C34
	Yielding knowledge and knowledge claims/results	E10, E24, E28	E10, E16, E24	C25, C31	C12, C21, C31, C34
	Multiple effect(s) of experiments	E18	E5, E12, E18, E28, E37	C12, C21	C8, C12, C21, C25, C34
	Providing active learning	E5, E12, E18	E5, E12, E18, E31, E37	C8, C21, C34	C6, C12, C8, C21, C34
Social and Cultural	Effect(s) of religious beliefs	E5, E16, E18, E24, E28, E31	E5, E10, E12, E16, E31, E37	C2, C6, C14. C12, C21	C2, C6, C8, C12, C14, C21, C25
	Effect(s) of customs and traditions	E5, E12, E16, E18, E24, E28, E37	E5, E12, E16, E18, E24, E28, E31	C2, C6, C8, C12, C14, C21	C2, C6, C8, C12, C14, C25, C34
	Effect(s) of lifestyles and culture	E5, E10, E12, E16, E18, E24, E28, E37	E5, E10, E12, E16, E18, E24, E28, E37	C2, C14, C25	C2, C6, C12, C25, C31
Observation and Inference	Comprehending inference and observation	E5, E10, E12, E16, E18, E24, E28, E31, E37	E5, E10, E12, E16, E18, E24, E28, E31, E37	C2, C6, C8, C12, C14, C21, C25, C31, C34	C2, C6, C8, C12, C14, C21, C25, C31, C34
	Reaching scientific inference via a certain number of observations	E5, E10, E16, E18, E24, E28, E31, E37	E5, E10, E12, E16, E18, E24, E28, E31, E37	C2, C6, C8, C14, C21, C25, C34	C2, C6, C8, C14, C21, C25, C34

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The codes 'Variability, situated precision or variability, precision, scientists' studies and technological developments' under the theme '*Tentative*' appeared in pre-interview for the experimental and control groups. In post-interview, frequencies of the codes 'variability (f: 6), scientists' studies (f: 6) and technological developments (f: 5)' were higher than the others--Situated precision or variability (f: 2) and Precision (f: 1). Similarly, the frequencies of the control group's post-interview under the same theme were identified as follows: precision (f: 5), situated precision or variability (f: 5) and scientists' studies (f: 6).

In pre-interview, the codes 'using the only creativity, inability to use imagination, using creativity at some certain phases and using creativity along with imagination' emerged under the theme '*Creative and Imaginary'* for both of the groups. In post interview, the highest frequencies of the experimental group for the same theme were belonging to the codes 'using creativity at some certain stages (f: 3), using creativity along with imagination (f: 9)' while those for the control group were 'using only creativity (f: 4), inability to use imagination (f: 3), using creativity at some certain phases (f: 4) and using creativity along with imagination (f: 8).'

Pre-interview findings emerged the codes 'personal differences, different interpretation of data, various tools in measurement, multi-dimensional nature of phenomena and various tools in measurement' under the theme *'subjectivity'* for both of the groups. In post-interview, the experimental group's responses for the same theme were mainly classified under the codes 'personal differences (f: 8), different interpretation of data (f: 7)' while those for the control group principally fell into the codes 'personal differences (f: 4), different interpretation of data (f: 5) and various tools in measurement (f: 2)'.

In pre- and post- interviews, the interviewees' responses appeared the codes 'Convenient empirical scaffold of science, facilitating conceptual (permanent) learning, yielding knowledge and knowledge claims/results, providing active learning' codes under the theme '*Empirical'*, whose frequencies were almost the same for both of the groups.

In pre and post-interviews, the interviewees' responses pointed to the codes 'effect(s) of religious beliefs, effect(s) of customs and traditions, effect(s) of lifestyles and culture' under the theme '*Social and Cultural'* for both of the groups. In a similar vein, their responses revealed to the codes 'comprehending inference and observation; and reaching the scientific inference via a certain number of observations' under the theme '*Observation and Inference'* whose frequencies were virtually equivalent for both of the groups.

Discussion

Before the teaching intervention, most of the students had 'transitional' views of the 'tentative' aspect of the NOS. For example; they thought that 'atom' knowledge was changeable whilst the existing knowledge of dinosaurs would be true. Such an apt may have resulted from their experiences with dinosaur toys and/or cartoons. That is, their images of dinosaur toys/cartoons may directly have attributed to the original/real ones (Çil, 2010; Metin, 2009; Tsai, 2006). Their inconsistent answers of the 'tentative' aspect of the NOS pointed out that they seemed to ignore various interpretations of the available data in constructing the scientific knowledge (Khishfe, 2012; Lederman, 2004). Also, higher ratios of 'naïve' and 'transitional' levels may stem from a lack of reading habits with the scientific magazines (i.e. Scientific and Technical Journal, Scientific Child), which are suitable for their ages. Further, this may come from limited integration of the NOS into previous Science and Technology Curriculum.

For the same aspect (tentative) of the NOS, increases in the experimental group's post-test and post-interview responses classified under 'informed' level may have resulted from the task 'Shapes of Pluto and World' in the CKCM- oriented education. In other words, the students seemed to have grasped functions of 'imagination and creativity' in generating scientific knowledge such as atomic structure or physical appearance of dinosaurs (Küçük, 2006; Solomon, 2001). The fact that the control group's responses to the 'tentative' aspect of the NOS fell into 'transitional' level (Table 3 and Table 5) may be viewed as a deficiency of the existing instruction (5Es learning model). At that point, the CKCM-oriented education was more effective in improving the 'tentative' aspect of the NOS as compared to the existing instruction. Such an issue may stem from an amalgam feature of the CKCM that explicitly embeds the NOS aspects within its own lesson sequence (Biernacka, 2006; Çepni, Özmen & Bakırcı, 2012; Ebenezer & Connor, 1998).

Before the teaching intervention, a significant proportion of the experimental and control groups implied that scientists did not use their imagination and creativity while conducting a scientific research of dinosaurs. This may result from the idea 'scientists have the same imagination without any personal difference(s)'. Hence, this indicated that students from different grades (i.e. Akerson, Morrison & McDuffie, 2006; Aydın et. al., 2013; Rannikmae, Rannikmae & Holbrook, 2006) possessed difficulties in understanding the 'imagination and creativity' aspects of the NOS.

For the same NOS aspects, the experimental group's post-test results showed an improvement from 'transitional' level to 'informed' one (Table 3) as well as they gave satisfactory responses in post-interview (Table 5). This seems to have resulted from the activity 'Story of the invention of the light bulb' throughout student-student and student-teacher discussions. Further, this may come from the first and third phases of the CKCM-oriented education that explicitly involved the 'imagination and creativity' aspect. Given the control group's post-test responses labeled under 'naïve and transitional' levels, it can be deduced that the 5Es learning model (as the existing instruction) made a limited contribution to development of the 'imagination and creativity' aspect.

In pre-test, the experimental and control groups' views of the 'subjectivity' aspect of the NOS were varied and categorized under 'naïve' and 'transitional' levels. This might have resulted from the idea 'science is always objective'. Also, they may have considered that empirical science restricts the scientists to infer differently what is observed (Arı, 2010; Bora, 2005; Buaraphan & Sung-Ong, 2009; Çil, 2010). Further, some of them tended to explain the scientists' different views via the idea 'various tools in measurement'. In a similar vein, this may stem from type of a scientific experiment selected in science classes. For instance, the fact that close-ended and demonstration experiments foster students to observe the same things/results may hammer the 'subjectivity' aspect of the NOS (McComes, 1996, 2000).

The CKCM- oriented education seems to have properly improved the experimental group's views of the 'subjectivity' aspect given a considerable improvement in 'informed' level of the 'subjectivity' aspect of the NOS (Table 3 and Table 5). In post-interview, the interviewees from the experimental group (Table 5) indicated that the scientists might differently interpret causes and effects of Van earthquake due to their varied views of the 'imagination, creativity and inference' aspects of the NOS. In other words, they seem to have understood interrelationships between the NOS aspects (Çelikdemir, 2006; Çil, 2010; Khishfe & Abd-El-Khalick, 2002; Küçük, 2006; Metin, 2009).

Pre-test and pre-interview results of the 'empirical' aspect were not only almost the same for both of the groups. This means that the students possessed similar views of the 'empirical' aspect of the NOS before the teaching intervention (Table 4). Their views of the 'empirical' aspect labeled under 'naïve' and 'transitional' levels in pre-test may be come from type of the experiment (e.g. close-ended and demonstration experiments) which are generally preferred by science teachers (Çil, 2010; McComes, 2000; Parker, Krockover, Lashar-Trap & Eichinger, 2008). Similarly, this result may stem from possible pitfalls such as 'A confusion between experimental data and results' and 'Inability to understand the role of the data in yielding the results' and 'A need for observation (seeing) in knowing something'.

After the teaching intervention, the experimental group's views of the 'empirical' aspect of the NOS shifted from 'transitional' level to 'informed' one (Table 5). This addresses that the CKCM-oriented education, especially activities in the second phase, seems to have influenced their views of the 'empirical' aspect of the NOS (Biernacka, 2006). In a similar vein, post-interview results showed their awareness of the 'empirical' aspect of the NOS. The control group's views of the 'empirical' aspect of the NOS were categorized under 'transitional' level in post-test (Table 3) and 'transitional' and 'informed' levels in post-interview. This may result from their active engagements with instructional experiments (within Science and Technology course) at the second phase (Explore) of the 5Es learning model (Çil, 2010; Küçük, 2006; Ültay & Çalık, 2016; Yiğit, Alev, Akşan & Ursavaş, 2010). The significant difference between the experimental and control groups' post-test mean scores of the 'empirical' aspect of the NOS in favor of the experimental one illuminates that the CKCM-oriented education was effective in evolving sixth grade students' understanding of the 'empirical' aspect than did the 5Es learning model.

The fact that the experimental and control groups' views of the 'social and cultural' aspect of the NOS fell into 'naïve' level in pre-test may stem from the idea 'scientists do not take customs, traditions and religious beliefs into account while producing scientific knowledge' (Arı, 2010; Ayvacı, 2007; Çil, 2010; Huang, Tsai & Chang, 2005; Küçük, 2006; Özbek, 2013). In other words, they might consider that scientific knowledge is independent from the 'social and cultural' aspect in that scientific knowledge is universal. Such a deficiency may result from a lack of integrating the 'social and cultural' aspect into science curriculum and course books.

After the teaching intervention, there was an improvement of the 'social and cultural' aspect in the experimental group's views classified under 'informed' level (see Tables 3-4). This implies that the CKCM-oriented education was more efficient in developing their views of the 'social and cultural' aspect of the NOS than did the 5Es learning model. Especially, the third phase (translating and extending) incorporating in discussing the socio-scientific issues seems to have directly influenced their views of the 'social and cultural' aspect. Hence, the current research is in a harmony with that of Biernacka (2006) reporting that embedding the socio-scientific issues within the CKCM lesson sequence facilitates the students' perceptions of the 'social' aspect of the NOS. However, post-interview

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results revealed that the experimental group even had difficulty giving moderate justifications and/or arguments for the roles of cultural and religious values in producing scientific knowledge. Sensitive scaffolds of these values and/or beliefs may deter the students from any critical comment. In other words, they may be closed-minded for these values/issues (e.g. Çalik & Coll, 2012; Çalık, Turan & Coll, 2014).

The students' views of the 'observation and inference' aspect of the NOS were classified under 'naïve' level in pre-test. This depicts that they may pay more attention to macroscopic issues (i.e. observing, seeing, feeling) to infer from the knowledge under investigation (i.e. Yıldırım, Çalık & Özmen, 2016). Such a view may result from a transitive Piagetian term from concrete operations to abstract thinking. In other words, this transitive term may have debarred sixth grade students from justifying the difference between observation and inference (Çil, 2010; Küçük, 2006).

Majority of the experimental group's responses (see Table 3) of the 'observation and inference' aspect of the NOS in post-test evolved from 'transitional' level to 'informed' one. Besides, results of post-interview indicated that most of the experimental group referred to contemporary (realistic) views. This may come from the prediction-explanation-observation-explanation (PEOE) activities affording the students to grasp the roles of the 'observation and inference' and 'imagination and creativity' aspects. The fact that some of the experimental group's views fell into 'naïve' and 'transitional' levels in pre-test and post-test may result from a short-term intervention, which may be viewed as a limitation of the current research. On the other hand, improving some aspects of the NOS require a longer period of the intervention time (Khishfe & Abd-El-Khalick, 2002; Rannikmae et al., 2006).

Conclusion and Recommendations

Overall, the CKCM-oriented education was more effective in properly improving the experimental group's views of the NOS. Because the NOS and socio-scientific issues are a part of the 'Science-Technology-Society-Environment (STSE)' learning area in a revised version of the Turkish Science Curriculum, the CKCM theoretically meets the demands of the Turkish Science Curriculum. Thus, the CKCM may be employed for accomplishing the objectives of the Turkish science curriculum. To generalize the effectiveness of the CKCM-oriented education, further research should be undertaken for other science units and/or courses. Also, given the idea 'attitude is a very important factor in the learning process' (Çalık, Ültay, Kolomuç & Aytar, 2015), the question 'Is there any influential relationship between students' views of the NOS and their attitudes towards science?' are supposed to be investigated. Further, how the CKCM-oriented education influences their attitudes towards science ought to be inquired in future studies.

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Hasan Bakırcı	PhD, Assistant Professor, Yüzüncü Yıl University, Faculty of Education, Turkey. E-mail: hasanbakirci09@gmail.com
Muammer Çalık	PhD, Professor, Karadeniz Technical University, Fatih Faculty of Education, Turkey. E-mail: muammer38@hotmail.com
Salih Çepni	PhD, Professor, Uludağ University, Faculty of Education, Turkey. E-mail: cepnisalih@yahoo.com