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THE NATURE OF SCIENCE INSTRUCTION WITH A DIRECT REFLECTIVE APPROACH: "HESS" AND "THERMODYNAMIC LAWS"

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Abstract
The purpose of the present study is to examine the effect of the nature of science instruction based on direct reflective approach on the level of student's understanding on the Hess Law and Thermodynamic Laws and on their beliefs about the nature of science. In this study, pretest-posttest control group design was used. The research was carried out with 50 students studying in two different classes in a Vocational and Technical Anatolian High School in Trabzon. While the experimental group students were taught with activities based on the direct reflective approach, the control group was taught with the traditional approach. Chemistry and Energy Achievement Test and Views of Nature of Science (VNOS-C) interview were used to collect data. The results showed that students have a lot of alternative conceptions about the nature of science and chemistry concepts under investigation and that the experimental group was more successful than the control group.

Keywords: The Nature of Science, Direct Reflective Approach, Thermodynamic, Hess Law.

INTRODUCTION

In international literature, while the concept of nature of science has been seen as an essential objective for students to learn science for the last one hundred years (Lederman, 2006), this concept in our country has been tried to be integrated into teaching programs in recent years. Important institutions and organizations such as the National Science Teachers Association (NSTA, 1982), the American Association for the Advancement of Science (AAAS, 1993) and the National Research Council (NRC, 1996) have emphasized the importance of the nature of science concepts. The sub-dimensions of the nature of science are expressed as empiricism, subjectivity, changeability, imagination and creativity, social and cultural influence, difference of observation and inference, difference between theory and law (AAAS, 1990, 1993; Millar and Osborne, 1998; NRC, 1996). The understanding of the nature of science is claimed to have an important role in understanding the science and the value of science as a part of contemporary cultures, managing technological tools and processes, and deciding on socio-scientific issues (Driver, Leach, Millar, and Scott, 1996). The chemistry teaching program, which was revised again in 2013, emphasized the importance of increasing the level of understanding of the students about the nature of science (MEB, 2013). The aim here is to train science literate individuals who know what science is and how to use science in everyday life. Scientific literate can be defined as a person who understands the nature of science and its sub-dimensions and can use scientific process skills. As can be understood from the definitions, scientific literacy and the nature of science are intertwined concepts. Hence it is thought that individuals who understand the nature of science and its sub-dimensions will be able to perceive the concepts of chemistry more easily.

As is known, students have difficulties in understanding the basic chemistry concepts and have many alternative conceptions about these concepts (Demircioğlu and Yadigaroğlu, 2014). One of these concepts is thermodynamic laws. Many students have difficulty in noticing the phrase "*Energy cannot be created or destroyed, it can only be changed from one to another*". They generally think that "the energy can be destroyed or crated". In addition to these, it has been identified that students held alternative conceptions as "Energy does not change", and "there is electricity in the battery" and resemble the energy to the electricity, motion, light, sun etc. types of the energy (İyibil, 2011; Yürümezoğlu, Ayaz and Çökelez, 2009). Yürümezoğlu, Ayaz and Çökelez (2009) investigated level of understanding of 120 elementary school students about the energy and the related concepts and how energy changed over time. They explored that the students' understanding of these concepts is inadequate and incomplete. According to these results, they suggested that different experiments and activities should be done while teaching these abstract concepts. Taking into account the nature and sub-dimensions of science, the teaching of thermodynamic laws and HESS law is expected to increase the level of students' understanding of these concepts and the nature of science.

When studies on the nature of science are examined, it is seen that teacher candidates are usually used as a participant (Ağlarcı and Kabapınar, 2016; Aguirere, Haggerty and Linder, 1990; Bloom, 1989). In these studies, it is emphasized that the science activities which are not aimed to directly teach the nature of science could not improve student' perceptions of nature of science and overcome their alternative conceptions about it, and new alternative conceptions could emerge. On the other hand, when the nature of science is taught with a direct reflective approach associated with science topics, there are studies that suggest that preservice teachers' understanding of the nature of science significantly improved (Lederman, Schwartz, Abd-El-Khalick and Bell, 2001). It is even thought that taking into account the historical development of concepts in science teaching provides important contributions about students' understanding of the development of science and changeability of scientific knowledge over time. When examined the studies in our country, it is understood that they has begun to emphasize on concepts of nature of science and scientific literacy. However, teaching plans and models on how to improve these concepts in students are needed. Erdoğan and Köseoğlu (2015) in their study conducted with 15 eleventh grade students used explicit-reflective inquiry activities to improve students' perceptions about nature of science while teaching the topic of chemical equilibrium. In the study, the nature and sub-dimensions of science have been tried to be integrated into the subject of chemical equilibrium. As a result of the study, it was determined that the students' perceptions of nature of science progressed considerably and participants developed a positive perspective towards chemistry. Ağlarcı and Kabapınar (2016) aimed to overcome chemistry student teachers' misconceptions about the nature of science by using the activities based on a direct reflective approach. As a result of the study, it was determined that the opinions of chemistry student teachers on the nature of science changed positively. They also indicated that teaching with activities based on the nature of science may facilitate to learn difficult chemistry topics. It is claimed that not only teacher candidates but also a great majority of teachers think that scientific knowledge is universal and that it will not change over time (Aguirere et al., 1990). Some teachers have misconceptions about the differences between theory and law (Bloom, 1989). The fact that the "nature of science" concept, which is of great importance in terms of the quality of education, is not properly structured even by teachers, shows how important this concept is and what it is worth investigating. As mentioned above, teachers, teacher candidates and high school students have similar difficulties and misconceptions about the nature of science. Indirect, direct-reflective and historical process approaches are used in the teaching of the nature of science. It is suggested that the direct reflective approach is more effective than an indirect approach (Önen Öztürk ve Bayram, 2017). For this reason, direct reflective approach was preferred in this study.

The Purpose of the study
The purpose of the this study is to determine the effect of the nature of science instruction based on direct reflective approach on the level of student's understanding on the Hess Law and 1st, 2nd and 3rd laws of Thermodynamic and on their beliefs about the nature of science.

METHOD

The experimental method is the most appropriate method to determine the effect of a variable. In this study, quasi-experimental method, which is often used in educational research (Thistlethwaite and Campell, 1969), was used. This method is preferred when groups cannot be created by random assignment. The present study was conducted with 50 students (EG: 29; CG: 21) in Trabzon Vocational and Technical Anatolian High School. In the school, one of the two classes at the 11th grade was randomly assigned to the experimental (29) group and the other control group (21). While the control group students were taught to with traditional approach, the experimental group students were taught with a direct reflective approach using various activities. The application was completed in 6 hours in the experiment group and in 8 hours in the control group.

Data Collection Tools
In this study, Chemistry and Energy Achievement Test and Views Nature of Science Form-C (VNOS-C) (Lederman, Abd-El-Khalick, Bell ve Schwartz, 2002) were used as data collection tools. Besides semi-structured interviews were conducted with the students in the experimental group in order to determine their opinions about application.

Chemistry and Energy Achievement Test (CEAT); the CEAT has been prepared by taking into consideration the learning outcomes of the Chemical and Energy unit in the 11th grade chemistry teaching program. This test consisting of 17 multiple-choice, 10 open-ended, total 27 questions, was applied to 12th grade 33 students as a pilot study. Some of the questions were taken from textbooks written in accordance with the chemistry teaching program. The others were prepared by the researchers by taking into consideration the alternative conceptions and learning outcomes. As a result of the item analysis, the reliability of the multiple choice was found to be 0.71 using the KR-20 formula. The reliability of the open ended part was calculated to be 0.96 using the inter-rater reliability method (two raters).

Views Nature of Science Form-C (VNOS-C); Form-C which designed by Lederman et al. (2002) was used to determine the students' understanding level about the nature of science. The scale contains 11 open ended questions. In this study, the test was applied twice as pre-test and post-test. Data analysis was made as suggested by Lederman et al. (2002). The answers given by the students were discussed and evaluated by two different researchers.

Procedure
While the control group students received traditionally designed chemistry education, the experimental group students were taught with activities based on student collaboration and active participation. The activities in experimental group included daily life samples such as thermos, pressure cooker, car engine and carburetor for open, closed and isolated systems. On the other hand, concept cartoon and tangram activity were used for the nature and the sub-dimensions of science.
Tangram Activity: The purpose of this activity is to make students' understanding that scientific information may change with new information, different perspectives and interpretations. The reason for choosing this activity is to allow to work with the scientists' mind. The activity was practised by following the steps below.
Application Steps:
1. To form a shape is asked by combining the fragments of the hands of the groups of five persons (Shape 1).

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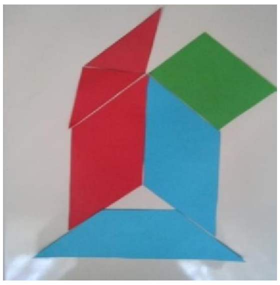
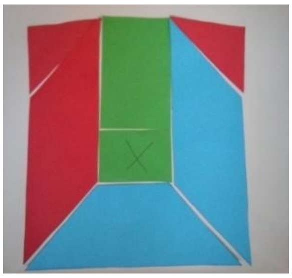
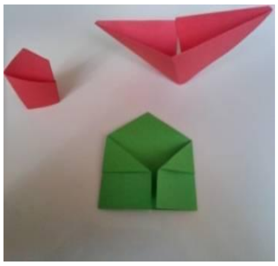
2. A piece marked with X is given each group, and it is said that this piece symbolizes a new scientific knowledge. Groups obtain following shape (Shape 2).
3. Each student in the group makes a shape that they want from a single piece in their hand (Shape 3).



Shape 1



Shape 2



Shape 3

Result: At the end of activity, students were asked to argue what aspects of a scientific work are similar with this activity, and what characteristics of nature of science reflects.

Concept Cartoon: The following concept cartoon were developed for the Hess Law to improve the students' understanding of the sub-dimensions of the nature of science (the effect of the social and cultural environment, the theory and law difference, empiricism and the effect of the imagination). Cartoon was used to determine and discuss students' existing alternative conceptions. First, the students read ideas of characters in the cartoon and expressed their own ideas. And then, ideas of each character were discussed and evaluated.

Analysis of Data
Multiple choice questions were evaluated by giving 1 for each correct answer and 0 for the wrong answer. Descriptive analysis techniques were used in analyzing open-ended questions (Yıldırım and Şimşek, 2000). The answers that the students gave to the questions were categorized as "sound understanding, partial understanding and unanswered". The t-test was used for the results of multiple choice and open-ended questions. The results of the VNOS-C scale were evaluated using percentages.

FINDINGS AND DISCUSSION

1. Findings from the multiple choice section of the test
Findings from the multiple choice section of the testfor pre-test and post-test are given in Table 1.

Table 1: Findings from the Multiple Choice Section of the Test

		Pre-test			Post-test		
		CA*	WA*	NA*	CA*	WA*	NA*
		%	%	%	%	%	%
1	EG	27.58	62.07	10.35	48.27	51.72	0
	CG	9.53	90.47	0	4.76	95.23	0
2	EG	13.79	86.21	0	62.06	37.93	0
	CG	14.28	85.72	0	19.04	80.95	0
3	EG	13.80	86.20	0	41.37	58.62	0
	CG	4.76	90.47	3.44	42.85	57.14	0
4	EG	37.93	55.17	6.89	79.31	20.68	0
	CG	14.28	85.71	0	42.85	57.14	0
5	EG	10.34	89.66	0	58.62	41.37	0
	CG	23.80	76.19	0	4.76	90.47	4.76
6	EG	20.68	79.31	0	68.96	27.58	3.44
	CG	28.57	71.42	0	42.85	57.14	0
7	EG	20.68	79.31	0	41.37	58.62	0
	CG	28.57	71.42	0	19.04	80.95	0
8	EG	41.37	58.62	0	27.58	72.41	0
	CG	14.28	85.71	0	23.80	76.19	0
9	EG	6.89	89.65	3.44	37.93	62.06	0
	CG	9.52	90.47	0	14.28	85.71	0
10	EG	10.34	86.20	3.44	82.75	17.24	0
	CG	19.04	72.72	4.76	42.85	52.38	4.76
11	EG	17.24	82.75	0	34.48	65.51	0
	CG	23.80	76.19	0	28.57	71.42	0
12	EG	27.58	68.96	3.44	24.13	75.86	0
	CG	28.57	71.42	0	42.85	57.14	0
13	EG	20.68	79.31	0	41.37	58.62	0
	CG	4.76	95.23	0	9.52	90.47	0
14	EG	24.13	75.86	0	65.51	34.48	0
	CG	19.04	80.95	0	52.38	38.09	9.52
15	EG	34.48	58.62	6.89	79.31	20.68	0
	CG	28.57	71.42	0	42.85	57.14	0
16	EG	13.79	86.20	0	41.37	58.62	0
	CG	14.28	85.71	0	9.52	90.47	0
17	EG	44.82	55.17	0	62.06	37.93	0
	CG	33.33	66.66	0	9.52	90.47	0

*CA: CorrectAnswer WA: WrongAnswer NA: No Answer

As shown in Table 1, the correct response rates of the students in the pre-test are between 6.89% and 44.82% for the experimental group; and between 4.76% and 33.33% for the control group. The highest achievement in the experimental group is on the 8th and 17th questions about the entropy and the heat concepts; the lowest achievement is on the 9th question about the heat, work and internal energy concepts. The highest achievement in the control group is on the 17th question about the heat concept; the lowest achievement is on the 3th and 13th questions about the heat of formation and the system types concepts. The correct answer rates of the students in the experimental and control groups in the post-test increased relative to the pre-test. However, success rates in the control group are not as expected. These rates are between 24.13% and 82.75% in the experimental group; in the control group is between 4.76% and 42.85%. The highest achievement in the experimental group is on the 10th question about the voluntary-involuntary event concepts; the lowest achievement is on the 12th question about the thermodynamic concept. The highest success rate in the control group is on the 3, 4, 6, 12 and 15th questions about the enthalpy of formation, constant volume-constant pressure, thermodynamic and heat-temperature concepts; the lowest achievement is on the 1st and 5th questions about the system and environment, internal energy concepts. t-test results for pre-test and post-test means of experiment and control group are given in Table 2.

Table 2: t-test Results for Pre-Test and Post-Test Means of Experiment and Control Group

Pre-test	**N**	**Mean**	**SD**	**df**	**t**	**p**
EG	29	4.06	1.73	48	2.01	0.13
CG	21	3.19	2.31			
Post-test						
EG	29	8.96	2.53	48	2.01	0.001
CG	21	4.47	2.80			

As seen in Table 1, the pre-test average of the experimental group is 4.06 and the control group is 3.19. The post-test average of the experimental group is 8.96 and the control group is 4.47. In order to compare the performance in the pre-test and post-test of the groups, an independent samples t-test was carried out. The Table 2 reports the results. Table 2 reveals that the difference between the means obtained from the pre-test of the EG and the CG students was not statistically significant ($p>0.05$). It can be said that both groups' preconceptions are equal about the studied subject. The difference between the means obtained from the post-test of the EG and the CG students was statistically significant ($p <0.05$). The experiment group is more successful about the studied subject for the multiple-choice questions.

2. Findings from the open-ended section of the test

The results from the open-ended section of the test for pre-test and post-test are given in Table 3.

Table 3: The Results from the Open-Ended Section of the Test

Item no		Pre-test			Post-test		
		SU*	PU*	NA*	SU*	PU*	NA*
		%	%	%	%	%	%
1	EG	0	17.24	82.75	17.24	58.62	24.13
	CG	0	4.76	95.23	0	0	100
2	EG	0	51.72	48.27	62.06	24.13	13.79
	CG	0	23.80	76.19	14.28	57.14	28.57
3	EG	0	27.58	79.31	31.03	13.79	55.17
	CG	0	0	100	0	4.76	95.23
4	EG	0	89.65	6.89	17.24	82.75	0
	CG	0	61.90	19.04	0	57.14	38.09
5	EG	0	17.24	82.75	27.58	31.03	41.37

	CG	0	0	100	0	0	100
6	EG	0	31.03	68.96	68.96	31.03	0
	CG	0	9.52	90.47	0	33.33	66.66
7	EG	0	37.93	58.62	96.55	0	3.44
	CG	0	4.76	95.23	38.09	0	61.90
8	EG	10.34	68.96	20.68	28.62	37.93	3.44
	CG	14.28	61.90	23.80	9.52	42.85	47.61
9	EG	72.41	20.68	6.89	89.65	3.44	6.89
	CG	42.85	33.33	23.80	28.57	4.76	66.66
10	EG	0	65.51	34.48	51.72	34.48	13.79
	CG	0	19.04	80.95	0	14.28	85.71

*SU: Sound Understanding PU: Partial Understanding NA: No answer

When the pre-test results are examined the percentage of answers of EG group students in the "Sound Understanding" category ranged from 0% to 72.41%, that of CG group students ranged from 0% to 42.85%. This result indicated that the students' understanding levels in this category are almost similar to each other except the 9th item about "reversible-irreversible processes". In the item, the experimental group had a higher level of understanding than the control group. In the "Partial Understanding" category, the percentage of the EG varied between 17.24% and 89.65%, that of the CG ranged from 0% to 61.90%. In the "Unanswered" category, the percentage of the EG varied between 6.89% and 82.75%, that of the CG ranged from 23.80% and 100%. The almost all of the control group students did not answer the questions (1, 3, 5) which required mathematical calculation mostly. When the post-test results are examined the percentage of answers of EG group students in the "Sound Understanding" category ranged from 17.24% to 96.55%, that of CG group students ranged from 0% to 38.09%. In the "Partial Understanding" category, the percentage of the EG varied between 0% and 82.75%, that of the CG ranged from 0% to 57.14%. In the "Unanswered" category, the percentage of the EG varied between 0% and 55.17%, that of the CG ranged from 28.57% and 100%. All students in the control group did not answer 1st and 5th questions about enthalpy of formation and entropy change. t-test results for pre-test and post-test means of experiment and control group are given in Table 4.

Table 4: t-test Results for Pre-Test and Post-Test Means of Experiment and Control Group

Pre-test	N	Mean	SD	df	t	p
EG	29	17.68	6.64	48	2.01	0.09
CG	21	14.33	7.15			
Post-test						
EG	29	66.68	19.15	48	2.01	0.001
CG	21	18.85	14.80			

As seen in Table 3, the pre-test average of the experimental group is 17.68 and the control group is 14.33. The post-test average of the experimental group is 66.68 and the control group is 18.85. In order to compare the averages in the pre-test and post-test of the groups, an independent samples t-test was carried out. The Table 4 reports the t-test results. Table 4 reveals that the difference between the means obtained from the pre-test of the EG and the CG students was not statistically significant ($p>0.05$). It can be said that both groups' preconceptions are equal about the studied subject. On the other hand, the difference between the means obtained from the post-test of the EG and the CG students was statistically significant ($p <0.05$). The experiment group is more successful about the studied subject for the open-ended questions. In the control group, the least success rate was on 1, 3, 5, and 10th questions which required mathematical calculation (Table 3). 4th and 6th questions are knowledge and comment questions. The control group could not answer these questions because the students were inadequate in making comments and mathematical calculations. It was observed that the students in the experiment group were able to comment on the events and situations with a different perspective during the treatment. The experimental group students were more successful in comment questions than in questions requiring mathematical calculations.

3. Findings from the VNOS-C scale

Table 5 contains students' alternative conceptions obtained from the VNOS-C scale. When the pre-test results (VNOS-C) are examined, the percentage of answers of EG group students ranged from 6.9% to 34.5% and that of CG group students ranged from 4.8% to 14.2% (Table 5). This indicated that EG students have a higher percentage of alternative conceptions than CG students. After the treatment, the percentages of EG ranged from 0% to 48.3% and that of CG ranged from 0% to 23.8%. While the experimental group students completely corrected 2nd and 4th alternative conceptions in Table 5, the control group students remedy 3rd and 6th alternative conceptions. The result from the VNOS-C test showed that the direct reflective approach was not effective on students' perceptions of the nature of science. However, Ağlarcı ve Kabapınar (2016) investigated that the effect of activities based on direct reflective approach on the chemistry student teachers' opinions about science and pseudo-science, and on their alternative conceptions about the nature of science and science. They found that the chemistry student teachers' opinions about the nature of science changed positively. Karaman & Apaydın (2014) used *"Views of Nature of Scientific Inquiry" instrument* in order to examine *the nature of scientific inquiry understandings of elementary teachers. They found that elementary teachers held a "inadequate" understanding about the nature of scientific inquiry.* It has been identified in many studies because there is no specific teaching activities about the nature of science, students and student teachers have inadequate or incomplete knowledge about the sub-dimensions of the nature of science in the world and Turkey (Akerson, Abd-El-Khalick and Lederman, 2000; BouJaoude, 1996; Doğan and Abd-El-Khalick, 2008; Meichtry, 1992).

Table 5: The VNOS-C Results of The Experimental and Control Group

Students' alternative conceptions	Grup	Pre-test		Post-test	
		f	%	f	%
1. Scientific knowledge can only be discovered by using experiment methods	EG	9	31	14	48.3
	CG	1	4.8	5	23.8
2. There is no difference between a scientific theory and a scientific law	EG	4	13.8	0	0
	CG	2	9.52	3	14.3
3. Scientific theories turn into laws with enough *research.*	EG	5	17.2	2	6.9
	CG	3	14.2	0	0
4. Scientists do not use their imagination in their research	EG	2	6.9	0	0
	CG	2	9.52	1	4.8
5. Scientific knowledge is universal and unchanging	EG	10	34.5	6	20.7
	CG	2	9.52	5	23.8
6. Scientists are not affected by each other	EG	7	24.1	1	3.4
	CG	2	9.52	0	0

As seen in Table 5, the most common alternative conception is "*scientific knowledge can only be discovered by using experimental methods*". Number of students in both groups who have this alternative conception increased from the pre-test to the post-test. It is understood that students are coded in their minds that the scientist and the experiment are two inseparable halves that comprise the whole. The alternative conception has also been encountered in studies in the literature (Karaman and Apaydın, 2014; Wening, 2006). In their study of Karaman and Apaydın (2014), they found that some elementary teachers believed that a the only way to produce scientific knowledge is to experiment. McComas (2000) stated that one of the most important tools was to experiment in science, but it's not the only way.

RESULTS AND SUGGESTIONS

The present study investigated the effect of the nature of science instruction based on direct reflective approach on the level of student's understanding on the Hess Law and Thermodynamic Laws and on their beliefs about the nature of science. To achieve the purpose, activities consisting of both chemistry concepts and the nature of science were developed and applied by the authors. The results indicate that teaching based on direct reflective approach was more effective in remedying students' alternative conceptions and on levels of students' understanding about the Hess Law and 1^{st}, 2^{nd} and 3^{rd} laws of Thermodynamic on than traditional instruction. However, the effect of the activities used in the study on students' perceptions of the nature of science was much lower than expected after the treatment. Students' low performance on the nature of science may be originated from their negative views on learning, school, and their future. Also, this result may be due to the lack of general chemistry knowledge of learners and lack of willingness to study. Most of the students do not repeat the concepts they have learned in classroom and do not do the homework given by the teacher. Many of participants do not want to take a responsibility of their learning and asks their teacher everything. This is a limitation for the study. The results of the present study should be evaluated by take into consideration the mentioned limitation. On the other words, the characteristics of the participants significantly affected the results of the study.

Chemistry teachers should directly be taken into consideration the nature and sub-dimensions of science emphasized in the chemistry teaching curriculum in order to grow scientific literate individuals.

To change the perception on any subject is hard and takes time. The present study which is based on only one unit was not effective enough on students' perceptions of the nature of science. For the expected effect, the study should be expanded to other chemistry subjects and done over a longer period.

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