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Reliability and Validity Studies of the Science and Technology Course Scientific Attitude Scale

Şefik YAŞAR[1], Şengül S. ANAGÜN[2]

[1] Prof.Dr., Anadolu University, Faculty of Education, Dept. of Primary Education, Eskişehir-TURKEY
[2] Assist.Prof.Dr., Eskişehir Osmangazi University, Faculty of Education, Dept. of Primary Education, Eskişehir-TURKEY

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ABSTRACT

Science is a basic course that improves the individuals in terms of cognitive aspects and increases their creativity. In this course, students acquire the habits of thinking objectively and making right decisions about the phenomena and events by examining their environment with scientific methods. In this process, an effort is spent to make students gain scientific knowledge, cognitive process skills and scientific attitudes. Scientific attitudes have an important role in developing scientific literacy. The purpose of this study is to bring up the results of reliability and validity studies of an instrument which is developed for determining scientific attitudes of fifth grade students. The data were collected from 887 students of randomly selected 14 elementary schools in the city of Eskişehir. As a result of factor analysis, the scale grouped in with three factors accounted for 42,08% of total variance with 28 items.

Keywords: Scientific Attitudes Scale; Constructivism; Science and Technology Course.

INTRODUCTION

Primary education can be described as an educational step where cultural heritage is transferred to, the basics of creating a democratic society are formed, a life-long learning process is initiated. It also serves to increase the quality of the lives of individuals shaping the society. For this reason, the quality of the education provided in primary schooling has a vital role in the development and progress of societies. The knowledge and skills acquired in this step affect the achievements of students to a large extent in their future learning experiences. Primary education, in this regard, performs a key role (Yaşar, Sözer & Gultekin, 2000). Performing its functions, the education provided at primary education level presents knowledge and skills from a number of disciplines together. One of the major disciplines in this step is Science and Technology course.

One of the most general objectives of the education in democratic societies can be defined as equipping students with the skills required for participating in discussions over the issues concerning the society and making comparisons about these issues. Today, very few societal issues are not related to science and technology. Many issues such as the environment, community health, production of the instruments facilitating living and protection of societies are related to science and technology in one way or another. Thus, ensuring that all citizens have knowledge of science and technology so as to be able to understand the basic issues which the society faces can be regarded as the most general objective of science education (Howe, 2002).

It is only through making individuals acquire science literacy that science education can accomplish its goals. Defining science literacy as the most significant target of science education Martin (1997) states that the three dimensions of science literacy are providing scientific content, acquiring the skills used by scientists in a scientific process and adopting positive attitudes towards science field. What is more, research show that science literacy consists of knowledge, skills, and attitudes (Mitman, Mergendoller, Marchman & Packer, 1987; Bybee, 1997; Koballa, Kemp & Evans, 1997; Wright & Wright, 1998; De Boer, 2000; Sutman, 1996; 2001; Kress, 2003).

In science teaching at schools, an effort is spent to make students gain scientific knowledge, scientific process skills and scientific attitudes (Yaşar & Selvi, 1997). Among these three dimensions, scientific attitudes have vital importance. The scientific attitudes of the individuals and whether the societal decisions made by them throughout their lives are reliable or not are closely linked. Regarded to be among the attitudes peculiar to science course, scientific attitudes can be described as the ways followed by scientists in accessing and interpreting knowledge. Science course is different from other courses, which value only one correct answer. It requires that certain attitudes be adopted and questioned. Any individual with scientific attitudes bears qualities such as being realistic, considerate towards events, consistent in his or her judgments, avoiding generalizations which are not based on phenomena, being unbiased, and not falling into dogmatic beliefs (Yıldırım, 2000).

Çilenti (1988) classifies scientific attitudes by highlighting affective domains such as curiosity, modesty, skepticism, truthfulness, open-mindedness and determination. Simpson et al (1994), on the other hand, group scientific attitudes like; willingness to knowing and learning, inquiry desire for everything, collecting and searching data, willingness to prove truthfulness, respect to logic, thinking pre and post test results. Carin (1997) puts forward to some features of scientific attitudes like curiosity, depending on proofs, skepticism, cooperation with others, respect for different approaches and being stand up on successfulness.

According to Karasar (1999), scientific attitudes are open-mindedness, searching logic in opposite views, skepticism, being objective on observations and thinking, postponing decision for proof, thinking and decision temperate, being patient and attentive in studies, being modest for making mistake and giving chance to different probabilities in his judgment. Soylu (2004) expresses his expectations from scientists as; persistence on proofs, being skeptical, accepting uncertainty, positive approaching to cooperation and unsuccessfulness. Scientific attitudes are gathered in five groups by Peters and Stout (2006) as; curiosity, persistence, uncertainty, inventiveness and critical thinking

The scientific attitudes of curiosity, skepticism, critical thinking, depending on proofs, persistency, cooperation with others, objectivism and accepting uncertainty are taken into account based on the synthesis of descriptions and classifications provided by various scholars such as Carin (1997); Çilenti (1988); Karasar (1999); Peters and Stout (2006); Soylu (2004). The limited number of scales measuring scientific attitudes in Turkey and lack of valid and reliable scientific attitudes scales for elementary education first stage have indicated a need for the development of a scale in this field.

The aim of this study is to present the results of reliability and validity studies of an instrument which is developed for determining scientific attitudes of fifth grade students for Science and Technology course. Within this scope, the following research questions were addressed:

1. What is the reliability level of the Scientific Attitudes Scale?
2. What is the validity level of the Scientific Attitudes Scale?

METHODOLOGY

a) Sample

The subjects of the study were the fifth grade students of elementary schools located in the centre of Eskişehir. The data were collected from randomly selected 14 elementary schools during 2006-2007 academic year in Eskişehir. There are 120 public and private elementary schools in Eskişehir. The design instrument was administered to 18 schools which basically represented 15 percent of population. However, 14 out of 18 elementary schools returned the instrument in voluntary basis. The schools involved in the study and the participation ratios are given in Table 1.

Table 1. *Distribution of schools and participation ratios*

S/N	Name of the School	Frequency	Percent (%)
1	Battalgazi İ.Ö.O	43	5
2	Vali Münir Raif Güney İ.Ö.O	48	5
3	Halil Yasin İ.Ö.O	56	6
4	Yenikent İ.Ö.O	50	6
5	Orhangazi İ.Ö.O	36	4
6	Fatih Sultan Mehmet İ.Ö.O	59	7
7	23. Nisan İ.Ö.O	76	9
8	Reşat Benli İ.Ö.O	81	9
9	Mehmet Gedik İ.Ö.O	72	8
10	Cumhuriyet İ.Ö.O	80	9
11	Yunusemre İ.Ö.O	69	8
12	100. Yıl İ.Ö.O	88	10
13	Şehir Ali Gaffar Okkan İ.Ö.O	67	8
14	Kılıçaraslan İ.Ö.O	62	7
	TOTAL	**887**	**100**

Six out of 887 forms were excluded from the study due to filling a significant numbers of questions with more than one answer. As seen in Table 1, the participation ratios are between 4-10 percent such that the schools may be represented as similar ratio in the scope of the study.

b) Scale Development Process

Scientific attitude scale for Science and Technology Course was developed to assess students' scientific attitude levels before and after the application process. The stages of the scale development process are given, as follows (Karasar, 1999, p. 136–153):

- Forming items of scientific attitude scale
- Obtaining expertise opinion
- Pre-application phase
- Calculating reliability and validity measures.

c) Forming Items of Scientific Attitude Scale

The scientific attitudes for Science and Technology course were examined before developing scientific attitude scale. While designing scientific attitude expressions, an extensive literature was reviewed and related scales were examined (Klopfer, 1971;

Fraser, 1978; 1981; Turgut & Baykul, 1992; Moore & Foy, 1997; Tavşancıl, 2005; Büyüköztürk, 2002; Osborne, Simon & Collins, 2003; Chin, 2005). By means of these scale examined, various views regarding the stages of developing a scientific scale were gained. Afterwards, a large number of scientific attitude items either directly or indirectly related to attitudes was collected in the form of positive and negative attitudes. The items of the scientific attitude scale were formed based on the following considerations;

1. All of the items were expressed both positive and negative, and an attention was paid not to include factual sentences.
2. Scale items were expressed as simple, easily understandable sentences, and not to include more than one judgment/thought/perception in each item.
3. The items were formed as half of them were positive, the remaining as negative regarding with the rule of neutrality.
4. "Strongly agree" and "agree" responses for positive items, "strongly disagree" and "disagree", responses for negative items, and "neither agree nor disagree" for neither positive nor negative items were used (Tavşancıl, 2005).

d) Obtaining Expertise Opinion

The preliminary scale consisted of 48 items. Ten experts who gave their views about the scale were working in the field of elementary education and educational sciences. The experts also had knowledge and skills on science and elementary education. The items were assessed in regard to discuss whether the items were suitable for the levels of the fifth grade students for elementary school and measure scientific attitudes in terms of sense, thought, and behaviours devoted to Science and Technology course. The items were also examined by two language experts in terms of comprehensibility and appropriateness to Turkish grammar. As a result of all the examinations, a total of four items–problematic in terms of student level, clarity of the statements and appropriateness for measuring scientific attitudes–were excluded from the scale and the 44-item scale in rough draft form was brought to final format.

e) Pre-Application Phase

In pre-application phase, the scale was applied to 45 fifth grade students for establishing time required for answering items and for determining to what extent they were meaningful. At the end of the application, the items which were not understood by students were changed and final form of the scale was given. Afterwards, scale was applied and analyses for distribution of items within the scale were conducted.

f) Calculating reliability and validity measures.

After the pre-application phase, the scale composed of 44 items was finalised. Each of the items had possible five responses based on likert scale. The possible responses were classified as "Strongly Agree", "Agree", "Neither Agree nor Disagree", "Disagree", and "Strongly Disagree" and the responses were scored as 5, 4, 3, 2, and 1, respectively. There were a number of negative items for which the scoring was reversed. These were randomly distributed throughout the scale. The scale was administered to the sample of 887 fifth grade students in elementary schools. However, six out of 887 forms were excluded from the study due to filling a significant numbers of questions with more than one answer. The data were analyzed in terms of factor analysis, the Cronbach alpha coefficient to assess the internal consistency of the scales by means of SPSS for Windows.

FINDINGS

A) Reliability Study of the Scale of Scientific Attitudes

Internal Consistency of the Scale (Cronbach Alpha Coefficient)

In order to determine the internal consistency of a scientific attitudes scale developed regarding with likert type, using Cronbach alpha coefficient is appropriate (Tavşancıl, 2005, p.152). It is acceptable that the higher Cronbach alpha coefficient provides higher homogeneity among the items within the scale. Such coefficient also points out whether the items are consistent with each other and the items indicate the same property. The original 44 items were reduced to 28 based on the reliability study and the Cronbach alpha coefficient for the remaining items was found as 0.83, which is considered as higher for studies in education and social sciences. Final version of scale consisted of 18 positive and 10 negative items out of 28 total.

B) Validity Study of the Scale of Scientific Attitudes

After reliability study, a validity study in terms of content and structure was implemented for the developed scale. Expert opinions were obtained for content validity.

Structural Validity: Factor Analysis

The structural validity of the developed scale was performed in four stages; investigating whether the data were suitable for factor analysis, designating factors, rotating factors, and naming factors, respectively (Kalaycı, 2005).

In order to verify the data were suitable for factor analysis, Kaiser-Meyer Olkin (KMO) coefficient and Barlett Sphericity test were utilised. As mentioned by (Büyüköztürk, 2001, p.120), KMO may be used to determine whether both the data and sample size are appropriate for factor analysis. When the KMO value is greater than 0.60 and Barlett test is significant, it is considered that the data may be analysed by means of factor analysis (Sharma, 1996, p.116). The KMO value was calculated as 0.833 for the data obtained. On the other hand, Barlett Sphericity test is used to evaluate if the data is obtained from multi variable normal distribution. The test was carried out using chi-square test statistics and a decision was made that the data come from such distribution. The test was found significant (χ^2 =7854.81; $p<0.01$).

A factor analysis study of the Scientific Attitudes Scale involved a principal components analysis technique. Exploratory principal components analysis of factor analysis was used to determine the factorial structure of the Scientific Attitudes Scale. A Scree plot is drawn and examined for supporting study and being able to decide appropriate factor numbers (Büyüköztürk, 2002). The scree plot is depicted in Figure 1. Based on the scree plot, the items were grouped into three factors.

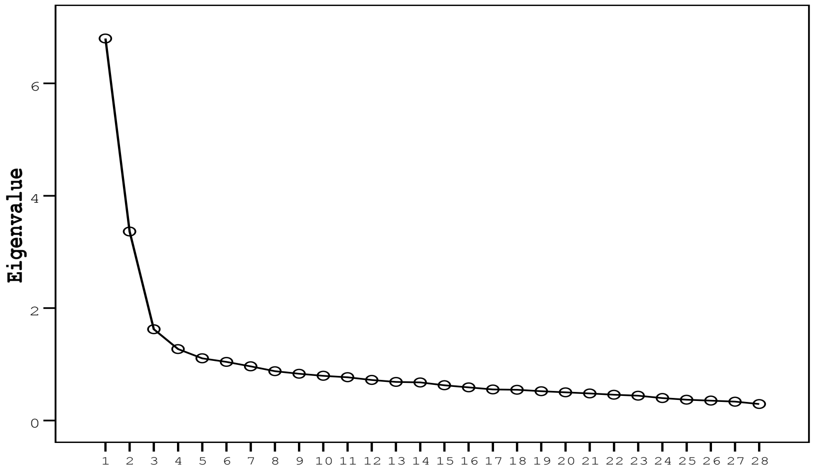

Figure 1. *Scree Plot for the scale*

In order to determine whether an item measures the same attitude, an attention was given to ensure factors' loading were above 0.35 and the difference in loading among factors was greater than 0.10.

A further analysis of the instrument involved a principal components analysis with varimax rotation (Büyüköztürk, 2002; Kalaycı, 2005). The factor analysis result of scale was shown in Table 2. Factor loadings of items before the varimax rotation were between 0.33 and 0.52 for single factor. However, the factor loadings appeared between 0.39 and 0.70 after the varimax rotation. This analysis resulted in the scale with three factors accounted for 42.08% of total variance with 28 items. Dunteman (1989) claims that between 0.40-0.60 is acceptable level. On the other hand, each item's factor loading was significantly lower than it appears underneath the other factor. While the principle component value for the first factor was obtained as 5.991, extremely greater than 1 for the remaining factors. This simply reveals that the scale composed of 28 items had structural validity.

Table 2. *Results of factor analysis*

		Factor Loadings after Varimax Rotation		
Item	**Single Factor**	**Factor 1**	**Factor 2**	**Factor 3**
M2	**0.684**	**0.684**		
M5	**0.664**	**0.664**		
M24	**0.650**	**0.650**		
M7	**0.648**	**0.648**		
M42	**0.633**	**0.633**		
M6	**0.625**	**0.625**		
M40	**0.611**	**0.611**		
M28	**0.605**	**0.605**		
M43	**0.604**	**0.604**		
M26	**0.573**	**0.573**		
M17	**0.565**	**0.565**		
M34	**0.562**	**0.562**		
M3	**0.556**	**0.556**		
M15	**0.554**	**0.554**		
M4	**0.551**	**0.551**		
M8	**0.526**	**0.526**		
M23	**0.490**	**0.490**		
M31	**0.017**		**0.698**	
M47	**0.138**		**0.697**	
M46	**0.255**		**0.625**	

Table 2. *Continued…*

Item	Single Factor	Factor 1	Factor 2	Factor 3
		Factor Loadings after Varimax Rotation		
M39	**0.241**		**0.616**	
M36	**0.257**		**0.590**	
M25	**0.272**		**0.521**	
M19	**0.351**		**0.486**	
M38	**0.321**		**0.482**	
M37	**0.120**			**0.583**
M18	**0.129**			**0.576**
M1	**0.151**			**0.394**
Principle Components Value		5.991	3.629	2.164
% Variance		21.396	12.962	7.727
Cumulative % Variance		21.396	34.358	42.085
Cronbach Alpha Coefficients	0.83	0.89	0.80	0.68

In the related literature, these factors are named as; dependent on proofs, curiosity and persistency, respectively. As a result of the factor analysis, a number of items was omitted from a number of the subscales and the items were renumbered suitable for the factors. The retained items for the developed scientific attitudes scale along with the named factors are shown in Table 3.

Table 3. *Items changed after factor analysis*

Attitude scale	Item(s) retained
Dependent on proofs	2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 16, 17, 19, 24, 25, 26
Curiosity	12, 15, 18, 20, 22, 23, 27, 28
Persistency	1, 11, 21

The discriminant validity of the instrument was measured using each subscale's mean correlation with the others. The correlation coefficients of subscales are shown in Table 4. The mean correlation coefficients ranged from 0.43 to 0.55 using the individual as the unit of analysis. The correlation coefficients between dependent to proofs and curiosity (r=0.508 p<0.01), dependent to proofs and persistency (r=0.552 p<0.01), and curiosity and persistency (r= 0.431 p<0.01) were found significant.

Table 4. *Mean correlation coefficients for the factors*

			Dependent on proofs	Curiosity	Persistency
Spearman's rho	Dependent on proofs	r		0.508(**)	0.552(**)
		p		0.000	0.000
		N		881	881
	Curiosity	r	0.508(**)		0.431(**)
		p	0.000		0.000
		N	881		881
	Persistency	r	0.552(**)	0.431(**)	
		p	0.000	0.000	
		N	881	881	

This range indicates that the items used in the instrument correlated far more with items in the same factors than with items in others. Consequently, the scale developed for Science and Technology course had satisfactory discriminant validity and each factor measured generally distinct although somewhat overlapping attitudes.

DISCUSSION

When the significance of scientific attitudes in science education is taken into consideration, developing the scales concerning the measurement of these qualities and measuring these qualities accurately possess vital importance. In this study, scientific attitude, regarded in the literature as one of the factors affecting learning science, was examined and a scale for scientific attitude towards Science and Technology was developed. Developing such a scale was considered as necessary due to the lack of a scale in Turkish literature which measures scientific attitudes at elementary fifth grade level and which has validity and reliability analyses. It is generally the case that the scales of foreign-origin are adapted for Turkish language and then used (Akdur, 2002).

A principal component analysis technique was used to check the structural validity of the scale. This analysis resulted in the scale with three factors and 28 items. According to the literature, these factors are named as dependent on proofs, curiosity and persistency, respectively (Fraser, 1978; 1981; Moore & Foy, 1997). Scientific attitudes are conceptualized differently by different scientists. Science is different from other subjects providing only one correct answer. It requires developing some attitudes and inquiring these attitudes. Scientific attitudes show how individuals approach and interpret science.

Basing things on evidence is a major scientific attitude towards science. Individuals who talk based on evidence possess qualities such as being reasonable, consistent in their judgements, and avoiding generalizations not based on phenomena. The items 5, 9, 17, 25 and 26 represent the fact that scientists express their opinions based on evidence. It could be suggested that the scale in this sense, matches with the statements in Carin (1997) and Karasar (1999) classifications. Curiosity dimension can be defined as an scientific attitude reflecting the fact that scientists are eager to do researches, join to learn and their open-mindedness. The items 12, 20 and 23 indicate that having the feeling of curiosity increases the desire to study in scientific studies. In this sense, it could be suggested that the scale is similar to the classifications of scientific attitudes by Çilenti (1978), Carin (1997), Soylu (2004) and Peters and Stout (2006). The qualities under the heading persistence represent the ways followed by widely-acknowledged scientists in achieving results and determination against difficulties. The items 1, 11 and 21 under the persistence factor represent the fact that scientist are persistent about getting to the truth in their studies. The scale is considered to be in parallel with the classification by Soylu (2004).

The Cronbach alpha coefficient for the items was found as 0.83. For sub-factors internal consistency coefficients were found as; for the first factor is 0.79, for the second factor is 0.80 and for the third factor is 0.68. According to these results, the internal consistencies of sub factors are high.

CONCLUSION

The findings concerning the validity and reliability of the scale show that it has the necessary quality so as to be used for determining primary fifth grade students' scientific attitudes towards the corresponding quality. As the scale was developed based on fifth graders, it is necessary to conduct validity and reliability studies with the findings from other groups when the scale is used with the groups other than fifth graders. Also, the study was conducted in 14 elementary schools with different student profiles in Eskişehir city centre, and on the students of these schools so that variety is ensured. In this regard, it is suggested that similar findings concerning the scale's validity and reliability could be obtained when employing it on fifth grade students in different regions.

As a result, scientific attitudes towards science has a key role in achieving science literacy, which is the vision of the curriculum of Science and Technology course that has been put into practise since 2005-2006 academic year. It is thought that this scale can contribute to the literature as a scale with proven validity and reliability that can be used for measuring fifth graders' scientific attitudes.

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APPENDIX

SCIENCE AND TECHNOLOGY COURSE SCIENTIFIC ATTITUDES SCALE

Scientific Attitudes in Science and Technology Course	**Strongly Agree**	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
1. The methods which are used during our Science and Technology course are similar to scientists' works.					
2. I can easily compose questions related to my research topic.					
3. I can easily handle the problems I face during my researches.					
4. I can use appropriate resources for the solution of the problems I face during Science and Technology course.					
5. I always form my result reports based on observations and experiments in Science and Technology course.					
6. I can look at my experiment results with a critical eye.					
7. I can logically interpret my experiment results.					
8. I use mathematics to conduct a scientific work in Science and Technology course.					
9. I always write exactly what I observe about the experiments I do in Science and Technology course.					
10. I am willing to do research on natural events.					
11. I am consistent on the truth of my research results.					
12. I can give up my work if it is too long and requires much effort.					
13. Science and Technology courses help me consider other's thoughts during decision making.					
14. I learn rational thinking ways in Science and Technology course.					
15. I do not care about doing a research while seeking a solution for the problems I face.					
16. What I learn in Science and Technology course helps me explain my opinions easily to the other people.					
17. Using scientific methods help me think correctly.					
18. I prefer working alone rather than working with my friends on topics that I need to do research.					
19. I believe senses are one of the most important tools a scientist has.					
20. The researches we do in Science and Technology course are boring for me.					
21. I accept the results written in books if they are different from my experiment results.					
22. I think I can not manage to do the tasks I am assigned to during the Science and Technology course.					
23. I do not care about my friends' opinions in discussions during Science and Technology course.					
24. I think the aim of the efforts of the scientists is to provide people with higher life standards.					
25. I trust the results of the researches following scientific processes.					
26. I use scientific processes to decide correctly.					
27. I think the topics we discuss during courses will have no influence on the decisions I make concerning the public.					
28. I think scientific and technologic inventions are hazardous rather than beneficial.					