DEVELOPMENT OF SCIENCE-PSEUDOSCIENCE SCALE FOR ELEMENTARY STUDENTS: WIDELY ACCEPTED OPINIONS SCALE

Behiye Bezir Akçay[1], Seda Usta Gezer[1] & Burak Kiras[2]
[1]Hasan Ali Yucel Education Faculty, Istanbul University
[2] Education Faculty, Abant İzzet Baysal University
bbezir@gmail.com, sedausta@İstanbul.edu.tr, burakkiras@gmail.com

ABSTRACT

Although all kinds of knowledge is valuable, some non-scientific knowledge can cause confusion on students' minds. Science-pseudoscience distinction should be taught in all levels of education to protect especially young age students from this confusion. It is hard to change gained beliefs so giving importance to demarcation from elementary to university levels needs to be the noticed. In this study it is aimed to develop a scale for science-pseudoscience distinction for elementary school students. For this purpose data was collected from 717 students who were attending 5th, 6th, 7th and 8th grades. 20 items scale was created by structural equation modeling. Lisrel 8.7 programme was used for analyze. The observed fit indexes were χ 2 /sd 3.21, RMSEA 0.056, RMR 0.0077, SRMR 0.048, GFI 0.93, AGFI 0.9, CFI 0.95, NNFI 0.94. All values were found acceptable according to literature. KR-20 internal consistency coefficient for the test was calculated and found as .836. Therefore according to findings, the scale which was named as "Widely Accepted Opinions Scale" and was developed by this study is a valid and reliable data collection tool for elementary school students.

Key words: Science- pseudoscience distinction, elementary school students, structural equation modeling.

INTRODUCTION

One of the main goals of science education is to have scientifically literate society. Scientific literacy has been defined over a five decades in literature. One of the definitions of the scientific literacy is to have an ability to distinguish science from non-science which is called problem of demarcation and understanding its limitations (Lii, Hand & Prain, 2002). However, Today's society is increasingly exposed to pseudoscientific and paranormal claims. To achieve scientific literacy, teachers should aware of these New Age beliefs (Hobson, 2008).

The majority of individuals viewed science as leading certain truth, objectivity, and includes step by step process doing research. Many students have difficulty understanding of scientific knowledge is tentative, product of human creativity, construct subjectively and socio-culturally. Researchers argued the role of teachers and effects of instruction on students' views of science and non-science (Cobern and Loving, 2000).

Educators aimed to teach not only scientific facts, theories and laws to individuals but also they need to teach value of scientific knowledge, power, validity and limitations of science (Turgut el at., 2010). The nature of science is a dynamic structure, brings ongoing development and change together. The perceptions about science can be differentiated in this process. Scientists don't use a single method in scientific studies because scientific problem solving ways have differences based on the problem (Çetinkaya et al., 2013). A scientific problem solving way has many characteristics like as being logical, has to be based on accurate and reliable observation and experiment.

Lederman and Zeidler (1987) explained nature of science as values and assumptions inherent to the development of scientific knowledge. Questions concerning the nature of science include such as what science is and what distinguishes it from `pseudoscience'? What is the scientific method? If there is any, how scientific claim can ensure the objectivity of scientific results? How does science explain our observations and experiences? These questions concerning the nature of science need to be discussing in science classrooms for helping students to distinguish science from pseudoscience (Sönmez, 2008).

The disciplines of science which doesn't meet these features together are called pseudoscience. Teaching nature of science is important for solving this distinction (Turgut at al., 2010). Pseudosciences do not value debate and criticism and rarely show intellectual development and genuine progress (Beyerstein, 1995). Students need to be provided with opportunities to apply the scientific method (or hypothetic deductive approach) during science classes. In this process they will likely be asked to suggest one or more hypotheses (i.e., proposed explanations) for an observed phenomenon and test it or them (Eastwell, 2011). It is conscious forward would be possible the recognition of pseudoscientific claims, the separation of wrong and right, to ensure the correct knowledge a more

active role in life and to evaluate different knowing forms in their own contexts (Turgut, 2009). Open and reflective discussions are effective on students' awareness (Lederman, 2007). If this distinction is being reached in young ages, students can be grown as individuals who make the separation between science and pseudoscience.

Even after acquiring a conclusion in the face of evidence, people tend to hold on beliefs that they believe (Wynn & Wiggins, 2002). Therefore it is needed to define the distinction between science and pseudoscience to prevent their superstitions get ahead of scientific truths. This distinction issue has been a debated case for scientists and philosophers. Especially in the early 20th century, the philosophy schools that were founded in several countries aimed to put a line between science and pseudoscience (Çetinkaya et al., 2013). This issue can be called as demarcation and there is not a clear distinction. Also this distinction was determined by different ways by scientists. For example Feyerabend discussed that all kinds of knowledge is valuable and necessary for scientific development (Feyerabend, 1999; Wynn & Wiggins, 2002).

When the studies about science-pseudoscience distinction scale are examined, there is a study found about scale adaptation on university level. The study was carried out by Çetinkaya et al. (2013) and it was seen that the adapted scale from Oothoudt (2008) was included three subscales as "science as a process of inquiry", "belief in pseudoscientific beliefs" and "applying the parameters of science to pseudoscience". In another study, Çetinkaya (2012) was designed science-pseudoscience distinction scale for middle school students. This scale was designed entirely by the context. It is quite necessary to give attention to science-pseudoscience distinction in elementary school level for protecting students from non scientific beliefs. Therefore, there is a need for a valid and reliable data collection tool for elementary school students on science-pseudoscience demarcation.

METHOD

This study was designed as a scale development work in order to determine whether the students can make the separation of science-pseudoscience and to establish a valid and reliable data collection tool. The study was conducted with 717 elementary school students who are attending 5th, 6th, 7th and 8th grades. According to Kline (2011), for structural equation modeling analysis it is needed 10 times more sample size of variable amount join to research. Therefore it can be seen that the study's sample size is convenient for the analysis.

A 52-question survey was created for getting the students' opinions on science and scientific studies. There were two choices; "Yes, I believe" and "No, I don't believe". The scoring was 1 for "Yes, I believe" answer and 2 for "No, I don't believe". Confirmatory factor analysis (analyzed by LISREL 8,7 programme) and Kuder Richardson-20 formula was used for data analysis and validity and reliability (Ada et al., 2012).

To develop a reliable and valid instrument five steps were used. These were doing national and international literature review on the subject, developing an item pool based on literature search and the data were collected from 250 elementary students' answers to open-ended questions about the subject, asking expert opinion about the items for content validity and refinement of items after expert opinions, pilot study and refinement of items after pilot study and finally statistically analysis for final version of the instrument.

After doing literature review, the items in the instrument were generated by using W.W. Cobern (2000)'s "The Thinking About Science Survey Instrument (TSSI)", and P.F.W. Preece and J. H. Baxter (2000)'s paper called "Skepticism and gullibility: the superstitious and pseudo-scientific beliefs of secondary school students". In addition 250 elementary students were asked to answer open-ended questions about science-pseudoscience distinction.

The goodness-of-fit tests about data-model correlation can be handled at the same time as a valid indicator of the model parameters (Aşkar & Yurdugül, 2009). The most common statistics that are using for model-data fit calculation by taking advantage of the confirmatory factor analysis are the chi-square ($\chi 2$), $\chi 2$ / sd and RMSEA. In this study first of all, it was analyzed by chi-square ratio between the degrees of freedom. This rate is expected to be up to 3-4. Being smaller than 5 of calculated $\chi 2$ / df ratio and RMSEA's decrease value from 0.055 indicate model-data compliance (Jöreskog & Sorbom, 1993). The other criteria are RMSEA (Root Mean Square of Approximation), GFI (Goodness of fit index), AGFI (Adjusted goodness of fit), CFI (Comparative fit index), IFI (Incremental fit index) and standardized RMR (SRMR/ The square root of the average standardized error). It is acceptable that RMSEA and SMRS should be below than 0.08 or even below 0.05 are considered more as a good compatibility index. It is expected that CFI, GFI and AGFI values are ≥ 0.90 (Şimşek, 2007). Also Sümer (2000) points out GFI and AGFI from the absolute fit index value 0.95 and higher mean very good fit, between 0,90-

0,95 mean the satisfactory compliance. Similar, when the incremental fit indexes CFI and NNFI are 0.95, it is a very good fit, and when they are between 0.90-0.95, it is acceptable fit (Olpak & Kılıç Çakmak, 2009).

FINDINGS

Validity

First, 52 questions had been created for scale development process. Survey questions were decreased from 52 to 46 by expert opinions. After the pilot study, it was decided to use 31of these questions. By the way overall the questions were mostly turned to "opinions which are widely accepted" more than science-pseudoscience distinction. More total grade that students get from the scale means the student have less superstition; less grade means more superstition. The items which were created according "Widely Accepted Opinions Scale" were assumed in one factor and confirmatory factor analysis was started depending on one factor (Kline, 2010; Şahin & Gizir, 2013). First, all 31 questions were analyzed and the fit indexes are shown in Table 1.

Table 1: The Fit Indexes of 31 questions after eliminating from 46 questions

Fit indexes	χ 2 /sd	RMSEA	RMR	SRMR	GFI	AGFI	CFI	NNFI
Observed	3.69	0.061	0.011	0.058	0.87	0.86	0.90	0.89
Limit	≤ 5	≤ 0.08	≤ 0.10	≤ 0.10	≥ 0.85	≥ 0.80	≥ 0.80	≥ 0.80

After getting the fit indexes, standardized Lambda (λ), t and R^2 values were investigated. According to confirmatory factor analysis results, for item elimination factor load values (lambda) were searched by 0.30 and upper values. The standardized values were examined previously in the diagram. Şimşek (2007) emphasize that for t value there shouldn't be any red arrows because red arrow means the item is not statistical meaningful on 0.05 level. High multi-frame correlation (R^2) which can be used as the validity index is also need to have value ≥.30. These items were priorly preferred according to Kline (2010).

Table 2: Standardized Lambda (λ), t and R^2 Values

First Items	Lambda	t	R^2	First Items	Lambda	t	R^2
1	**0.29**	7.45	0.91	**32**	0.45	11.77	0.80
2	**0.30**	7.58	0.91	**33**	0.59	16.26	0.65
15	**0.08**	**1.91**	0.99	**34**	0.41	10.67	0.83
16	**0.01**	**0.26**	1.00	**35**	0.49	13.00	0.76
20	**0.26**	6.58	0.93	**36**	**0.29**	7.26	0.92
21	**0.22**	5.61	0.95	**37**	0.44	11.52	0.81
22	0.32	8.17	0.90	**38**	0.40	10.37	0.84
23	**0.16**	4.09	0.97	**39**	0.53	14.21	0.72
24	0.39	10.21	0.85	**40**	0.49	12.98	0.76
25	**0.27**	6.88	0.93	**41**	**0.10**	10.28	0.84
26	0.31	7.94	0.90	**42**	0.47	12.43	0.78
27	**0.22**	5.58	0.95	**43**	0.57	15.45	0.68
28	0.33	8.32	0.89	**44**	0.52	14.08	0.73
29	0.55	14.94	0.70	**45**	0.46	12.26	0.78
30	0.51	13.65	0.74	**46**	0.52	7.78	0.91
31	0.49	12.90	0.76				

As seen from Table 2; the items 1, 2, 15, 16, 20, 21, 23, 25, 27, 36 and 41 from 31 questions were removed

because of low factor load values. Also, 15th and 16th items were removed because of not being statistically meaningful (red arrows) on 0.05 level. By the way 11 questions were eliminated and 20 questions were analyzed again. The new questions' fit indexes can be seen from Table 3.

Table 3: The Fit Indexes of the last 20 questions

Fit indexes	χ 2 /sd	RMSEA	RMR	SRMR	GFI	AGFI	CFI	NNFI
Observed	3.21	0.056	0.0077	0.048	0.93	0.91	0.95	0.94
Limit	≤ 5	≤ 0.08	≤ 0.10	≤ 0.10	≥ 0.85	≥ 0.80	≥ 0.80	≥ 0.80

As seen from Table 3, the new model's fit indexes according to structural equation modeling were χ 2/sd 3.21, RMSEA 0.056, RMR 0.0077, SRMR 0.048, GFI 0.93, AGFI 0.9, CFI 0.95, NNFI 0.94. It can be said that one factor depending scale model's fit indexes are acceptable. The 20 questions model's path diagram can be seen from Figure 1.

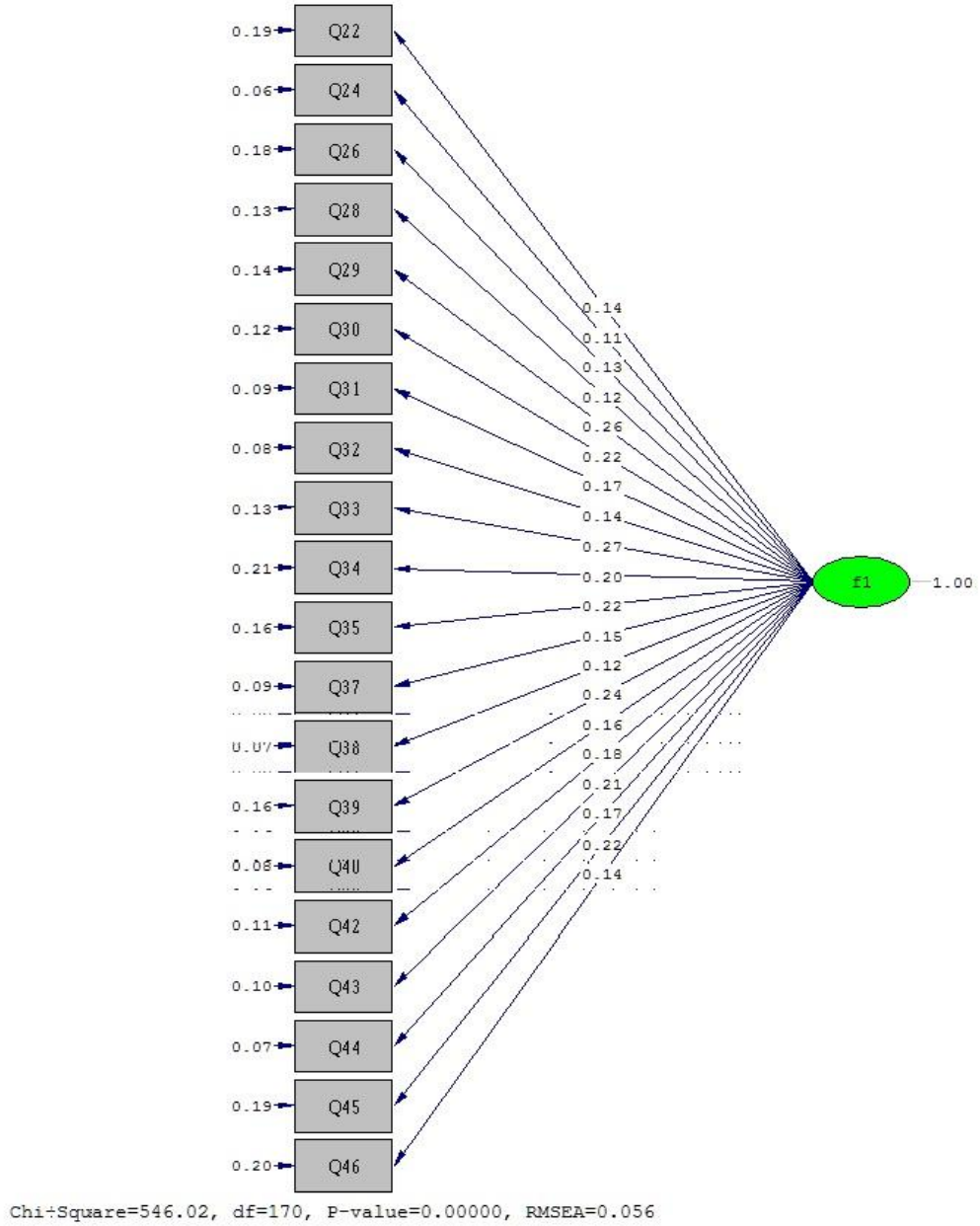

Figure 1: Path Diagram of the Model

Reliability

In this study, because of working with a nominal scale (there were two choices for the answer of the questions), the KR-20 internal consistency coefficient for the test was calculated. Reliability factor was found as .836. This finding shows that the scale is a reliable measurement tool for elementary school students**.**

CONCLUSIONS

In this study according to findings, a "Widely Accepted Opinions Scale" was developed. The scale has one factor and 20 questions that aimed to figure out elementary school students' superstitions. The amount of questions was decreased by expert opinions and pilot study. There are two answers of the questions. The students get 1 point for "Yes, I believe" answer and 2 point for "No, I don't believe" answer. The lower grade is 20; the highest grade is 40 that can be taken from the scale. There are no reverse items. The lower score means student has high superstitions, the higher score means student has low superstitions. These scores also can give an idea about students' science- pseudoscience distinctions. Having superstitions can be correlated with demarcation. Students may not make science- pseudoscience distinction if they get lower grade from the scale because of having more superstitions. The scale was analyzed by confirmatory factor analysis and the model showed acceptable fit indexes. The indexes are χ 2/sd 3.21, RMSEA 0.056, RMR 0.0077, SRMR 0.048, GFI 0.93, AGFI 0.9, CFI 0.95, NNFI 0.94. At the end of the study KR-20 was found as .836. As a result, it can be seen that the researchers who aim to determine elementary school students' science-pseudoscience distinction can use this scale as a valid and reliable measurement tool.

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Yaygın Olarak Kabul Edilen Görüşler Ölçeği

Eski no	**Yeni no**	**Yaygın Görüşler**	**Evet İnanıyorum**	**Hayır İnanmıyorum**
22	1	Bazı taşlardan yapılan takıları takmak, sağlıklı olmanızı sağlar. Örneğin Zümrüt taşı sindirim sistemini düzenler.	☐	☐
24	2	Bir ipin ucuna metal bir cisim bağlayıp el üzerinde sallayarak ileride olacak çocukların cinsiyeti belirlenir.	☐	☐
26	3	Geçmiş yıllarda, başka gezegenlerden uzaylılar dünyaya gelmiştir.	☐	☐
28	4	Hava karardıktan sonra dışarıya sıcak su dökmek uğursuzluk getirir.	☐	☐
29	5	Üzerine kuş pislerse, şansın açık olur.	☐	☐
30	6	Tahtaya vurmak uğursuzluğu önler.	☐	☐
31	7	'Y' harfi şeklindeki ağaç çubuklar iki ucundan tutulursa, hazineye yaklaştıkça ağaç çatal titremeye ve aşağıya, hazinenin bulunduğu yere doğru dönmeye başlar.	☐	☐
32	8	Merdiven altından geçmek uğursuzluk getirir.	☐	☐
33	9	Kara kedi görmek uğursuzluktur.	☐	☐
34	10	Mavi renkli nazar boncukları insanları nazardan korur.	☐	☐
35	11	Kurşun dökmek nazara karşı korur.	☐	☐
37	12	Avucunuzdaki çizgilerden gelecekte başınıza neler geleceğini tahmin etmek mümkündür.	☐	☐
38	13	Kızlar kapı eşiğinde otururlarsa çocukları olmaz.	☐	☐
39	14	Sağ el kaşınması, para geleceğine işarettir.	☐	☐
40	15	Sarımsakları evin duvarına asmak evi uğursuzluklardan korur.	☐	☐
42	16	13 uğursuz bir sayıdır.	☐	☐
43	17	Ayna kırmak uğursuzluk getirir	☐	☐
44	18	At nalını kapı üstüne takmak uğur getirir	☐	☐
45	19	Köpeğin gece havlaması kötü şeylere işarettir.	☐	☐
46	20	Gece tırnak kesmek günahtır.	☐	☐