

THE EFFECT OF THE DIRECTLY REFLECTIVE APPROACH TO TEACHING THE NATURE OF SCIENCE IN SCIENCE AND TECHNOLOGY EDUCATION ON ACADEMIC ACHIEVEMENT AND SCIENTIFIC ATTITUDE

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Abstract

Information is constantly renewed and changed all over the world, which has reflections on all aspects of our lives. It is education that is especially influenced by the process. Various alternatives are put forward to how to teach students knowledge. One of these alternatives is teaching the nature of science. The present paper is a study on the effect of the directly reflective approach, a method used for teaching the nature of science, on students' academic achievements and attitudes towards science. The study was based on a quasi-experimental design and conducted on one of the primary schools located in Kirikkale. The study included a test on academic achievement designed by the researcher and the scientific attitude inventory (Demirbaş and Yağbasan, 2006) for data collection. The data were analyzed through the SPSS. The study concluded that the directly reflective approach did not have an influence on the students' academic achievements but enabled them to maintain their scores in the scientific attitude scale. Another conclusion is that the students included in the control group tended to have lower scores in the scientific attitude scale in the course of time.

Keywords: The Nature of Science, Teaching the Nature of Science, The Directly Reflective Approach, Science Education

Introduction

We are currently experiencing a period of fast and constant advancement, and therefore improvement and change in every field. Hardly a day passes without an innovation or production in any field. Scientists are constantly working and researching, thus making the structure of knowledge change every single day. As well as leading to changes in each aspect of our lives, the process requires modifications also in the field of education. It is currently believed that it is better to train individuals in a way that will enable them to construct and explore knowledge rather than simply taking in existing information.

The process has resulted in radical changes in the curricula used in Turkey since 2005. The changes have also been reflected in the curriculum for science and technology. The name of the course was transformed from simply science to science and technology, which, in turn, brought about changes in the objectives of the course. In its current form, the curriculum for science and technology expects students to exhibit the following behaviors (MEB, 2005):

- To comprehend the nature of science and technology, the relationship between the two, and the interplay between the two and society and environment.

- To make use of the tools, processes and strategies for issues related to science and technology.
- To develop the kind of knowledge and skills required for developing critical and responsible attitudes towards innovations.
- To understand the development of scientific exploration, technological advancement, and the changes in the knowledge and comprehension of human beings from past to present within several scientific and social contexts.
- To be aware of certain values, perspectives and decisions on issues related to science and technology and to act responsibly.
- To explore scientific processes and technological solutions in a critical manner.

In short, the curriculum was expanded to include a number of new attainments such as certain attitudes and values, scientific literacy, and the ability to use skills in scientific processes. Not a day goes without a new dimension to the discussions and studies on how to enable students to get these attainments in a better way. Teaching the nature of science is one of the methods that can be used to enable students to get these attainments.

Approaches to Teaching the Nature of Science in Science Education

The nature of science generally refers to science as a way to know things, values and beliefs in the roots of scientific knowledge or the development of scientific knowledge. In brief, the nature of science includes the characteristics of scientific activities and scientific knowledge (Bayrakçeken and Çelik 2008). For instance, observation, hypothesizing and deduction are all related to scientific process; on the other hand, whether these processes are influenced by the perceptions of scientists is linked with the nature of science. In this case, a student who has mastered the nature of science completely can be argued to get many of the attainments brought about by the new curriculum. Studies on teaching the nature of science are generally conducted by three methods, namely the historical approach, the indirect approach and the directly reflective approach.

The historical approach is a method that argues that the nature of science can be taught through a combination of the history of science and science education. In broad terms, the method requires students to be provided with the opportunity to participate in activities that enable them to explore the development of scientific theories within the social and cultural context of a particular historical period (Köseoğlu, Tümay and Budak, 2008). In a study conducted by Solomon et al (1992) through historical approach, it was discovered that teaching science in reference to the history of science could have influences on students' views on uncertain nature of scientific ideas and on the interplay between these ideas and the social and cultural contexts in which they are developed. In this study, a total of 94 students, whose ages ranged from 11 to 14, were asked to study six science units with a historical dimension in which they explored the development of scientific theories. In accordance with these units, they designed simple experiments on the models established by some scientists. After the study, the students did not experience any change in their image of scientists or in their views on why scientists have different theories. Following the study, the students started believing that the

objective of conducting experiments was to provide explanation rather than discovering something, that scientists knew what to expect from an experiment, and that theories were different from facts. Even so, the researchers argued that these improvements might have resulted from the fact that the participant teachers were so enthusiastic and provided their students with additional help. Nevertheless, the study suggests that the participants were not satisfied with their views on historical contexts. The reason for this is that students cannot empathize with old ideas and dismiss old theories as types of wrong information. Many students say that playing a scientist is very difficult, especially when they know that he/she is wrong. Students have failed to appreciate social conditions and ideas that lead scientists to develop particular ideas and to make particular decisions. There is not enough evidence to support the efficiency of historical approach on teaching the nature of science to students.

The indirect approach assumes that students can learn concepts about the nature of science indirectly by doing science and working together with science doers. It argues that research-based activities and teaching skills in scientific processes are enough to teach the nature of science. However, various studies reported that students have an insufficient amount of knowledge about the nature of science, for indirect approach does not focus on discussions over the specific aspects of the nature of science (Moss, Abrams and Kull, 1998).

The study conducted by Moss, Abrams and Kull (1998) used the indirect approach. The researchers studied the effect of an environmental science class on 11th and 12th grade students' concepts regarding the nature of science. During the study, the students worked with scientists and participated in research projects that encouraged them to do science. Individual interviews with a group of participants during the school term could not report significant changes in their views on the nature of science. It is thought that participation in research activities through the indirect approach will automatically improve students' understanding of the nature of science. The fact that the indirect approach fails to strengthen students' opinions about the nature of science is reported to result from the hypothesis underlying the approach. The hypothesis is that "students who participate in research activities on science or activities towards attaining the skills in scientific processes will automatically learn the correct concepts about the nature of science as a side product. Abd-El-Khalick and Lederman (2000) attributes this hypothesis to the idea held by some science educationalists who regard learning the nature of science as an affective learning product. An alternative approach emphasizes that learning the nature of science should be considered as a cognitive learning product and that the nature of science should be taught directly rather than waiting for it to be internalized through regularly-held science activities.

The present paper studied the effect of the directly reflective approach, which is used for teaching the nature of science. According to this approach, students should be taught the different elements of the nature of science in a direct manner. In this approach, students are provided with a framework related to the nature of science in a way that will enable them to reflect the experiences they have from scientific studies. Additionally, students are expected to be clearly aware of the elements of the nature of science in the activities they take part in. The approach requires special activities for teaching the elements of the nature of science in order

to enable students to comprehend the nature of science. These activities are carried out during science classes between units. In this way, students are expected to be clearly aware of and discuss the elements of the nature of science, and to draw an analogy between the experiences they have from the subject and actual studies of scientists. In other words, a discussion is organized over how and in which studies the knowledge they acquire about the nature of science through activities appears (Ayvaci, 2007). In recent years, there has been increased interest in studies on the nature of science in Turkey. Most of the studies, like the ones in the foreign literature, have focused on teachers or prospective teachers (Macaroğlu, Şahin and Baysal, 1999; Oyman, 2002; Taşar, 2003; Erdoğan, 2004; Taşkın- Can, 2005; Turgut, 2005; Muğaloğlu, 2006; Muşlu, 2008). There are a limited number of studies on students.

Views of learning science and the nature of science were measured with a focus on a number of different groups in the past. Currently, many international documents aim for scientific literacy for everyone. Therefore, the purpose of the present study, a descriptive one, is to reveal what prospective music teachers think about science and to make comparisons. Accordingly, the Nature of Scientific Knowledge Scale was implemented on prospective music teachers and postgraduate students. The postgraduate students got higher scores. It was observed that the undergraduate students got significantly lower scores than the postgraduate ones. In the light of the findings, it is argued that the development of scientific literacy could benefit from incorporating such interdisciplinary courses as the nature of science and the history of science into different curricula in an interesting way (Tufan, 2007).

In his study, Kaya (2005) studied the effects of adopting the traditional teaching method or teaching based on the theory of discussion on seventh and eighth grade students' academic achievements and views of the nature of science. In this experimental study, the Views of Nature of Science Questionnaire (VNOS) was implemented on the students as a pretest and posttest before and after lecturing respectively. The statistical analyses following the study suggested that the students in the experimental group who were taught science through teaching activities based on the theory of discussion significantly improved their academic achievements and perspectives on the nature of science when compared to the ones in the control group.

A study conducted by Macaroğlu, Taşar and Çataloğlu (1998) investigated the beliefs of prospective primary school teachers in Turkey about the nature of science. The study employed a two-part questionnaire. The first part included five open-ended questions to measure the prospective teachers' ability to combine the nature of science with their teaching. On the other hand, the second part consisted of 10 questions, which were in the form of 5 point likert type items, to reveal what the prospective teachers thought about scientific knowledge. A total of 21 prospective teachers participated in the study. The study found that the participants believed scientific knowledge was objective and changeable.

The present paper is a study on the effect of the directly reflective approach, a method used for teaching the nature of science, on students' academic achievements and attitudes towards science. The following sections focus the purpose of the study and the sub-problems.

The Purpose of the Study

The purpose of the study is to analyze the effect of the directly reflective approach, a method used for teaching the nature of science, on students' academic achievements and attitudes towards science.

The Sub-Problems

1. Is there a significant difference between sixth grade students in the experimental and control groups in terms of their pretest scores on scientific attitude?
2. Is there a significant difference between sixth grade students in the experimental and control groups in terms of their pretest scores on academic achievement?
3. Do the activities carried out for teaching the nature of science through the directly reflective approach result in a significant difference between the scores of the students in the experimental group in the pretest and posttest on scientific attitude?
4. Do the activities carried out for teaching the nature of science through the directly reflective approach result in a significant difference between the scores of the students in the experimental group in the pretest and posttest on academic achievement?

Materials and Methods

The study was conducted within the scope of the course "science and technology" in primary schools during the first term of the educational year 2010-2011. The study was based on "quasi-experimental design" (Çepni, 2005). The method is an experimental design in which individuals are not randomly distributed to experimental and control groups. Pre-composed groups are directly adopted; however, haphazardly, one individual is assigned to experimental group while another is sent to control group. Even so, great care is taken to have participants with similar characteristics (Büyüköztürk et al., 2010).

Throughout the study, the classes in the experimental group were taught through activities based on the directly reflective approach whereas those in the control group were carried out in accordance with the curriculum. The study lasted five weeks, four hours per week. The study investigated the concepts of sixth grade students about the nature of science.

Population

The study was conducted on a total of 52 sixth grade students from Ataturk Primary School, a central primary school located in Kırıkkale. The population of the study was comprised of 27 students in the experimental group (15 male, 12 female) and 25 students in the control group (11 male, 14 female).

Measurement Instruments

The measuring instruments employed in the study were the Scientific Attitude Scale (Demirbaş and Yağbasan, 2006) and the test on Academic Achievement. The Scientific Attitude Scale was implemented on both groups as a pretest and posttest in order to measure their attitudes towards science and to determine any possible change in their attitudes. The scale had already been used for similar groups in the literature, and analyzed for validity and reliability purposes. Thus, no need was felt for analyzing the scale for validity and reliability purposes again. The scale was comprised of 40 items with five options.

The test on Academic Achievement was comprised of 20 items designed in reference to various sources for the subjects “Weight is a Force” and “Particles of Matter”. Following the pilot scheme, the test had a reliability coefficient of 0.80 by the KR-20 formula. Furthermore, the items were analyzed in terms of their discrimination indices and difficulty, which resulted in five items being excluded from the test owing to their insufficient discrimination indices and difficulty. The finalized form, a 15-item multiple-choice test, was implemented on the groups as a pretest and posttest.

Data Analysis

The data for the study were analyzed through a qualitative research method. The data on achievement and attitude tests were analyzed through the SPSS. The instruments were implemented on both groups as a pretest and posttest. An analysis was made of the effect of the activities used throughout the process on the students’ comprehension of the subjects “Weight is a Force” and “Particles of Matter”, and certain comparisons were made. In the multiple-choice test, each correct answer was graded 1 whereas each wrong answer was assigned 0. Afterwards, the SPSS was used for making comparisons and determining whether the activities were efficient or not. A dependent t test, level of significance being $p=0.05$, was conducted in order to determine the differences presented by the calculations. The effects on the students’ attitudes towards scientific knowledge were compared after the data obtained from the questionnaires implemented before and after the practice had been analyzed through the SPSS.

Each answer to the question items in the Likert type scale was graded from 5 to 1 for affirmative question items and from 1 to 5 for negative question items. In this way, it was possible to calculate total scores of each participant in the “Scientific Attitude Scale”, which was used as a five point Likert type scale. A dependent t test, level of significance being $p=0.05$, was conducted in order to determine the differences presented by the first and last implementation of the scale.

Results

The Findings on the Scores of the Students in the Experimental and Control Groups in the Pretest and Posttest on Scientific Attitude

Table 1. The t-test results of the scores of the experimental and control groups in the pretest on scientific attitude

	N	\bar{x}	S	df	t	p
Experimental Group	27	137	8,6	50	1,6	0.1
Control Group	25	141	11,7			

There was not a significant correlation between the experimental group and control group in their scores in the pretest on scientific attitude ($t(49)=1,6, p>.05$) (Table 1). The control group had a more positive scientific attitude ($\bar{x} = 141$) than the experimental group ($\bar{x} = 137$). The finding could be interpreted as a more positive scientific attitude on the part of the students in the control group prior to the study.

Table 2. The t-test results of the scores of the experimental and control groups in the posttest on scientific attitude

	N	\bar{x}	S	df	t	p
Experimental Group	27	137	13,5	50	0,28	0.2
Control Group	25	137	11			

There was not a significant correlation between the experimental group and control group in their scores in the posttest on scientific attitude ($t(50)=0,28, p>.05$) (Table 2). There was not any difference between the experimental group ($\bar{x} = 137$) and control group ($\bar{x} = 137$) in their scientific attitude. This finding could be interpreted as equal scientific attitudes following the study.

Table 3. The t-test results of the scores of the experimental group in the pretest and posttest on scientific attitude

	N	\bar{x}	S	df	t	p
Pretest	27	137	8,6	26	0,23	0.8
Posttest	27	137	13,5			

There was not a significant correlation between the scores of the experimental group in the pretest and posttest on scientific attitude ($t(26)=0,23, p>.05$) (Table 3). The experimental group had the same scientific attitude in the pretest and posttest ($\bar{x} = 137$). The finding could be interpreted as a lack of change in their scientific attitudes following the study.

Table 4. The t-test results of the scores of the control group in the pretest and posttest on scientific attitude

	N	\bar{x}	S	df	t	p
Pretest	25	141	11	24	1,5	0.1
Posttest	25	137	11			

There was not a significant correlation between the scores of the control group in the pretest and posttest ($t(24)=1,5, p>.05$) (Table 4). The control group had a more positive scientific attitude in the pretest ($\bar{x} =141$) than in the posttest on scientific attitude ($\bar{x} =137$). The finding could be interpreted as a decrease in the scientific attitude of the control group during the study.

The Findings on the Scores of the Students in the Experimental and Control groups in the Pretest and Posttest on Academic Achievement

Table 5. The t-test results of the scores of the experimental and control groups in the pretest on academic achievement

	N	\bar{x}	S	df	t	p
Experimental Group	27	7,7	2,9	50	1,5	0.1
Control Group	25	9,0	3,0			

There was not a significant correlation between the experimental group and control group in their scores in the pretest on academic achievement ($t(50)=1,5, p>.05$) (Table 5). The control group had higher scores in the pretest on academic achievement ($\bar{x} = 9,0$) than the experimental group ($\bar{x} =7,7$). The finding could be interpreted as a more positive academic achievement on the part of the students in the control group prior to the study.

Table 6. The t-test results of the scores of the experimental and control groups in the posttest on academic achievement

	N	\bar{x}	S	df	t	p
Experimental Group	27	8,8	3,11	50	2,1	0.03
Control Group	25	10,7	3,4			

There was a significant correlation between the experimental group and control group in their scores in the posttest on academic achievement ($t(50)=2,1, p>.05$) (Table 6). The students in the control group had higher scores in the posttest on academic achievement than the ones in the experimental group.

Table 7. The t-test results of the scores of the experimental group in the pretest and posttest on academic achievement

	N	\bar{x}	S	df	t	p
Pretest	27	7,7	3	26	1,8	0.07
Posttest	27	8,8	3,1			

There was not a significant correlation between the scores of the experimental group in the pretest and posttest on academic achievement ($t(26)=1,8$, $p>.05$) (Table 7). The experimental group had more positive scores in the posttest ($\bar{x} =8,8$) than in the pretest on academic achievement($\bar{x} =7,7$).

Table 8.The t-test results of the scores of the control group in the pretest and posttest on academic achievement

	N	\bar{x}	S	df	t	p
Pretest	25	9	3	24	3,2	0.004
Posttest	25	10,7	3,4			

There was a significant correlation between the scores of the control group in the pretest and posttest on academic achievement ($t(24)=3,2$, $p>.05$) (Table 8). The students in the control group had even higher scores in the posttest on academic achievement.

Discussion

The present study made an attempt to teach the nature of science to sixth grade students through the directly reflective approach. Furthermore, it investigated the effect of teaching the nature of science through this approach on students' scientific attitudes and academic achievements. The findings, especially those presented in Table 7, suggest that the directly reflective approach has no influence on students' academic achievements. Interviews were conducted with school administrators and teachers of the classes in order to find out the reasons. It turned out that the group chosen as the control group was, in fact, a special class in which successful students were gathered for a reason. This might be a reason why there was not a significant difference between the two groups in their scores in the tests on academic achievement. A similar study in the literature, conducted by Ayvacı (2007), reported that the students could not learn the subject "gravitation", which had been particularly chosen for the study, in a proper way, although the directly reflective approach enabled them to comprehend many of the elements of the nature of science. In *"The effect of Historical Approach on Improving Seventh Grade Students' Views of the Nature of Science"*, a study conducted by Doğan and Özcan (2010), it was found that teaching the nature of science through the historical approach has a positive effect on students' academic achievements. There is a lack of consensus on the effect on academic achievement in the literature, including the present study. However, it turned out in the present study that the group chosen as the control group was, in fact, a special class in which successful students were gathered for a reason. Therefore, it is recommended that the present study should be carried out again, this time with a homogenous population.

The study also measured the students' scientific attitudes. A decrease was observed in the mean scores of the control group in the posttest on scientific attitude (Table 4) whereas no

difference existed between the mean scores of the experimental group in the pretest and posttest on scientific attitude. In general, attitude is difficult to change. Seeing that the present study was confined to a short period, five weeks, it is recommended that another study should be conducted over a longer time period. For instance, in his dissertation, Küçük (2006) studied the effect of the activities for the nature of science on students' attitudes towards science over a ten-week period. Subsequently, it was observed that such activities have a significant influence on students' attitudes towards science.

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