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Effectiveness of the Nature of Science Activities Developed for 5th Grades

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Within the context of new findings about nature of science, literature has been reviewed and it was seen that the activities to develop nature of science understanding were not adequate. For this reason, new activities were developed as a part of 5th grade 'Matter and Change' unit and their effectiveness was tested. The research was conducted with 5th grade students from two classrooms, who were attending to a middle school in a village of city of Tokat. Activities developed about the unit; 'Thermoscope to Thermometer', 'Bingo Game' and 'Science Wheel' activity from the literature were applied to experimental group with textbook content, as for control group the nature of science concepts were integrated with textbook content. VNOS-E questionnaire was conducted both for pretest and posttest to experimental and control group, the questionnaires were coded by three researchers and the coefficient of consistency was calculated as 0,78. Results indicated that, experimental group's view of nature of science in all dimensions was changed in a positive way, a significant difference was found between the posttests of two groups in experimental group's favor. The activities were effective in developing students' views about the nature of science. The regular curriculum was not effective in nurturing nature of science views as a consequence because the theoretical basis regarding the nature of science in the renewed science curriculum is not supported with appropriate activities, methods and classroom resources. As a result, essential and applicable suggestions were made for those who concerned.

Introduction

Today those scientific developments happened intensely, in most countries, the ultimate purpose of science education is stated as developing individuals' scientific literacy. Scientific literacy is defined as individual's decision making in such cases as required for science and technology which he shows responsibility and having necessary skill and information to activate him cognitively (Laugsksch, 2000).

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Global climate change, energy resources, stem cell researches and socio-scientific problems that related to most developments in modern medicine are matters interest not only scientist and specialists who works in those fields but also every individual in society. Individuals have high scientific literacy may attend processes by stating their opinions about these topics. Therefore, it is important that scientific literacy to be developed and for this Nature of Science to be understood (Fowler, Zeidler & Sadler, 2009). In renewed science curriculum it was given wide publicity to ability of questioning about socio-scientific matters in the fields of understanding science-technology-society and environment to understand the Nature of Science (MEB, 2013). Without an common portrayal of researchers, the Nature of Science was defined by McComas, Clough and Almazroa (2002) on explaining matters such as what the science is, how it works, how scientists work as a social group and how society steers scientific efforts and reacts to explanations of matters; as a mixture of various social sciences which includes philosophy of science that was integrated by research with cognitive sciences like psychology, history of science and sociology of science. As for science educators, they indicated that NOS determines the intersection of issues addressed by philosophy of science, history of science, sociology of science, psychology of science as they apply to and potentially affect science education and science learning; and were fundamental domains for science education.

According to researchers studying on science and Nature of Science, features that have to be mentioned are specified as: 1)The Tentative Nature of Scientific Knowledge, 2)Th e Empirical Nature of Scientific Knowledge, 3) Subjectivity, 4) Creative nature of scientific knowledge, 5)The Social and Cultural Embeddedness of Scientific Knowledge, 6) Observations, inferences and theoretical entities in science, 7) Scientific theories and laws, 8) The theory-laden nature of scientific knowledge, 9) Myth of scientific method (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). The Nature of Science involves understanding what science is, which roles it includes, who scientists were and which roles they played, scientific facts, observations, events, rules, scientific method and how they do science (Taşar, 2003).

There are three approaches to develop understanding on the Nature of Science in general. These are historical, implicit and explicit-reflective approaches. Studies have shown that explicit-reflective approach is the most effective method among these approaches. Explicit-reflective approach is a kind of successful approach which was found effective on teaching the Nature of Science to a lot of groups (Abd-El-Khalick, Lederman 2000). Developing students' understanding about the Nature of Science in early classes may help them to comprehend both the Nature of Science and course content of science better (Akerson, Buck, Donnelly, Nargund-Joshi &Weiland, 2011). Akerson and Donnelly (2010) indicated that explicit-reflective approach was a successful approach even for the pre-school period children. Akerson, Nargund-Joshi, Weiland, Pongsenon and Avsar (2013) carried out explicit-reflective approach to 3rd grades (8 year old groups according to American education system) for a school year and found out that it was effective. It was seen that among three students chosen situational at the end of teaching period of the Nature of Science rest upon explicit-reflective approach, low-successful student was able to discuss the Nature of Science, middle-successful student was able to discuss and write about it and high-successful student was able to discuss, write and put forward some questions about the Nature of Science. It was clearly seen that students were able to learn concrete extents of the Nature of Science (like difference between experimental data and observation and inference) easier in comparison with abstract ideas (like being subjective, creative and tentative) about it. Hence, Akerson et al. (2013) indicated that at first more concrete ideas has to be emphasized then more abstract ones while teaching young students the Nature of Science.

It was observed in literature and most studies about the Nature of Science that it was given independently of the content of science. Besides, studies done with primary school, 5th grade and pre-school period students are in a limited number. In this study, 5th grade students were chosen as working group and explicit-reflective method integrated with the 'Matter and Change' unit was interiorized then students' ideas about the Nature of Science were analyzed . It was thought that this research would shed light to studies about teaching the Nature of Science in early ages on account of choosing 5th grade students as sample and involving new the Nature of Science activities aimed at 'Matter and Change' unit.

Method

Research Model

In the study, quasi-experimental method with pretest posttest control grouped was used. One of the 5th grades from the school that intervention was performed was experimental group, the other one was chosen as control group; before and at the end of study a the Nature of Science questionnaire was conducted to both groups for the purpose of defining their opinions about the Nature of Science.

Sample of Study

Study; was carried out with 30 5th grade students studying in a primary school in a village of city of Tokat. There are two 5th grade classes in the school that the questionnaire was conducted in. socio-economic status, success average and family profiles of students are equal. Also, same teachers lectured those students. Within the scope of the study, fifteen students were chosen randomly from classes for each experimental and control groups. During 'Matter and Change' unit; activities were used from 5th grade Science course book in control group, any different activities related with nature of science aspects were not conducted. While in experimental group the Nature of Science activities developed by researchers were combined with teaching of 'Matter and Change' unit and performed with explicit-reflective method. Neither of groups was taught about the aspects of the Nature of Science.

Data Collecting Tools

In study, VNOS-E Questionnaire, developed by Lederman and Ko (2004) and brought in our literature by Erenoğlu (2010), is used. Aspects about questions that the questionnaire includes are ranked below.

Table1. Aspect of VNOS-E questionnaire

Nature of Science Aspect	VNOS-E Items						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Scientific knowledge is reliable and valid	X		X	X		X	
Scientific knowledge involves logical, mathematical and experimental inferences	X	X					
Scientific knowledge is subjective	X				X		
Imagination and creativity has a great role in acquiring	X			X			X

scientific knowledge			
Observation and inference are different concepts	X	X	X

Reference: Seçkin, 2013; 34.

Practices

Research was conducted with 5th grade students during "Matter and Change" unit in Science lesson for 5 weeks total of 20 course hours. In experimental group the Nature of Science was taught via explicit-reflective method, while in control group activities were in line with regular curriculum in Science lesson, nothing different had been done about the Nature of Science apart from content of course book.

Activities Used for Experimental Group

In study; a new drama activity called 'Thermoscope to Thermometer', proper to explicit-reflective approach which was created by researchers and 'Bingo Game' and 'Science Wheel' which takes part in literature were customized to the subject and carried out. Expert opinions were received for activities that developed by researchers and activities were used integrated with curriculum. In *Table 2* activities and aspects of the Nature of Science that those activities reflected are given. Besides, explanations belong to relevant activities are presented.

Table 2. Activities' nature of science aspects

Nature of Science Aspects	**Activities**		
	Science Wheel	Thermoscope to Thermometer	Bingo Game
Scientific Knowledge is reliable and valid	X	X	
Scientific Knowledge involves logical, mathematical and experimental inferences	X	X	X
Scientific Knowledge is subjective		X	
Imagination and creativity has a great role in acquiring scientific knowledge	X		
Observation and inference are different concepts	X		X

Science Wheel: It is an activity aims to reveal students' ideas about science, scientists and scientific knowledge (Doğan, Çakıroğlu, Bilican & Çavuş, 2010). It was expected from students to observe and make inferences from experiments on the subject of states of matter. In activity a wheel of concept was generated on the board.

Bingo Game: Teacher picks up three children that he stated before and arranges a seating order as students able to see each other. Then gives Bingo cards to chosen students. After picking another student, he gives a bag full of colorful cartons. There are pictures in the bag represents Expansion, Contraction, Boiling, Condensation and Sublimation. Each of the students representing those concepts takes the picture from bag and acts like it. Meanwhile, the teacher wants students to observe their friends and find out which student represents which concept. He wants them to explain their observations and inferences.

Thermoscope to Thermometer: This drama is an activity consisting of part reading and

discussions. In activity, students are primarily given drama activities to work at home, are asked to research the creation of thermometer. The materials used in the experiments to be made are previously obtained. Then, the experiment of the inflation of hot water containing balloon which was put at the end of the bottle is done. Students are expected to reach the conclusion that when the air expands the volume increases. "Thermoscope to Thermometer" reading part is read and drama part begins. Drama is based on an imaginary conversation between Galileo and his friends Santorio Santorio and Gian Francesco Sagredo who were living with him in Vienna. After the speeches, the lack of the invention made at the time is introduced and the need for a transition to a modern thermometer is emphasized.

Data Analysis

The Nature of Science questionnaire was tested out to experimental and control groups as pretest and posttest. Those tests are evaluated by three researchers, wrong answer was coded as inadequate, partly adequate as convenient and desired leveled answers were coded as modern opinion and they were scored in order of 0,1 and 2. In study interceder reliability was calculated as 0,78. The descriptive analysis of students' answers was done and change in dimensions of the Nature of Science was tried to be set via comparing pretest and posttest results.

Findings

The descriptive analysis of pretest and posttest points of the Nature of Science questionnaire tested out to experimental and control groups is given in Table 3.

Table 3. The descriptive analysis of groups according to aspects of the nature of science

	Group		1			2			3			4			5			6			7		
			0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Pretest	Experiment	n	12	2	1	13	2	0	7	8	0	8	6	1	11	4	0	10	4	1	5	10	0
		%	***80***	**13**	**7**	***87***	**13**	**0**	***47***	**53**	**0**	***53***	**40**	**7**	***73***	**27**	**0**	**67**	**27**	**7**	**33**	**67**	**0**
	Control	n	12	2	1	14	1	0	8	6	1	4	10	1	12	3	0	15	0	0	5	10	0
		%	**80**	**13**	**7**	**93**	**7**	**0**	**53**	**40**	**7**	**27**	**67**	**7**	**80**	**20**	**0**	**100**	**0**	**0**	**33**	**67**	**0**
Posttest	Experiment	n	6	7	2	3	12	0	3	8	4	7	4	4	7	5	3	7	4	4	2	10	3
		%	***40***	**47**	**13**	***20***	**80**	**0**	***20***	**53**	**27**	***47***	**27**	**27**	***47***	**33**	**20**	**47**	**27**	**27**	**13**	**67**	**20**
	Control	n	12	3	0	5	10	0	4	9	2	12	2	1	11	4	0	11	4	0	6	8	1
		%	**80**	**20**	**0**	**33**	**67**	**0**	**27**	**60**	**13**	**80**	**13**	**7**	**73**	**27**	**0**	**73**	**27**	**0**	**40**	**53**	**7**

0: Inadequate 1: Convenient 2: Modern Opinion

When groups' answers were analyzed in the basis of categories, it was seen that both groups got almost same points. It was observed that change among inadequate questions percentage decreased in every questions of experimental group but increased in 4th and 7th questions of control group. The rate of convenient ideas increased in 1St -2nd and 5th questions, never changed in 3th-6th and 7th questions but decreased in 4th question of experimental group. As for control group there was a decrease in 4th and 7th questions but an increase in others. For modern opinions; in experimental group there was an increase but a decrease in 2nd question; in control group there was a decrease in first question, a decrease in 3rd and 7th questions but no change in others.

When questions' posttest test points according to the aspects of the Nature of Science were analyzed for "Scientific Knowledge is reliable but can change" dimension pretest 1, 3, 4, 6; after teaching, convenient and modern ideas were increased 40% (from 20% to 60%), in 3rdquestion 27% (from 53 to 80), in 4th question 7% (from 47 to 54) and in 6th question 20%. In control group rates of change are in order of 0, 26, -44 and 7. It was found that answers

given to 1st and 2nd questions related to the dimension of "Scientific Knowledge involves logical, mathematical and experimental inferences" changed widely to convenient from inadequate (idea of convenient in 2nd question from %13 to %80, in control group from 7% to 67%), and rates of change in control group were 67 and60. Total change of convenient and modern ideas for the 5th question from 1st and 5th which are related to the "Scientific Knowledge is subjective" dimension is 26% in experimental group and 7% in control group. When questions 1, 4 and 7 which are in the "Imagination and creativity has a great role in acquiring scientific knowledge" dimension were analyzed in the change in 7th question was observed as 20% in experimental and 3% in control groups. The last dimension "Observation and inference are different concepts" involves questions 1, 4 and 6 and an increase was observed an increase in countenance to experimental group on a par with first sub-dimension and in order of 40, 7 and 20 percentages. It is seen that increase of point of experimental group in all dimensions related to the Nature of Science is surplus. Change is surplus in the dimensions as "Scientific Knowledge is reliable but can change", "Imagination and creativity has a great role in acquiring scientific knowledge", "Scientific Knowledge is subjective", "Observation and inference are different concepts."

It was controlled whether data distribute normally via Kolmogorov – Smirnov test in order to define which statistical analysis will be used to compare pretest and posttest point of experimental and control groups. The pretest value for control group was found as K –S z=0,599 p=0,866 and posttest z=0,527 p=0,944. For control group it was found as K-S z=0,778 p=0,580 and for posttest z=0,672 p=0,757 which shows normal distribution. Parametric tests can be carried out (Pallant, 2005).

Pretest and posttest total scores were compared between groups with independent sample t-test. Results of independent samples t test are given in Table 4.

Table 4. t test results for pretest and posttest

	Groups	N	$\bar{X}$	S	sd	t	p
Pre-test	Control	15	2,53	1,73	28	-0,344	0,733
	Experiment	15	2,80	2,45			
Post-test	Control	15	3,20	2,21	28	-2,365	0,025*
	Experiment	15	6,00	4,02			

As it is seen in Table 4 there is not any significant difference between students' pretest results (t= 0,344, p>0,05). Accordingly, it can be said that both groups are similar to each other before activities was done in terms of ideas about the Nature of Science. A significant difference between pretest results was found after activities about the Nature of Science practiced in experimental group at the end of unit (t= -2,365, p<0,05). It shows that those activities done oriented to the Nature of Science are effective to develop students' ideas about the Nature of Science. Calculated effect size (n^2=0,2) is quite extensive (Büyüköztürk, 2012). Accordingly, it can be said that 20% of variance seen in the Nature of Science originated from carried out activities.

In control group, activities only in curriculum were done. Although there is an emphasis on teaching the Nature of Science in new Science curriculum, it is obvious that this was not reinforced with appropriate activities and methods. In that case, it can be alleged that usage of activities for the Nature of Science is significantly more effective in accordance with the lesson that activities in not used.

Discussion

In this study, changes in 5th grade students' ideas about the Nature of Science after activities that performed to develop their understanding on the topic of the Nature of Science were analyzed. In control group some other activities were carried out beside ones in course book while in control group any activities were carried out except for activities in 5th grade Science course book that are used convenient for Science lesson curriculum. As a result of activities; a significant difference in points of experimental group from the Nature of Science questionnaire was seen but not in the points of control group (Table 4). There are some studies supporting indications about idea intended to the Nature of Science intellects can be developed via applying variable activities in early ages (Akerson et al., 2011; Can & Şahin Pekmez, 2010; Erenoğlu,2010).

When points of students in control group analyzed, an increase was seen for inadequate questions in 3rd (Scientific knowledge can change) and 7th (Role of imagination and creativity) questions. This, conjures up that teaching based upon course book resulted in that situation. It is observed that students' ideas on the tentative nature of scientific knowledge changed to inadequate idea at the rate of 50%. This is can be because; they were not given feedback about their answers to questions in questionnaire after practice, students' exchanging opinions about their answers on questionnaire and changing their ideas by reason of being unsure about the answers they gave. It can be indicated as another reason to affect each other's idea that expressions in course book were written in such a manner that they were largely indicating certainty of scientific knowledge. However, it is quite apparent that teaching merely depended on course book activities and approach as in control group is not sufficient to develop ideas about the Nature of Science which was envisioned in renewed science program.

When experimental group students' the Nature of Science perceptions were handled in terms of different dimensions it was seen obviously that there was a point rise in all dimensions and inadequate ideas changed to convenient or modern opinion. This reveals that carried out activities were effective in expected level. It was found out that the least point rise was in the dimension of "Scientific Knowledge involves logical, mathematical and experimental inferences." The reason of shortage in observed development, despite giving place to this dimension in activities, can be that deducing may become majorly abstract for students. In addition to activities in this study allowing activities involving mathematical operations and statements without ignoring educational attainments can be very effective on developing ideas in that dimension. In survey questions about this dimension, students were presented the definition of science and feature that make it different from other fields. Due to associating science only with situations faced in science lessons, they might have thought on the basis of lesson and have difficulty in making distinction. Another reason is the relatively quiet shortage of questions about this dimension. Asking questions about all dimensions for revealing students' ideas can increase validity. When analyzed on the basis of questions, it is in 6th question that inadequate opinions changed into convenient and modern opinions in the least numbers. In this question, students were expected to comment on certainty of information that meteorologists gave about weather conditions. The question is about observation and aspect of deducing and changeability of scientific knowledge. Even though these dimensions were given place in activities students had difficulty in commenting in this question. The reason of this can be the information about climate and weather they were given during former educations. Also, 5th grade students are generally in tendency to confuse climate with weather and they have misconceptions about these subjects (Henriques, 2000; Doğar & Başıbüyük, 2005). This may prevent those making right inferences in this question.

Especially if ideas in this dimension at the level of 5th grade are about a subject that students do not have difficulty in understanding, it will be able to get convenient and modern opinions in high rate

Conclusion and Suggestions

Within the context of progress about the dimension of the Nature of Science; considering that activities aimed at understanding the Nature of Science were not in expected level within the 5th grade "Matter and Change" unit, new activities were developed and productivity of activities was tested. It was defined with research findings that experimental students got higher points in comparison with control group from VNOS-E scale. Accordingly, it was ascertained that under the favor of generated activities experimental group students made more progress in comparison with control group students in understanding the Nature of Science. Moreover, when pretest and posttest points were analyzed in themselves it can be said that comprehension ability of both group about the Nature of Science was increased, thus both teachings (the Nature of Science activities and teaching in curriculum) made a contribution to students about understanding the Nature of Science. In the considerations of this study it can be said as:

- In order to make students understand the Nature of Science some activities like these and similar to these must be added to course books and these activities must be integrated to the unit.
- Teacher of Science of Technology/Physical Sciences can take advantage of these activities while teaching different units and in different classes.
- Field researchers, can do research in different levels with these activities.
- Prospective teachers can be lectured about how to organize the Nature of Science activities.
- In service trainings can be organized for Teacher of Science of Technology/Physical Sciences aimed at how to organize the Nature of Science activities.
- By putting emphasis on the studies of nature of science on the level of primary school, we can raise awareness of class masters.

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