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Middle School Students' Views of Scientific Inquiry: An International Comparative Study

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ABSTRACT: The aim of this study is to investigate middle school students' views of scientific inquiry. A total of 489 middle school students (238 from the United States, and 251 from Turkey) participated in the study. The Views of Scientific Inquiry-Elementary (VOSI-E) was used to assess participants' scientific inquiry views. The instrument covered four aspects of scientific inquiry which are "all investigations begin with a question", "there is no single scientific method", "scientists collect empirical data to answer their questions", and "data and prior knowledge are used to answer questions". A series of chi-square test of independence tests were employed to examine differences in views of scientific inquiry as an effect of the country. The results revealed that there is a significant difference in students' views of scientific inquiry between the countries. The USA sample demonstrated more contemporary views on the aspects of "all investigations begin with a question", "scientists collect empirical data to answer their questions", and "data and prior knowledge are used to answer questions" while Turkish sample demonstrated more contemporary views on the aspect of "there is no single scientific method". The differences between middle school students' views of scientific inquiry and implications are discussed.

KEY WORDS: Comparative study, middle school students, scientific inquiry, Turkey, USA

INTRODUCTION

In recent years, the issue of scientific literacy has been at the center of debate among the science education community and it is indicated to be the main aim of science reform in many countries. Science educators have emphasized the importance of nature of science and scientific inquiry as these subjects are fundamental and essential components of scientific literacy (e.g. Lederman; Lederman & Antink, 2013; Roberts, 2007). Scientific inquiry is a major curriculum standard in many countries (e.g. American Association for the Advancement of Science, 1990, 1993; Council of Ministers of Education of Canada, 1997; Ministry of Education

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of the People's Republic of China, 2001 as cited in Liang et al., 2009; National Research Council [NRC], 1996; Turkish Ministry of National Education [MONE], 2005). According to the NRC,

> *"Scientific inquiry refers to the diverse ways in which scientists study the natural world and proposes explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and views of scientific ideas, as well as views of how scientists study the natural world" (NRC, 1996, p. 23).*

Based on the statement above, it is important to help students to understand "what/why scientist work as they do and how knowledge is accepted within the scientific community" (Schwartz, Lederman, & Lederman, 2008, p.2), in other words, it is important to engage students in the activities to think and act like scientists (Yeh, Jen, & Hsu, 2012). Scientific inquiry involves, but is not limited to, scientific knowledge and science process skills. Scientific inquiry encompasses science methodology and merges it with scientific knowledge, scientific reasoning and critical thinking (Lederman, 2006). In spite of the fact that there is a close connection between scientific inquiry and nature of science, scientific inquiry focuses on processes of inquiry whereas nature of science focuses on the product of inquiry (Schwartz et al. 2008).

Turkey's educational institutions put scientific literacy at the center of the science education. Indeed, the institutional vision for the curriculum in Turkey is: ''all students, regardless of individual and cultural differences, should develop scientific and technological literacy'' (MONE, 2005, p. 5). Consequently, the importance of the scientific inquiry and the nature of science are promoted in the ongoing design of the curriculum.

According to results found by the Organization for Economic Cooperation and Development (OECD) by means of the Program for International Student Assessment (PISA), both the United States, a developed country and Turkey, a developing country, are below the OECD average score (OECD, 2013). In addition, science curricula in the US and Turkey both feature a spiral model design and are student-centered. However, the educational bureaucracy and administration is decentralized in USA while that of Turkey is highly centralized. Teachers of middle schools use multiple textbooks, explain science ideas to whole class, prefer whole group discussion, and have students work in small groups, and employ hands-on and laboratory activities on a weekly basis in U.S. (Banilower et al., 2013). On the other hand, teachers use a textbook which is selected by MoNE, prefer lecturing and whole class discussion in Turkey (Turkmen, & Pedersen, 2005). Even Turkish teachers who are eager to include hands-on activities and small group works to their instruction have

limited opportunities to implement this due to lack of equipment and science materials in their classrooms (Yilmaz, & Turkmen, 2007).

There is considerable research on the nature of science in both Turkey (e.g. Cavas, Ozdem, Cavas, Cakiroglu, & Ertepinar, 2013; Dogan & Abd-El-Khalick, 2008; Dogan, Arslan, & Cakiroglu, 2006; Irez, 2006; Kilic, Sungur, Cakiroglu, & Tekkaya, 2005; Koksal, 2010; Kucuk, 2008) and the US (e.g. Abd-El-Khalick & Akerson, 2004; Abd-El-Khalick & Lederman, 2000a; Akerson, Morrison & McDuffie, 2006; Khishfe, 2008; Lederman, 1992; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Marra & Palmer, 2005). Considering the belief that doing inquiry develops views of scientific inquiry, studies focused on the doing of inquiry rather than that on views of scientific inquiry (Lederman et al., 2013). Indeed, studies on students' views of scientific inquiry are scarce. For instance, a limited number of studies concentrated on how to improve learners' views of scientific inquiry. These studies revealed that explicit instruction (Gess-Newsome, 2002; Lederman et.al, 2003; Schwartz, 2007), working with scientists (Bahbah et al., 2013), and engaging in authentic scientific research (Aydeniz, Baksa & Skinner, 2011) are effective in developing learners' views of scientific inquiry. Therefore, due to the lack of related studies, identifying and examining students' views of scientific inquiry is warranted. Considering the similarities and the differences of educational systems in the US and Turkey, examining middle school students' views of scientific inquiry in these two distinct contexts was the aim of the present study. The questions guiding this study are as follows:

1. Is there a difference between middle school students' views of scientific inquiry in the United States and Turkey?
2. Is there a difference in students' views of scientific inquiry with regard to different aspects of scientific inquiry?

METHODOLOGY

Participants

Two convenience samples were involved in the study. A total of 489 middle school students from the region of the Midwest in the United States, and the region of the southwest in Turkey participated in the study. The American sample consisted of 238 middle school students (103 female, 135 male). The Turkish sample included 251 (120 female, 131 male) middle school students. Table 1 displays the distribution of the participants' grades. The participants in both samples attended public schools in urban areas. The US participants were from low-middle socioeconomic status homes, while those from Turkey were from middle socioeconomic status families.

Table 1 Distribution of participants' grade

	N (The USA)	N (Turkey)
6th grade	66	87
7th grade	77	72
8th grade	95	92
Total	238	251

Instrument

The Views of Scientific Inquiry-Elementary (VOSI-E, Lederman & Ko, 2003) is used to assess participants' views of scientific inquiry. Four aspects emerged in the instrument which are explained as follows (Lederman & Ko, 2003):

1. All investigations begin with a question: Scientific studies and researchers integrate interviews and questionnaires with a series of questions, answering questions in those questionnaires and probing questions from interviews, and most significantly making comparison between the collected data and what is already known from the scientific field. Therefore, the scientific studies are initiated through questions, although they do not essentially confirm or disconfirm a hypothesis.
2. There is no single scientific method: There is no defined set or series of procedures that characterize all scientific studies. With the inclusion of a classic investigational design, descriptive and correlation studies are also considered to be valid techniques for developing scientific knowledge and skills. Scientific researchers employ various research techniques in different studies depending on the research questions they aim to answer.
3. Scientists collect empirical data to answer their questions: The use of experimental evidence as the foundation for explaining their findings distinguishes science from other fields such as social studies. Scientific researchers always focus on collecting accurate and evidence-based data from observations of facts and events. This helps them to draw precise and evidence-based conclusions that are consistent with the facts collected.
4. Data and prior knowledge are used to answer questions: Scientific investigators extract their explanations from evidence and facts and interrelate this the scientific knowledge and information they already have about the universe.

In order to assess Turkish participants' views of scientific inquiry, a Turkish version of the instrument was developed. The VOSI-E was translated and adapted into Turkish by Cetinkaya, Sariaydin, Kutukcu and Akcay (2010). They conducted a study with 253 (106 6th grade, 50 7th grade,

and 97 8th grade) middle school students validating the Turkish version of VOSI-E.

Because the correspondence of items to aspects are not one-to-one, the responses from participants were evaluated holistically throughout the questionnaire, based on a rubric. Each response was categorized as 3 point = informed (contemporary views on the scientific inquiry), 2 point = transitional (partially contemporary views on the scientific inquiry), 1 point = naïve (completely inconsistent with contemporary views or misconceptions on the scientific inquiry), 0 point = no response or unclear. In the rubric, the contemporary views, referring to "the questions guide the approach and the approaches vary widely within and across scientific disciplines and fields" (Lederman, Antink, & Bartos, 2014, p.290), were those accepted by scientists, science philosophers, and science educators. Scores of the aspects and total scores were computed for each student. Along with the author, a researcher, whose research interest was in the fields of the nature of science and scientific inquiry, scored the questionnaires. The inter-rater reliability was found to be 88% of the total number of questions scored. If disagreements arose, the two researchers discussed their scores until they reached a consensus on their joint categorization.

RESULTS

Descriptive Statistics

Descriptive statistics for the students' scores on the VOSI-E aspects were as displayed in Table 2. As shown in the table, the middle school students in the US sample, generally had transitional views of scientific inquiry (56.3%). More specifically, most of the students had transitional views for: "all investigations begin with a question" (66.0%), and naïve views "there is no single scientific method" (43.8%) while they held informed views for: "scientists collect empirical data to answer their questions" (50.4%), and "data and prior knowledge was used to answer questions" (49.6%).

On the other hand, in the Turkish sample, most students held naïve views of scientific inquiry (75.3%) as well as: "all investigations begin with a question" (88.0%), and "scientists collect empirical data to answer their questions" (64.1%). They had transitional views for: "there is no single scientific method" (49.8%), and "data and prior knowledge was used to answer questions" (33.9%).

Table 2 Descriptive statistics

Aspects	USA (*N*=238) (%)				Turkey (*N*=251) (%)			
	0	*1*	*2*	*3*	*0*	*1*	*2*	*3*
All investigations begin with a question	6.3	13.8	66.0	13.9	0.4	88.0	1.6	10.0
There is no single scientific method	0.4	43.8	39.0	16.8	18.3	4.0	49.8	27.9
Scientists collect empirical data to answer their questions	14.3	16.8	18.5	50.4	0	64.1	0.4	35.5
Data and prior knowledge are used to answer questions	8.4	6.3	35.7	49.6	25.8	33.1	33.9	7.2
Total	8.8	9.7	56.3	25.2	2.4	75.3	2.0	20.3

Table 3 demonstrated examples of participants' responses to the questions in terms of their categories for the related aspects.

Inferential Statistics

A series of chi-square test of independence were conducted to answer the research questions. The results revealed that Turkish and American students differed significantly on their views of scientific inquiry, $\chi 2$ (3, N = 489) = 263.57, p≤ .001, Cramer's Φ= .73 representing a large effect. The results also revealed that there was a statistically significant difference in students' views of scientific inquiry with respect to all aspects, by country.

(1) Investigations begin with a question: According to the results, there is a significantly difference in responses between American and Turkish students' views measured as $\chi 2$ (3, N = 489) = 357.58, p≤ .001, Cramer's Φ= .86 representing a large effect. Most American middle school students had transitional views while most Turkish students' had naïve views on guiding investigations with scientific questions.
There is no single scientific method: A significant difference was found in proportions accepting multiple methods of scientific investigations between American and Turkish students' views, $\chi 2$ (3, N = 489) = 70.06, p≤ .001, Cramer's Φ= .38 representing a medium effect. Most American middle school students had naïve views while most Turkish students had transitional views on this aspect.

Table 3 Examples of the responses

Naïve	*Transitional*	*Informed*
All investigations begin with a question		
They use their brains to do their research.	They set up a hypothesis and test it.	First of all they find a question. They try to find different ways to solve it. Then, they choose the best of these solutions.
There is no single scientific method		
It is scientific because scientist did an experiment.	It is scientific because scientist made observation and inference. It is not an experiment.	It is scientific because scientist made observations and related beaks to food. It is not an experiment because scientist didn't do testing.
Data and prior knowledge are used to answer questions		
They ask their scientists friends.	They use historical and biological information.	Scientists come to conclusions based on the fossils.
Scientists collect empirical data to answer their questions		
They come up with the same reasons because they influence each other.	Since they know different 'stuff', they do not come up with the same reasons at the beginning. But at the end they all agree among themselves.	They do not come up with the same reasons. They all have different knowledge, ideas and theories. They do their job in different ways and get different results.

(2) Scientists collect empirical data to answer their questions: The results revealed a significant difference in responses between American and Turkish students' views, $\chi 2$ (3, N = 489) = 168.18, $p \leq .001$, Cramer's $\Phi = .59$ representing a large effect. Most American middle school students had informed views while most Turkish students had naïve views on this aspect.

Data and prior knowledge are used to answer questions: A significant difference was found in responses aspect between American and Turkish

students' views, $\chi 2$ (3, N = 489) = 146.13, p≤ .001, Cramer's Φ= .55 representing a large effect. Most American middle school students had informed views while most Turkish students had naïve views on this aspect.

DISCUSSION

In this comparative study, American and Turkish middle school students' views of scientific inquiry were examined. The Views of Scientific Inquiry-Elementary (VOSI-E) was used as the research instrument. The comparisons were conducted between the total proportions, as well as aspect proportions, to explore variations. A difference was identified between the countries. American students' views were notably more contemporary than Turkish students. This result was expected since the curriculum focused on scientific inquiry for a longer period of time in the US than in Turkey. Although the curriculum was well-prepared and had been filling the gap in the Turkish science education system, there have been some obscurities in application processes (Dindar & Yangin, 2007; Sert, 2008). Even teachers seemed to have difficulties in understanding views of scientific inquiry. Because teachers could not possibly teach a subject they did not understand (Carlsen, 1987; Steinberg, Haymore, & Marks, 1985), it was critical to educate them for teaching scientific inquiry.

Fortunately, the current science teacher education program in Turkey includes a specific course on nature of science and scientific inquiry. Eventually, it is hypothesized that Turkish students hold more contemporary views about scientific inquiry. Nevertheless, seminars and professional development programs may be organized on these subjects for pre-service and in-service teachers to raise views of scientific inquiry both for themselves and their students. Additionally, since participating in inquiry activities do not necessarily develop views of inquiry (Trumbull, Bonney, & Grudens-Schuck, 2005), explicit reflection through reading, mentoring and other means is also suggested (Abd-El-Khalick & Lederman, 2000b).

Analyses of the aspects reveal further differences. American students' views are more contemporary than Turkish students' views on the aspect "all investigations begin with a question." This result indicates that according to Turkish students, investigations do not start with a question; instead they begin by testing a hypothesis. The hierarchical development of hypotheses, theories, and laws is actually a common misconception in Turkey. For instance, studies reveal that teachers believe this hierarchical relationship (e.g. Ayvaci & Er, 2010; Leblebicioglu, Metin & Yardimci, 2012).

Regarding the aspect "there is no single scientific method," Turkish students' views are more contemporary than their American counterparts. Although the Turkish education system stresses and promotes use of the

laboratory in science courses (Ayvaci & Kucuk, 2005; MONE, 1997), many Turkish science teachers prefer demonstration rather than letting students do their own hands-on experiments due to lack of equipment and time (Demir, Boyuk, & Koc, 2011; Gecer & Ozel, 2012; Yildiz, Akpinar, Aydogdu, & Ergin, 2006). As such, they may be better able to develop their observation skills. However, this may lead them to think descriptive studies alongside experiments are also scientific.

On the other hand, due to the curricula in American middle schools, American participants in this study engaged with hands-on science activities and scientific experimentation most of the time. Unfortunately, hands-on activities tend to be called experiments even if they do not involve aspects such as controlling and testing variables (McComas, 1998). Taking these facts into account, American students may view experimentation as the only proper scientific method.

On the aspects "scientists collect empirical data to answer their questions" and "data and prior knowledge are used to answer questions," American students' views are more contemporary than Turkish students. Although the latest reform on science education promotes nature of science and scientific inquiry in Turkey, people, regardless of whether being teachers, pre-service teachers or students, tend to believe that science is objective (Ozdem, Demirdogen, Yesiloglu, & Kurt, 2010; Dogan & Ozcan, 2010; Ozgelen & Yilmaz-Tuzun, 2011). For instance in one study, teachers state that science does not depend on individuals and is affected by their beliefs or opinions (Ozdem et al., 2010). Thus, it can be said that scientists' prior knowledge, experiences, and methodologies towards the interpretation of the same data are ignored. Consequently, in the current study, the majority of Turkish middle school students believe that scientists come up with the same reasons for why dinosaurs died.

Limitations of the study

Unlike the American curriculum, the Turkish curriculum does not include a study about dinosaurs at all. Turkish middle school students' knowledge about the ancient reptiles is very limited; most of the students left this question blank. This issue limits the scope of the questionnaire. Since the students are not familiar with dinosaurs, this question may not enable accurate assessment of their view of these aspects.

Another limitation is related to sample size in the current study. The samples are relatively small and do not represent average students within each country. In addition, although the participants were middle school students in both countries, due to the differences between cultures, their science backgrounds and experiences may be dissimilar.

Future studies

Overall, in order to get in-depth views and provide better explanations, a qualitative approach may be employed in future studies in this area of inquiry. Such an approach can help determine deeper students' views of scientific inquiry, and the differences among their views. Moreover, how culture, curriculum, and the use of science terminology affect students' views of scientific inquiry may be investigated to understand the differences between students' views of scientific inquiry in these two countries.

REFERENCES

Abd-El-Khalick, F. (2006). Over and over and over again: college students' views of nature of science. In L. B. Flick & N. G. Lederman (Eds.), *Scientific Inquiry and Nature of Science* (pp. 389–426). Dordrecht: Springer.

Abd-El-Khalick, F., & Akerson, V. (2004). Learning as conceptual change: factors mediating the development of preservice elementary teachers' views of nature of science. *Science Education*, *88*(5), 785-810.

Abd-El-Khalick, F., & Lederman, N.G. (2000a). Improving science teachers' conseptions of nature of science: a critical review of the literature. *International Journal of Science Education*, *22*(7), 665-701.

Abd-El-Khalick, F., & Lederman, N. G. (2000b). The influence of history of science courses on students' views of nature of science. *Journal of Research in Science Teaching*, *37*(10), 1057-1095.

Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching*, *43*(2), 194-213.

American Association for the Advancement of Science. (1990). *Science for all Americans: A project 2061 report*. New York: Oxford University Press.

American Association for the Advancement of Science. (1993). *Benchmarks for scientific literacy: A project 2061 report*. New York: Oxford University Press.

Aydeniz, M., Baksa, K., & Skinner, J. (2011). Understanding the impact of an apprenticeship-based authentic scientific research program on high school students' understanding of scientific inquiry. *Journal of Science Education and Technology*, 20(4), 403-421.

Ayvaci, H., & Kucuk, M.S. (2005). Ilkogretim okulu mudurlerinin fen bilgisi laboratuvarlarinin kullanimi uzerindeki etkileri [The influence of the primary school principals on usage of laboratory in science]. *Milli Egitim Dergisi, 165*, 1-10.

Ayvaci, H. S., & Nas Er, S. (2010). Fen ve teknoloji ogretmenlerinin bilimsel bilginin epistemolojik yapisi hakkindaki temel bilgilerini belirlemeye yonelik bir calisma [A study to determine science and technology teachers' basic knowledge about epistemological structure of scientific knowledge]. *Kastamonu Egitim Dergisi, 18*(3), 691-704.

Bahbah, S., Golden, B. W., Roseler, K., Elderle, P., Saka, Y., & Shoutherland, S. A. (2013). The influence of RET's on elementary and secondary grade teachers' views of scientific inquiry. *International Education Studies, 6*(1), 117-131.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 national survey of science and mathematics education.* Chapel Hill, NC: Horizon Research, Inc.

Carlsen, W. S. (1987, March). *Why do you ask? Effects of science teacher subject matter knowledge on teacher questioning and classroom discourse*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Cavas Huyuguzel, P., Ozdem, Y., Cavas, B., Cakiroglu, J., & Ertepinar, H. (2013). Turkish pre-service elementary science teachers' scientific literacy level and attitudes toward science. *Science Education International, 24*(4), 383-401.

Cetinkaya E., Sariaydin S., Kutukcu Y., & Akcay H. (2010, September). *Ilkogretim ogrencilerinin bilimin dogasina yonelik algilari* [Elementary students' understanding of nature of science]. Paper presented at the annual meeting of the IX. Ulusal Fen Bilimleri ve Matematik Egitimi Kongresi (UFBMEK-9), Izmir, Turkey.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Council of Ministers of Education of Canada. (1997). *Common framework of science learning outcomes.* Toronto: Council of Ministers of Education.

Demir, S., Boyuk, U., & Koc, A. (2011). Fen ve teknoloji dersi öğretmenlerinin laboratuvar sartlari ve kullanimina iliskin gorusleri ile teknolojik yenilikleri izleme egilimleri [Views of science and technology teachers on laboratory conditions and use of laboratory with their tendencies to follow technological innovations], *Mersin Universitesi Egitim Fakultesi Dergisi, 7*(2), 66-79.

Dindar, H., & Yangin, S. (2007). Ilkogretim fen ve teknoloji dersi ogretim programina gecis surecinde ogretmenlerin bakis acilarinin degerlendirilmesi [Teachers' perceptions about the transition process to elementary school science and technology teaching curriculum]. *Kastamonu Egitim Dergisi, 15*(1) 185-198.

Dogan, N., & Abd-El-Khalick, F. (2008). Turkish grade 10 students' and science teachers' conceptions of nature of science: A national study. *Journal of Research in Science Teaching, 45*(10), 1083–1112.

Dogan, N., & Ozcan, M.B. (2010). Tarihsel yaklasimin 7. sinif ogrencilerinin bilimin dogasi hakkindaki goruslerinin gelistirmesine etkisi [Influence of historical perspective approach on 7th grade students' views about nature of science]. *Ahi Evran Universitesi Kirsehir Egitim Fakultesi Dergisi, 11*(4), 187-208.

Dogan Bora, N., Arslan, O., & Cakiroglu, J. (2006). Lise ogrencilerinin bilim ve bilim insani hakkindaki gorusleri [What do high school students think about science and scientists?]. *Hacettepe Universitesi Egitim Fakultesi Dergisi, 31*, 32-44.

Gecer, A., & Ozel, R. (2012). Ilkogretim fen ve teknoloji dersi ogretmenlerinin ogrenme-ogretme surecinde yasadiklari sorunlar [Elementary science and technology teachers' views on problems encountered in the instructional process]. *Kuram ve Uygulamada Egitim Bilimleri, 12*(3), 2237-2261.

Gess-Newsome, J. (2002). The use and impact of explicit instruction about the nature of science and science inquiry in an elementary science methods course. *Science and Education, 11*, 55-67.

Irez, S. (2006). Are we prepared?: An assessment of preservice science teacher educators‟ beliefs about nature of science. *Science Education, 90*(6), 1113 – 1143.

Khishfe, R. (2008). The development of seventh graders' views of nature of science. *Journal of Research on Science Teaching, 45*, 470–496.

Kilic, K., Sungur, S., Cakiroglu, J., & Tekkaya, C. (2005). Ninth grade students' understanding of the nature of scientific knowledge, *Hacettepe Universitesi Egitim Fakultesi Dergisi, 28*, 127-133.

Koksal, M. S. (2010). Discipline dependent understanding of graduate students in biology education department about the aspects of nature of science. *Education and Science, 35*(157), 65-83.

Kucuk, M. (2008). Improving preservice elementary teachers' views of the nature of science using explicit-reflective teaching in a science, technology and society course. *Australian Journal of Teacher Education, 33*(2), 16-40.

Leblebicioglu, G., Metin, D., & Yardimci, E. (2012). Bilim danismanligi egitiminin fen ve matematik alanlari ogretmenlerinin bilimin dogasini tanimalarina etkisi [Effect of science workshop on science and mathematics teachers' views of the nature of science]. *Egitim ve Bilim, 37*(164), 57-70.

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*, 331–359.

Lederman, N.G. (2006). Syntax of nature of science within inquiry and science instruction. In L.B. Flick & N.G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp. 301- 318). Dordrecht: Springer.

Lederman, N.G., Abd-El-Khalick, F., Bell, R.L., & Schwartz, R.S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching, 39*(6), 497-521.

Lederman, N. G., Antink, A., & Bartos, S. (2014). Nature of science, scientific inquiry, and socio-scientific issues arising from genetics: A pathway to developing a scientifically literate citizenry, *Science & Education, 23*, 285–302.

Lederman, N. G., Lederman, J.S., Khishfe, R., Druger, E., Gnoffo, G., & Tantoco C. (2003, April). *Project ICAN: A Multi-Layered Model Of Professional Development.* Paper presented at the annual meeting of the American Educational Research Association (AERA), Chicago, IL.

Lederman, J. S., & Ko, E. (2003). *Views of scientific inquiry-elementary school version.* Unpublished paper. Illinois Institute of Technology, Chicago, IL.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of science and scientific inquiry as contexts for the learning of science and achievement of scientific literacy. *International Journal of Education in Mathematics, Science and Technology, 1*(3), 138-147.

Liang L. L., Chen S., Chen X., Kaya O. N., Adams A. D., Macklin M., & Ebenezer, J. (2009). Preservice teachers' views about nature of scientific knowledge development: An international collaborative study. *International Journal of Science and Mathematics Education, 7*(5), 987–1012.

Marra, R.M., & Palmer, B. (2005). University science students' epistemological orientations and nature of science indicators: how do they relate? *Science Education International, 18*(3), 165-184.

McComas, W. (1998). The principal elements of the nature of science: Dispelling the myths. In W.F. McComas (Ed.), *The nature of science in science education: rationales and strategies,* (pp. 53–70). Dordrecht: Kluwer Academic Publishers.

Ministry of Education of the People's Republic of China. (2001). *Science education standards (7-9).* Beijing: Beijing Normal University.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academic Press.

Organisation for Economic Co-operation and Development (OECD) (2013). *OECD, the Programme for International Student Assessment (PISA)*. Retrieved from http://www.oecd.org/pisa/

Ozdem, Y., Demirdogen, B., Yesiloglu, N.S., & Kurt, M. (2010). Farkli branslardaki alan ogretmenlerinin sosyal yapilandirici yaklasimla bilim anlayislarinin gelistirilmesi [Development of science views held by teachers in different disciplines through social constructivist approach]. *Ahi Evran Universitesi. Kirsehir Egitim Fakultesi Dergisi, 11*(4), 263-292.

Ozgelen, S., & Yilmaz-Tuzun, O. (2011). Bilimsel bilginin teoriye bagli oznel yapisi: "Evrim teorileri" etkinligi ve sonuclari [The structure of subjectivity with theory-laden of scientific knowledge: the "evolution theories" activity and its results]. *Mustafa Kemal Universitesi Sosyal Bilimler Enstitusu Dergisi, 8*(16), 535-550.

Roberts, D. A. (2007). Scientific literacy/Science literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729-780). London: Lawrence Erlbaum Associates.

Schwartz, R. S. (2007, April). *Beyond Evolution: A thematic approach to teaching NOS in an undergraduate biology course.* Paper presented at the international meeting of the National Association for Research in Science Teaching, New Orleans, LA.

Schwartz, R. S., Lederman, N., & Lederman, N. (2008, March). *An instrument to assess views of scientific inquiry: The VOSI questionnaire.* Paper presented at the international conference of the National Association for Research in Science Teaching. Baltimore, MD.

Sert, N. (2008). Constructivism in the elementary school curricula. *Journal of Theory and Practice in Education, 4* (2), 291-316.

Steinberg, R., Haymore, J., & Marks, R. (1985, April). *Teachers' knowledge and structuring content in mathematics*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Boston, MA: Allyn and Bacon.

Trumbull, D. J., Bonney, R., & Grudens-Schuck, N. (2005). Developing materials to promote inquiry: Lessons learned. *Science Education, 89*, 879-900.

Turkish Ministry of National Education (1997). *Fen laboratuvarlari kilavuzu [Science laboratory manual]*. Ankara: MEB Arastirma ve Gelistirme Dairesi Baskanligi.

Turkish Ministry of National Education (2005). Ilkogretim fen ve teknoloji ogretim programi. *[The elementary science and technology education curriculum]*. Ankara: TTKB.

Turkmen, H., & Pedersen, J. (2005). Examining the technological history of Turkey impacts on teaching science. *Science Education International, 17*(2), 115-123.

Yeh, Y., Jen, T., & Hsu, Y. (2012). Major strands in scientific inquiry through cluster analysis of research abstracts. *International Journal of Science Education, 34*, 2811-2842.

Yildiz, E., Akpinar, E., Aydogdu, B., & Ergin, O. (2006). Fen bilgisi ogretmenlerinin fen deneylerinin amaclarına yonelik tutumlari [Attitudes of science teachers towards science experiments' objectives] *Turk Fen Egitimi Dergisi, 3*(2), 2-18.

Yilmaz, H., & Türkmen, H. (2007). An accurate picture of what is currently happening in Turkish science classrooms. *Science Education International, 18*(4), 255-266.