ISSN 1648-3898

DEVELOPMENT OF NATURE OF SCIENCE SCALE (NSS) FOR ADVANCED SCIENCE STUDENTS

Mustafa Serdar Koksal,
Jale Cakiroglu

Abstract. *Frequent use of open-ended questionnaire plus interview application for nature of science as a requirement for informed decision making has been criticized by many researchers and a need for an easily administrable and scorable instrument has been emphasized. At the same time, existing instruments were developed with the students out of advanced students. Therefore, the purpose of this study is development of a nature of science scale for advanced science students. The study was conducted with 224 advanced science students. Both confirmatory and exploratory factor analysis were done to collect evidence for validity of the scores on the instrument and it was found that both of the analyses approved appropriate validity of the scores. Cronbach alphas for subscales were found as from .55 to .77 as acceptable values. The implications and importance of the instrument will be discussed in this article.*

Key words: *nature of science, scale development, advanced science students.*

Mustafa Serdar Koksal
Karaelmas University, Turkey
Jale Cakiroglu
Middle East Technical University, Turkey

Introduction

Educational needs of society have been continuously changing in parallel with scientific innovations and impacts. Today, understanding science and its aspects is one of the core aims of many educational attempts in the world (BSCS, 1994; PISA, 2006). The term used for conceptualization of science and its aspects for educational purposes is scientific literacy. Scientific literacy requires being able to make informed decisions that are based on knowledge about science and its aspects (Damastes & Wandersee, 1992). Scientifically literate individuals are active participants of their daily lives by integrating what they have learnt into their lives to solve problems (Klymkowsky, Garvin-Doxas & Zeilik, 2003; Mbajıorgu & Ali, 2003 ;). Nature of science as an important aspect of scientific literacy provides information about science as a beginning point of informed decision making process. Knowing about nature of science might provide a frame to evaluate and to make critics on science issues of newspaper and journal writings, news on TV and formal explanations provided by states. Therefore, informed nature of science understanding might contribute to more democratic and scientifically literate society as entities for prosperous society and personal lives.

Nature of science refers to "the values and assumptions inherent to science, scientific knowledge, and /or the development of scientific knowledge" (Lederman, 1992, p.331). Nature of science has many aspects for education from scientific method to science in society. As a result of epistemological and educational studies, some aspects were determined to be necessary to teach about nature of science in formal education in spite of lack of consensus about some aspects of nature of science among educators, philosophers and sociologists (McComas, 1998). These aspects of nature of science might be described as the following sentences;

ISSN 1648–3898

1. Scientific knowledge is based on evidence and observation
2. Creativeness and imagination are important to produce scientific knowledge
3. Scientific knowledge is tentative
4. Scientific knowledge is embedded in social and cultural context
5. Scientist is not objective when he or she begins to study, he or she has a background
6. There is no hierarchy among hypothesis, theory and law and they have different roles
7. Science is a way of knowing
8. There is no universally accepted one way to do science (McComas, 1998, Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

Although having informed understanding about nature of science is an important aspect of daily life of future society, nature of science aspects have not been understood by teachers, teacher educators, prospective teachers and students (Blanco & Niaz, 1997; Dagher & Boujaoude, 200; Irez, 2006; McComas, 2003; Sandoval & Morrison, 2003; Thye & Kwen, 2003; Tsai, 2006). While the problem of misunderstandings about nature of science aspects has been continuing up to date, validity and reliability problems of tools used for measurement of understandings about nature of science aspects have also been discussed by many researchers (Liang et al., 2008; Wenning, 2006). There are many research tools and approaches in the literature to measure understandings about nature of science (see Lederman, Wade & Bell, 1998 and Lederman, 2007 for a comprehensive review). In spite of large amount of instruments about nature of science assessment, the most frequently used tool is VNOS (Views on Nature of Science Questionnaire) derivations (Akerson, Abd-El-Khalick, Lederman, 2000; Khisfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006; Morrison, Raab, & Ingram, 2009). VNOS is an open-ended questionnaire which can not produce scores to get validity and reliability evidence and its application should be followed by an interview to get more comprehensive data. When taken into consideration of questionnaire plus follow-up interviews, it is seen that consuming certain time and efforts is an important issue in nature of science studies. In addition, use of VNOS in a study requires having ability and knowledge to use complex qualitative coding, analyzing and interpretation techniques. For instance; VNOS-C application takes about 45-60 minutes and follow-up interview adds more time to the application (Liang et al., 2008). Apart from these, test and scales such as NSKS (Nature of Scientific Knowledge Scale), VOSTS (Views on Science-Technology-Society) and NOSS (Nature of Science Scale) have also been used for the assessment of understandings about nature of science (Aikenhead & Ryan, 1992; Tsai &Liu, 2005). However, all of them have been developed for the students out of advanced students in any fields. Considering the fact that advanced science students are better individuals on science content than other students who are at the same educational grade level they play important role in nature of science studies. Because, they have more information about science content and are getting higher scores on science tests in national and international examinations. At the same time, they are dealing with science issues for a longer time than the other students. Although there have been very few studies with advanced, gifted or talented students focusing on their epistemological understandings as an higher order construct for nature of science understandings, none of the studies conducted with advanced science students on nature of science (Thomas, 2008; Shommer & Dunnell, 1994; Neber & Schommer-Aikins, 2002). By considering importance of advanced science students for nature of science studies and lack of instruments to use in studies with this group, the purpose of this study is to develop a Likert type scale to measure understandings of advanced science students.

Methodology of Research

The research was conducted with quantitative perspective by using survey technique as data collection way. In this study, validity and reliability of scores on the scale have been investigated by expert opinion, internal reliability investigation and factor analysis techniques.

Analysis

In this study, exploratory factor analysis including principal components analysis with varimax rotation and confirmatory factor analysis on five-factor solution derived from exploratory factor analysis were conducted to get evidence on construct validity of the scores of the advanced science students. In addition to the factor analyses, analysis of expert opinions on the scale was also conducted by considering scale values of the critics on the whole scale and its items. This way was used to establish face and content validity of the instrument. At the same time, internal reliability values on the factors were also analyzed by considering Cronbach alpha reliability. For analyses, all of the scores were converted into standardized t-scores to get equal intervals for continuous data.

Process

At the first stage, an item pool has been structured by investigating the previous studies (McComas, 1998, p. 53-70, Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Liang et al., 2008; Aikenhead & Ryan, 1992). The item pool has been including a total of 60 items. All of these items have directly been translated into Turkish by a researcher and then, comparison for translated items and original items have been requested from two bilingual researchers who are experts on nature of science and science education. After their recommendations and corrections, the translated items have been applied to two advanced ninth grade male students to check readability, understandability, time requirement and difficulty level of terminology on the items in the second stage. In this stage, they have not reported any sentence or term they could not have read or understand. The instrument has been structured as a Likert type five choice scale that has ranged from "absolutely true", thorough "true in higher probability", "undecided", "wrong in higher probability", to "absolutely wrong". Time requirement to complete the scale has been about 25 minutes.

Participants

The participants of this study are 224 advanced ninth grade science students at the age of 15 (80 female, 142 male, 2 missing). They have been enrolled in three different "Science High Schools" where more time and focus have been given to science content and science courses. The students have been selected to these schools with a nation-wide examination. Taking the examination is optional and is limited to eight grade students. This examination includes science and technology content, Turkish language, mathematics and content of social sciences. According to 2007 records of the Ministry of Education, 818.359 students have taken the examination (Turkish Ministry of Education, 2007). The students to be selected for Science High Schools should get higher scores on science and mathematics part of the examination. Majority of the students are in the 2% highest scorers and the range for the participants of this study is from 0.73% to 1.79%.

Results of Research

Validity and Reliability of the Instrument

Face and Content Validity

For the face validity of the scale, opinions of two experts were consulted. Both of them are experts on nature of science and science education. To get ideas of the experts, evaluation form was used (see Table 1). It has six items in Likert type format and a space was provided for writing recommendation at the end of the form. Items of the evaluation form can be seen in table 1 (5 for very good, 1 for very poor). The experts provided some important recommendations about the language and number of items. For instance; one of them recommended that some items should be written with appropriate wordings for 15–age individuals, especially "thinking pattern" for theory-ladenness aspect might be problematic for many of the students at this age. But, pre-study with two students showed that "thinking pattern" was appropriate term for them. For that reason, this term was remained for further pilot study. One of the experts also recommended changes in number of items. But, for a pilot study, 60-item scale was thought to be appropriate with the support of evidence provided by two students. The scale and items

ISSN 1648–3898

were found by the experts as appropriate in terms of all of the other criteria.

Table 1. Items of the evaluation form.

Criteria for Evaluation	1	2	3	4	5
Understandability of the items					
Difficulty levels of words in the items					
Appropriateness of number of the items					
Appropriateness of language of the items					
Appropriateness of the items for their aims					
Appropriateness of the items in terms of reading load					

For content validity, appropriateness of items for measuring what they purposed was decided by considering the experts' opinions and existing literature. The experts approved the appropriateness of items in the scale to measure related nature of science aspects. Required changes in the scale were made by considering the expert opinions and pre-study with two students before the scale was applied.

Construct Validity

To test construct validity of the scale scores (t-scores), exploratory factor analysis was conducted with principal component analysis and varimax rotation at the beginning. Then, confirmatory factor analysis was conducted to provide "fit index values" for further use of the scale.

Exploratory Factor Analysis

The first step in analysis was to check normality, KMO (Kaiser-Meyer-Olkin) index and Barlett's sphericity test to conclude about factorability of the scores coming from the scale. According to 1.5 value as rule of thumb for skewness and kurtosis, item-based normality analysis showed that majority of the scores on the items had normal distribution except for three items; 8, 29, 30. After the elimination of these items, principal component analysis was run again and 0.66 for KMO and statistically significant Bartlett's test result (p=0.00, chi-square=3429.22, df=1596, < 0.05) were found. Pallant (2001) stated that any value above 0.60 for KMO and significant result for Barlett's test were appropriate criteria to conclude about factorability of the scores on any instrument. In addition to KMO and Barlett test results, factor loadings of the items and factor structure were investigated and it was found that the items numbered as 13, 14, 2 and 43 were loaded as separate one factor respectively. After their elimination, analysis was run again and loadings of 21 and 39 on the factors more than one and loading of item 7 as a separate factor were determined. In the third run of the analysis, it was found that 50, 24, 6, 23, and 37 loaded on more factors than one and 3, 1, and 31 loaded as separate one factors respectively. In the forth run of the analysis, negatively loaded items; 19, 22, 54, 60 and loadings of item 4 and 5 on more factors than one were determined. The remained thirteen items loaded on one-factor structures including two items. In the literature, three items per factor were recommended to get appropriate variability in future use of the instrument (Hatcher, 1994).Therefore; they were also eliminated from the analysis. As to be seen in reliability section of this paper, the last factor items; 55, 56, and 59 negatively affected whole scale reliability by being negatively correlated with total score and so, decreasing scale reliability. Therefore, this factor was also eliminated. As a result, final five-factor solution with 18 items was found as appropriate by explaining 55.55 % of total variance. The names of the factors are "Tentativeness", "Observation and Evidence Based Science", "Theory-Ladenness", "Social and Cultural Embeddedness", "Creativity and Imagination in Science". Meanings of the factors and example items can be seen in the table 2.

Table 2. Definitions of the factors and item examples.

Factors	Explanation	Example Item
Tentativeness	Every type of scientific knowledge changes by different factors	Theories might change over time
Observation and Evidence Based Science	Science is based on observation and evidence	Scientific knowledge as like religion and philosophy is depended on personal ideas
Theory-Ladenness	Theories are basic tools which drive all of processes of science	The theories advocated by scientists provide “thinking pattern” that is effective on how to explain results of a scientific study.
Social and Cultural Embedded-ness	Science is affected by social and cultural structures	Scientists make their studies by using certain scientific methods and techniques, so they are not affected by social and cultural environment
Creativity and Imagination in Science	Science includes use of creativity and imagination	Scientists deal with facts by studying in certain rules

The communalities can be seen in the table 3.

Table 3. Communalities for items.

Items	Initial	Extraction
9	1,000	,338
10	1,000	,579
11	1,000	,588
12	1,000	,590
15	1,000	,627
16	1,000	,637
17	1,000	,636
20	1,000	,548
33	1,000	,570
34	1,000	,365
35	1,000	,548
36	1,000	,374
40	1,000	,667
41	1,000	,730
42	1,000	,491
47	1,000	,681
48	1,000	,424
49	1,000	,606

Extraction Method: Principal Component Analysis.

ISSN 1648–3898

The factor loadings, eigenvalues, names of factors, KMO and Barlett's test results can be seen in the table 4.

Table 4. Rotated five-factor solution, factors and factor loadings.

Items	Factors				
	Tentativeness	Observation and Evidence Based Science	Theory-Ladenness	Social and Cultural Embeddedness	Creativity and Imagination in Science
	Factor Loading	Factor Loading	Factor Loading	Factor Loading	Factor Loading
Item 9	*.517*				
Item 10	*.734*				
Item 11	*.669*				
Item 12	*.748*				
Item 15		*.758*			
Item 16		*.747*			
Item 17		*.779*			
Item 20		*.698*			
Item 33			*.730*		
Item 34			*.555*		
Item 35			*.647*		
Item 36			*.597*		
Item 40				*.810*	
Item 41				*.834*	
Item 42				*.647*	
Item 47					*.819*
Item 48					*.535*
Item 49					*.730*
Eigenvalues	*1,789*	*3.065*	*1.611*	*2.132*	*1.402*
Explained Variance %	*10.60*	*14.45*	*10.28*	*10.74*	*9.49*
KMO	.67				
Barlett Test	.00				
df	153				
Aprox. Chi-square	820.856				

Note: Factor loadings above .40 are reported here.

Apart from these, scree plot analysis was conducted and it was seen that five-factor solution was also supported by the results of scree plot. It can be seen in the following Figure 1.

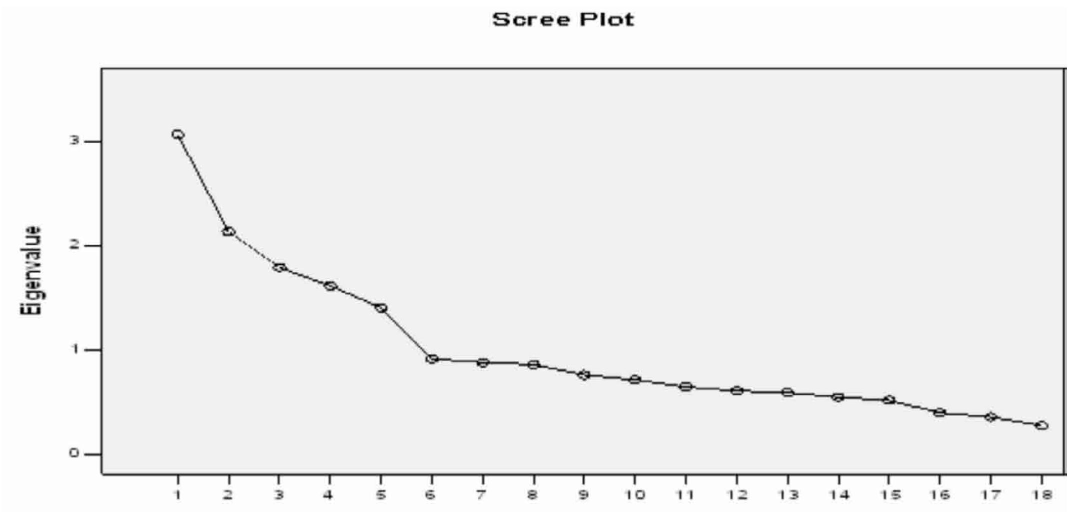


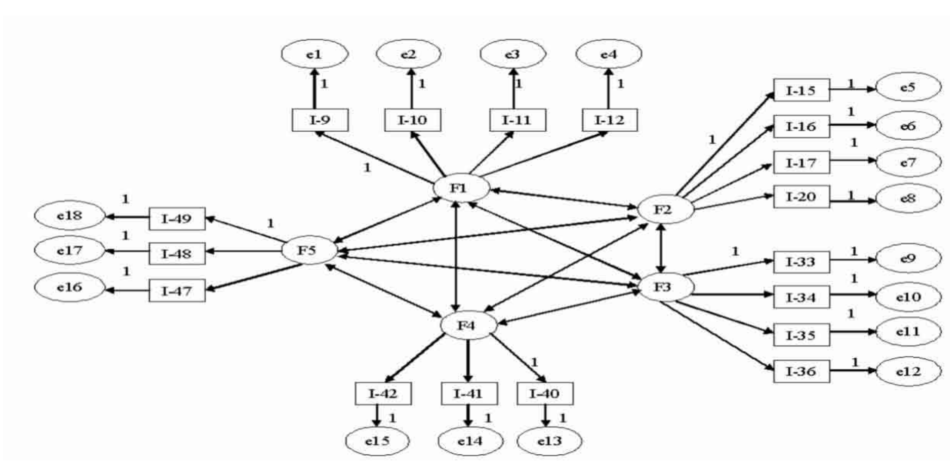
Figure 1. Scree plot analysis result.

As seen in Figure 1, the line is clearly broken after the sixth point that means existence of five factors above that point.

Confirmatory Factor Analysis

To get more comprehensive evidence, confirmatory factor analysis was conducted by using SPSS. AMOS program. First of all, Mahalonobis d^2 values were investigated for normality in the level of cases to find farthest observations from centroid. For this investigation, the observations that had smaller probability values than 0.005 were not considered and 6 cases were eliminated from the analysis. Critical ratio of multivariate normality was found as 8.64 and it was smaller than 10.00 as a cut-off score for multivariate normality.

Secondly, model for factorial structure was drawn. It can be seen in the following Figure 2.



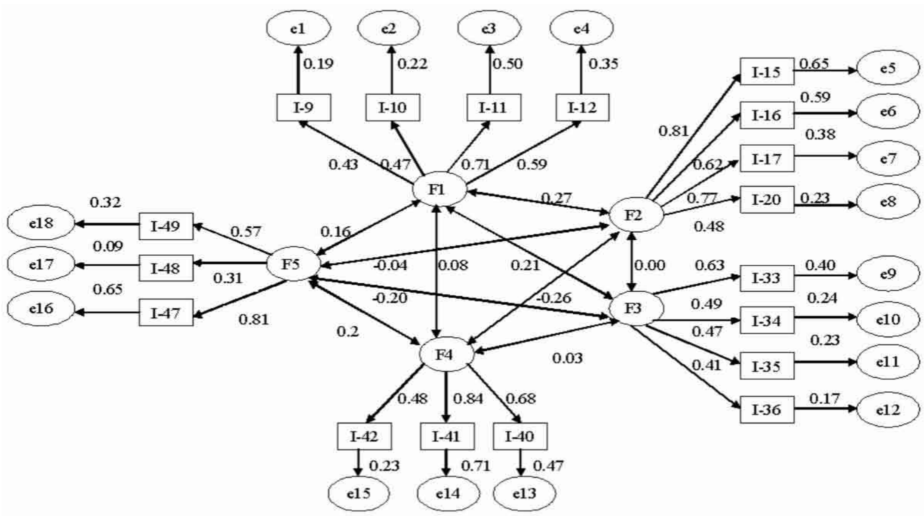
Note: F1=Tentaviness, F2= Observation and Evidence Based Science, F3=Theory-Ladenness, F4= Social and Cultural Embeddedness, F5= Creativity and Imagination in Science, I=item (I-9=item 9), e= error.

Figure 2. Factorial structure model for testing validity of the scores.

Based on this model, confirmatory factor analysis was run and appropriate fit indexes were gath-

ISSN 1648–3898

ered. Most of them were found in appropriate ranges to show evidence for fitting. Standardized model can be seen in Figure 3.



Note: F1=Tentaviness, F2= Observation and Evidence Based Science, F3=Theory-Ladenness, F4= Social and Cultural Embeddedness, F5= Creativity and Imagination in Science, I=item (I-9=item 9), e= error.

Figure 3. Results for standardized model.

When the fit indexes were considered in this study, Chi-square ratio index, CFI, GFI and RMSEA were examined. Chi-square ratio index on the scores is under the 5.00 as a highest cut-off acceptable value (Chi-square ratio= 1.99, N=218) (Marsh & Hocevar, 1988). In this study, two goodness of fit indexes (CFI and GFI) and one lack of fit index (RMSEA) were examined. The indexes of CFI and GFI for the scores on the instrument were also near to acceptable cut-off scores as 0.90 for CFI and for GFI as 0.85 (Hoyle, 2000; Marsh, Balla & McDonald, 1988). It was found that fit index values were 0.87 for GFI and .83 for CFI. Value of RMSEA was found as 0.07 and this value was also smaller than cut-off value of .08 as an indication of good fit (Raykov & Marcoulides, 2006).

Reliability

For the get reliability evidence on the scores of the participants, internal reliability (Cronbach alpha) coefficients were investigated. The Cronbach Alpha coefficient for scores on the whole scale was found as 0.56. The reliabilities for each factor can be seen in the following table.

Table 5. Reliabilities of the scores on factors of the instrument.

Variable	Factors				
	Tentativeness	Observation and Evidence Based Science	Theory-Ladenness	Social and Cultural Embeddedness	Creativity and Imagination in Science
Cronbach Alpha Reliability	0.63	0.77	0.55	0.68	0.55

Although whole scale score reliability is not good as expected, it is seen as appropriate evidence to use scale for further purposes with academically advanced science students. At the same time, reporting the whole scale reliability coefficient is seen as problematic by some researchers (Osborne, Simon & Collins, 2003). According to the Gardner (1975) as cited in the study of Osborne, Simon and Collins (2003, p.1058), "*the weight, length and height can all be measured meaningfully, but adding these three variables together to form some kind of 'Dining Table index' simply produces a meaningless, uninterpretable variable. The best that can be done is to ensure that the components are valid and reliable measures of the constructs they purport to measure and look for the significance of each of these aspects*". By taking into consideration of this approach, it can be said that the scores on the instrument sub-components are reliable. The final form of the instrument can be seen in table 6.

Table 6. Final form of the instrument.

	Items	Absolutely True	True in higher probability	Undecided	Wrong in higher probability	Absolutely wrong
1.	Theories might change over time.					
2.	Old scientific knowledge might change when new points of view are used.					
3.	Old scientific knowledge might change when new evidence is added.					
4.	Old scientific knowledge might change when new technologies are used for the same problem.					
5.	Scientific knowledge as like religion and philosophy is depending on personal ideas.					
6.	Scientific knowledge as like religion and philosophy is depending on ideas of certain groups.					
7.	Scientific knowledge is more dependent on personal ideas of scientists than evidence.					
8.	Scientific knowledge is more dependent on personal ideas of groups of scientists than evidence.					
9.	The theories advocated by scientists provide "thinking pattern" that is effective on selection of problem situations by scientists to study.					
10.	The theories advocated by scientists provide "thinking pattern" that is effective on how to conduct a scientific study.					
11.	The theories advocated by scientists provide "thinking pattern" that is effective on observations made by scientists.					
12	The theories advocated by scientists provide "thinking pattern" that is effective on how to explain results of a scientific study.					
13.	Scientific knowledge is not affected by social factors and cultural differences.					
14.	Scientists make their studies by using certain scientific methods and techniques, so they are not affected by social and cultural environment.					

ISSN 1648–3898

	Items	Absolutely True	True in higher probability	Undecided	Wrong in higher probability	Absolutely wrong
15.	Scientific knowledge develops in a social and cultural environment.					
16.	Scientists don't use their creativity and imagination for production of scientific knowledge.					
17	Scientists deal with facts by studying in certain rules.					
18	Scientists can use their creativity and imagination in any steps of their study such as planning and making inference from data.					

Discussion

Lack of easily administrable and scorable instruments on NOS understandings of advanced science students has been forcing this study. Expert opinions and pilot study with two students have approved the instrument to be easily usable, understandable and valid in terms of consistency between the purpose of the instrument and the items. The evidence gathered on the instrument scores shows that the instrument might be used to determine NOS understandings of advanced science students. As another evidence to reach such a decision, both goodness of fit indexes and lack of fit indexes have also showed appropriate fit values of the scores.

In the items of this instrument, NOS aspects were treated as cognitive variables, so Likert scaling were structured from "true" to " wrong". This way is important due to the fact that there is no implication of feeling, attitude or other affective variables. Therefore, it can be said that format of the instrument items is in line with the recommendation in NOS literature that NOS aspects are cognitive variables (Khisfe & Abd-El-Khalick, 2002; Khisfe & Lederman, 2006).

Although total reliability of the scores is not good as expected, it can be said that relatively low reliability should be thought with other evidences on validity qualities of the scores gathered by the instruments. Some researchers have been making important critics on use of whole scale reliability (Osborne, Simon & Collins, 2003). At the same time, low reliability problem has been shown in many instruments on epistemology of science and nature of science (Liang et al., 2008; Tsai & Liu, 2005). As a support for reliability of the scores, Hatcher and Stepanski (1994) stated that a Cronbach alpha as low as 0.55 can still be accepted for statistical consideration. In addition to the reliability values, face, content and construct validities of the instrument were also found as appropriate by the two experts, two students and the researchers. Especially, factor analytic evidence with two different approaches has provided enough support to usability of the instrument for the purposes in advanced science classrooms.

Conclusion

In this study, it was found that nature of science scale has been providing a valid and reliable instrument scores to use for future purposes. Validity evidence on face, content and construct validities have been showing consistency between the purpose and the items of the instrument. In addition, internal consistency of the scores has also provided another set of evidence to use the instrument. This is an indication of relationship between the item scores under the same factor explaining one aspect of NOS.

The importance of this instrument can be seen by considering use of it in the experimental studies. By this way, researchers could investigate cause-effect relationship. Nature of science as an important component of science curriculum should also be an important and natural part of the advanced science classrooms. Lack of studies on nature of science with advanced science students adds importance to the existence of such an instrument due to its easiness for administration, scoring and analysis.

In spite of importance of development of this instrument, there are some limitations that need to be further consideration. The instrument includes only five aspects of the nature of science, so there is a need to study on other aspects of nature of science with advanced science students. In addition, the study was conducted with 224 advanced ninth grade science students. The increase in sample size might provide a clearer picture. The instrument validity is limited to three validity types; face, content and construct. Divergent and convergent validities are needed to be studied with other sound instruments.

References

Aikenhead, G. S. & Ryan, A. G. (1992). The development of a new instrument: "Views on science-technology-society" (VOSTS). *Science Education,* 76, 477-491.

Akerson, V. L., Abd-El-Khalick, F. & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of the nature of science. *Journal of Research in Science Teaching,* 37, 295-317.

Blanco, R. & Niaz, M. (1997). Epistemological beliefs of students and teachers about the nature of science: from 'baconian inductive ascent' to the 'irrelevance' of scientific laws. *Instructional Science*, 25, 203-231.

Biological Science Curriculum Study (BSCS) (1994). *Investigating Patterns of Change. Middle School Science and Technology. Level A, Teachers Guide and Resource Book*. Kendall/Hunt Pub. Co, Dubuque, Iowa, USA.

Dagher, Z. R. & Boujaoude, S. (2005). Students' perceptions of the nature of evolutionary theory. *Science Education*, 89(3), 378 - 391.

Damastes, S. & Wandersee, H. J. (1992). Biological literacy in a college biology classroom *BioScience*, 42(1), 63-65.

Gardner, P. L. (1975). Attitudes to science. *Studies in Science Education*, 2, 1-41.

Hatcher, L. (1994). *A Step-by-step approach to using the SAS system for factor analysis and structural equation modeling*, (1st Ed.) Cary, NC: SAS Institute.

Hatcher, L., & Stepanski, E. J. (1994). *A step-by-step approach to using the SAS system for univariate and multivariate statistics.* Cary, NC: SAS Institute.

Hoyle, R. (2000). Confirmatory factor analysis. In H.E.A. Tinsley, & S. D. Brown (Eds.), *Handbook of applied multivariate statistics and mathematical modeling.* California: Academic Press.

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

Kishfe, R & Lederman, N. (2006). Teaching nature of science within a controversial topic: Integrated versus nonintegrated. *Journal of Research in Scıence Teaching*, 43(4), 395-418.

Khisfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective views versus implicit 'inquiry orientated' instruction on sixth graders views of the nature of science. *Journal of Research in Science Teaching*, 39(7), 551-578.

Klymkowsky, M. W., Garvin-Doxas, K. & Zeilik, M. (2003). Bioliteracy and teaching efficacy: What biologists can learn from physicists? *Cell Biology Education,* 2(3), 155-161.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In Abell, S. & Lederman, N. (Eds.) *Handbook of Research on Science Education.* Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

Lederman, N. G., Wade, P. D., & Bell, R. L. (1998). Assessing the nature of science: What is the nature of our assessments? *Science and Education,* 7, 595-615.

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(4), 331-359.

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.

Liang L. L., Chen, S., Chen, X., Kaya, O, N., Adams, A. D., Macklin, M. & Ebenezer, J. (2008). Assessing preservice elementary teachers views on the nature of scientific knowledge: A dual-response instrument. *Asia-Pacific Forum on Science Learning and Teaching*, 9 (1), 1.

Marsh, H. W., Balla, J. R., & McDonald, R. P. (1988). Goodnessof- fit indexes in confirmatory factor analysis: The effect of sample size. *Psychological Bulletin,* 103, 391-410.

Marsh, H.W. & Hocevar, D. (1988). A new more powerful approach to multitrait-multimethod analysis: Application of second-order confirmatory analysis. *Journal of Applied Psychology*, 73, 107-117.

Mbajıorgu, N. M. & Ali, A. (2003). Relationship between STS approach, scientific literacy, and achievement in biology. *Science Education*, 87, 31-39.

McComas, W. F. (1998). The principle 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, the Netherlands: Kluwer Academic Publishers.

ISSN 1648–3898

McComas, W. F. (2003). A textbook case of the nature of science: Laws and theories in the science of biology. *International Journal of Science and Mathematics Education,* 1, 141-155.

Morrison, J. A., Raab, F., & Ingram, D. (2009). Factors influencing elementary and secondary teachers' views on the nature of science. *Journal of Research in Science Teaching,*46(4), 384-403.

Neber, H. & Schommer-Aikins, M. (2002). Self-regulated science learning with highly gifted students: The role of cognitive, motivational, epistemological, and environmental variables. *High Ability Studies*, 13(1), 59-74.

Osborne, J.,Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9), 1049-1079.

Pallant, J. (2001). *SPSS survival manual.* Open University Press Buckingham Philadelphia.

PISA (2006). Assessing scientific, reading and mathematical literacy: A framework for PISA 2006. OECD Publication. Retrieved from http://www.oecd.org/document/32/0,3343,en_2649_39263231_37468320_1_1_1_1,00.html in 06-June-2008.

Raykov, T., & Marcoulides, G. A. (2006). *A first course instructural equation modeling.* Second Edition, London: Lawrence Erlbaum Associates, Publishers.

Sandoval, W. & Morrison, K. (2003). High school students' ideas about theories and theory change after a biological inquiry unit. *Journal of Research in Science Teaching*, 40(4), 369-392.

Schommer, M & Dunnell, P. A. (1994). A comparison of epistemological beliefs between gifted and non-gifted high school students. *Roeper Review*, 16 (3), 207-210

Wenning, C. J. (2006). Assessing nature-of-science literacy as one component of scientific literacy. *Journal of Physics Teacher Education Online,* 3 (4), 3-14

Thomas, J. A. (2008). An analysis of epistemological change by gender and ethnicity among gifted high school students. *Gifted Child Quarterly,* 52(1), 87-98.

Tsai, C. & Liu, S. (2005). Developing a multi-dimensional instrument for assessing students' epistemological views toward science. *International Journal of Science Education*, 27(13), 1621-1638.

Tsai, C. (2006). Reinterpreting and reconstructing science: Teachers' view changes towards the nature of science by courses of science education. *Teaching and Teacher Education*, 22, 363-375.

Thye, T.L. & Kwen, B.H. (2003). Assessing the nature of science views of Singaporean Pre-service teachers. Paper presented at The Anual Conference of the New Zealand/Australian Association for Research in Education. November 30- December 3. Auckland.

Turkish Ministry of Education, (2007). 2007 OKS istatistikleri. (In English, "2007 OKS statistics"). Retrieved from http://oks2007.meb.gov.tr/oks_ista.htm#2 in 23.06.2009.

Received 19 August 2009; accepted 08 February 2010.

Mustafa Serdar Koksal	Dr., Lecturer, Karaelmas University, Eregli Education Faculty, Elementary Education Department, 67300, Kdz. Eregli-Zonguldak, Turkey. Phone: + 90 372 323 38 70. E-mail: bioeducator@gmail.com Website: http://w3.karaelmas.edu.tr/
Jale Cakiroglu	Assoc. Professor, Middle East Technical University, Education Faculty, Science Education Department, 06531, Ankara, Turkey. Phone: + 90 312 210 40 51. E-mail: jaleus@metu.edu.tr Website: http://www.metu.edu.tr/