



The Scale of Scientific Epistemological Beliefs: Adapting for Turkish Culture, Language Validity and Examination of Factor Structure

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Received: 14.03.2009

Revised: 13.11.2009

Accepted: 20.11.2009

The original language of the article is Turkish (v.7, n.4, December 2010, pp.67-89)

Key Words: Scientific Epistemological Beliefs; Scientific Knowledge; Epistemology Of Science; Validity; Reliability.

SYNOPSIS

INTRODUCTION

When examining the objectives of science education, it can be realized that students' learning scientific information and understanding the philosophy of science take place on the top (Çepni, 2008; Doğru & Kıyıcı, 2005). However, it is expressed that science is not a total of knowledge but a way of knowing; students' understanding the nature, structure of knowledge and how knowledge is developed is important in science education (National Research Council [NRC], 2007). In this respect, studies about science and scientific knowledge in science education come into prominence.

As a result of this long running debate and developments in science education, the curriculum in primary education in Turkey has been reformed, based on constructivist approach in 2004. When addressed as an epistemology, constructivism differentiates the views with regard to both knowledge and acquiring the knowledge. Addressing the constructivism as an approach and dwelling on scientific knowledge revive the questions: What is knowledge? How is knowledge constructed? Philosophical branch which deals with such questions is Epistemology as it is known. If we look from the viewpoint of primary education, we can see that students' opinion about scientific knowledge has gained



importance. This is called as the scientific epistemological beliefs. Scientific epistemological beliefs reflect individuals' philosophical understanding about the issue such as what the science and valid-reliable scientific knowledge are, how the scientific knowledge is produced and shared (Deryakulu & Bıkmaz, 2003, p.245).

The term genetic epistemology which Piaget used for theory of cognitive development builds up the beginning stage of showing interest in this field and all of the studies carried out in relation to epistemological beliefs follow cognitive and moral development model which Perry developed as a result of two long term studies (Hofer & Pintrich, 1997). Perry constituted a cognitive and ethic development scheme which is comprised of nine successive conditions and in which gradation from one level to another is enabled in accordance with the results he accomplished with *Control List of Education Values* (Hofer & Pintrich, 1997). It was criticized that Perry's paradigm consists of male only. Whereupon Belenky, Clichy, Goldberger and Tarule (1986) touched on women and examined women's epistemological development. Kuhn (1991) discussed how the individuals in different ages response to daily problems without absolute solution and he constituted argument-based reasoning model as a result of this study. Baxter Magolda (1992) carried out a study with university students by applying *Measure of Epistemological Reflection*. Epistemological reflection model constituted by Magolda (1992) includes four knowing ways: (i) absolute, (ii) transitional, (iii) independent and (iv) contextual. King and Kitchener (1994, as cited in Hofer & Pintrich, 1997), focused on epistemic acceptances underlying the reasoning process, constituted a development model with seven stages at the end of study. Unlike the models that were dealt before, Schommer (1990) developed a belief scale including 63 items, dealing epistemological beliefs as frequency distribution.

It is seen that models that were constituted in epistemology researches and some scales that were developed have been dealt within the context of science. Pomeroy (1993) give place to items including (i) traditional sense of science, (ii) modern sense of science and (iii) traditional understanding of science education in *Scale of Scientific Epistemological Beliefs*. Holschuh (1998) dealt with whether scenarios could be used in measuring the epistemological beliefs, the relationship between epistemological beliefs and use of strategy dealt within the scope of biology lesson; he used *Epistemological Belief Scale* developed by Schommer (1990) and his own epistemological scenario in measuring epistemological beliefs. Saunders (1998) constituted *Science Knowledge Scale* comprising of 28 items and one-dimension for measuring the students' epistemological beliefs within the scope of chemistry lesson. Tsai and Liu (2005) developed a scale comprising of five sub dimensions; (i) role of social negotiation, (ii) creative nature of science, (iii) theory-laden explanation, (iv) cultural effects and (v) variable and temporary quality of scientific knowledge and they aimed to measure the high school students' scientific epistemological beliefs.

Several studies have been carried out in this field in Turkey. These studies mainly focuses on adapting existing scales to Turkish context: (i) Schommer's (1990) *Epistemological Belief Scale* (Deryakulu & Büyüköztürk, 2002), (ii) *Scientific Epistemological Scale* developed by Pomeroy (1993) (Deryakulu & Bıkmaz, 2003), (iii) the scale developed by Rubba and Andersen (1978) (Kılıç et al., 2005).

When examining the studies apart from the adaptation studies to Turkish context, (i) Oksal, Şenşekerçi and Bilgin (2007) developed a *Central Epistemological Beliefs Scale* to examine epistemological beliefs from different dimensions; social, political, economical, religious and psychological dimensions; (ii) Çoban and Ergin (2008) also developed a *Scale for Determining the Views of Primary School Students Towards Scientific Knowledge* to determine the views of primary school students towards scientific knowledge.

PURPOSE OF THE STUDY

As the number of scales to measure scientific epistemological beliefs is insufficient and all of the scales are for adults, the purpose of this study is to adapt *The Scale of Scientific Epistemological Beliefs* developed by Elder (1999) to Turkish culture for primary school students and define its structural validity regarding its dimensions; (i) objective of science, (ii) knowledge's variability in science, (iii) role of experiments in developing theories, (iv) consistency of science and (v) source of scientific knowledge.

METHODOLOGY

As the first stage of this study, the original scale items were translated into Turkish by four academicians. After this procedure, all translated documents were gathered in a form and retranslated into original language (English) by researchers. At the end of this process, a Turkish Form was constituted after all translated items were checked. As there is no primary school student who knows English, the original language of the scale and Turkish sufficiently to carry out the non-inferiority studies of scale items, Turkish form has been constituted after the translation process in determining the linguistic non-inferiority of items composing the scale. Validity and reliability studies of this form were carried out after this process. Structural validity and reliability analysis of scale items were carried out with 212 primary school student who were determined with purposeful sampling method. The scale was on Likert Scale format with 5 options: *I strongly disagree* 1 (one), *I disagree* 2 (two), *Neutral* 3 (three), *I agree* 4 (four) and *strongly agree* 5 (five). *Pearson Product Moment Correlation Analysis* was used to determine item-total values and item-remainder values of item differentiation of scale items and the *independent group t-test* was used to compare the bottom and top group points. There has been no consensus in literature about whether factor analysis is done in linguistic adaptation for *structure validity* of scale. (Fielding & Gilbert, 2006; Hambleton, Marenka & Spielberger, 2005; Tosun & Karadağ, 2008). First, *confirmatory factor analysis* and then *exploratory factor analysis* are preferred to have an idea about the similarities between structure validity of Turkish form and the original scale, and cultural changes in scientific epistemological beliefs. *Cronbach Alpha* coefficient was used as internal consistency in determining the internal reliability level of scale and inhomogeneity of items. *Pearson Product Moment Correlation Analysis* was used to determine the relation between the average and standard deviation values of sub factors of scale and sub scales. Test-retest method was used to determine the stability factor of scale. The scale was applied to a group of 169 people twice at three-weeks-intervals. *Pearson Product Moment Correlation Analysis* was used to determine the relation between points obtained as a result of two applications. Besides, programs named SPSS 15.0 and LISREL 8.80 were used in validity and reliability analysis of scale.

FINDINGS

Item-total and item-remainder correlations were calculated over data obtained from 212 students in order to determine how adequate item criteria in Turkish form were to distinguish the people in terms of qualifications (Baloglu & Karadağ, 2008). Correlation coefficients obtained from item-total correlations are between .20 and .74; they are statistically significant in all items. Correlation coefficients obtained from item-remainder correlations are between .08

and .61; they are statistically significant in all items. Raw scores obtained from scale were arranged from the highest to the lowest in order to determine item differentiation which is another validity criterion. As a result of this arrangement, point averages of bottom group comprising 27 % and top group comprising 27 % were compared with independent group t-test. There is a significant difference on the level of $p < .01$ between top group and bottom group obtained from items as a result of independent group t-test. This shows that the scale is distinctive in respect of measuring the difference between low point and high point obtained from scale (Baloğlu & Karadağ, 2008). According to the obtained results, the scale is said to have the features of item-total, item-reminder and item differentiation.

According to the evaluation of confirmatory factor analysis results of sub factors obtained in scale's original factor structure, the results don't exceed the theoretic limits; although chi-square (χ^2) value and statistical significance levels have been determined for consistency indexes regarding confirmative factor analysis, model's consistency indexes [$GFI=0.78$, $AGFI=0.75$, $PGFI=0.68$, $RMSEA=0.07$, $CFI=0.86$] show that the proposed model isn't appropriate for the scale. The standard consistency values of these indexes are the followings: the coefficients obtained from GFI [Goodness-of-fit index,], AGFI [Adjusted Goodness-of-fit index,], CFI [Comparative Fit Index] and PGFI [Parsimony Goodness of Fit Index] vary between 0 and 1. Although there is not a compromise about coefficient value in literature, it is said to be a good consistency when the coefficient is over 0.85. (see Anderson & Gerbing, 1984; Cole, 1987; Marsh, Balla & McDonald, 1988). Values obtained from RMSEA [Root-mean-square error approximation] vary between 0 and 1. Unlike the situation in the other consistency indexes, it is acceptable to obtain the nearest value to 0 in RMSEA which expresses the error margin between observed and produced matrixes. 0.05 or values lower than 0.05 are acceptable for the consistency in RMSEA. It is a good consistency if χ^2/df rate is between 2 and 5; it is a perfect consistency if χ^2/df rate is lower than 2. (Jöreskog & Sörbom, 2001). This result showed that values obtained regarding study models didn't confirm the modeled factor structure. It is a difficult effort to study over the intercultural changing and non-changing in relation with individuals' life experiences such as perceiving the science. First of all; researchers need to develop the assessment instruments which will produce the same categories for the answers nonaffiliated with culture and linguistic content in which the instrument is presented in order to determine the permanent characteristics among the cultures. Secondly, assessment instruments must comprise of items reflecting the respondents' ordinary behaviors. Thirdly, respondents must be under the influence of tendencies such as consistency and inconsistency tendency, giving extreme responses, responding in a socially-desired way or undervaluing some distinctive qualifications which are channeled by culture. It is a slim chance to obtain constancy among cultures in consideration of these confusing situations (Gülgöz, 2005). Consequently, it was found out that the original factor structure of Scientific Epistemological Beliefs Scale didn't provide the same factor structure in the Turkish culture.

DISCUSSION

As a result of exploratory factor analysis, it was seen that equity value of items were gathered under 5 sub scales which are higher than 1; every item gave a high value under only one sub scale when re-examining this solution using Varimax rotation. Total latent value of scale gathered under five (5) sub scales is 13.193 and its variance amount is 52 %. Factor load values of scale items are between .49 and .76. When examining scale factors, *Authority and Accuracy* factor include the belief that scientific knowledge takes place outside of individual

and scientific knowledge is certain. Factor of *process of knowledge production* deals with the empirical base of constituting scientific knowledge. Factor of *resource of knowledge* deals with the beliefs regarding the accuracy of inquiries made from sources of knowledge apart from the individual himself/herself. *Reasoning* factor deals with the belief regarding the advance information logic and scientific curiosity in constituting the scientific knowledge. Factor of *variance of knowledge* deals with the beliefs regarding the indefinite nature of scientific knowledge. Factors obtained at the end of the study are said to reveal the scientific epistemological beliefs in scale of scientific epistemological beliefs in literature more transparently and scale is said to be convenient for measuring epistemological beliefs as the scale is dealt for a specific field and context (Holschuh, 1998). Moreover, the acquired structure with multi-factor supports the presumption that epistemological beliefs have not one-dimensional structure but multi-dimensional structure and consequently, it must be regarded as a belief system.

Correlations among sub scale points of scale vary between -.188 and -.400. Total point for sub scale of *Authority and Accuracy* is 2.53 (SS=.83), total point for sub scale of *Process of Knowledge Production* is 4.11 (SS=.56), total point for sub scale of *Resource of Knowledge* is 2.95 (SS=.82), total point for sub scale of *Reasoning* is 4.14 (SS=.61) and total point for sub scale *Variance of Knowledge* is 3.72 (SS=.63). The result that the relation between two sub scales is negative and the relation between some sub scales isn't significant in the analysis of correlation among the sub scales reveals that sub scales of scale must be evaluated as independent scales.

While the internal consistency coefficient alpha of scale is between .57 and .86 in sub scales, consistency coefficient is .82 for the general scale. Test-retest correlation coefficient which reveals the consistency of scale varies between .374 and .758. This situation shows that there has been no change in short time period when examining Scale of Scientific Epistemological Beliefs with test-retest method. The more reliability coefficient comes close to 1, the more consistency level rises; the more reliability coefficient comes close to 0, the more consistency level decreases. (Turgut, 1997; Yıldırım, 1999). As Dağ (2002) specifies, internal coefficient of a scale is an indicator of structure validity.

Consequently; Turkish form of Scale of Scientific Epistemological Beliefs can be evaluated as an assessment instrument which has acceptable validity indicators and sufficient reliability coefficient. This scale is thought to be a useful scale which can be used in studies carried out with the students who maintain their education with science program based on constructivist education. It is thought that testing the scale in terms of different variables (for example; gender, social-economical level, settlement, approaches to learning, perceptions of learning environment) will enable to achieve stronger data. Testing the scale on different samples will enable to achieve stronger indicators and Turkish scale form should be examined in terms of psychometric qualifications. Examining the scale in terms of psychometric qualifications is a study subject by itself (Baloglu, 2005).

REFERENCES

- Anderson, J. C., & Gerbing, D. (1984). The effect of sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. *Psychometrika*, 49, 155-173.
- Baloğlu, M. (2005). Matematik kaygısını derecelendirme ölçeğinin Türkçeye uyarlanması, dil geçerliği ve ön psikolojik incelemesi. *Kuram ve Uygulamada Eğitim Bilimleri*, 5(1), 7-30.
- Baloğlu, N., & Karadağ, E. (2008). Öğretmen yetkinliğinin tarihsel gelişimi ve Ohio öğretmen yetkinlik ölçeği: Türk kültürüne uyarlama, dil geçerliği ve faktör yapısının incelenmesi. *Kuram ve Uygulamada Eğitim Yönetimi*, 746, 571-606.
- Baxter Magolda, M. (1992) *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco: Jossey-Bass.
- Belenky, M. F., Clinchy, B. M.; Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing*. NY: Basic Books.
- Çepni, S. (2008). Bilim, fen ve teknoloji kavramlarının eğitim programlarına yansımaları. S. Çepni (Ed.), *Kuramdan uygulamaya fen ve teknoloji öğretimi* içinde (s.2-13). Ankara: Pegem.
- Cole, D. A. (1987). Utility of confirmatory factor analysis in test validity research. *Journal of Consulting and Clinical Psychology*, 55, 1019-1031.
- Çoban, G. and Ergin, Ö., (2008). The Instrument for Determining the Views of Primary School Students about Scientific Knowledge. *Elementary Education Online*, 7(3), 706–716.
- Dağ, İ. (2002). Kontrol odağı ölçeği (KOÖ): Ölçek geliştirme, güvenirlik ve geçerlik çalışması. *Türk Psikoloji Dergisi*, 17(49), 77-90.
- Deryakulu, D., & Bıkmaz, F. H. (2003). Bilimsel epistemolojik inançlar ölçeğinin geçerlik ve güvenirlik çalışması. *Eğitim Bilimleri ve Uygulama*, 2(4), 243-257.
- Deryakulu, D., & Büyüköztürk, Ş. (2002). Epistemolojik inanç ölçeğinin geçerlik ve güvenirlik çalışması. *Eğitim Araştırmaları*, 2(8), 111-125.
- Deryakulu, D., & Büyüköztürk, Ş. (2003). Epistemolojik inanç ölçeğinin faktör yapısının yeniden incelenmesi: Cinsiyet ve öğrenim görülen program türüne göre epistemolojik inançların karşılaştırılması. *Eğitim Araştırmaları*, 5(18), 57-70.
- Doğru, M., & Kıyıcı, F. B. (2005). *Fen eğitiminin zorunluluğu*. M. Aydoğdu, & T. Kesercioğlu (Eds.), *İlköğretimde fen ve teknoloji öğretimi* içinde (s.1-8). Ankara: Anı Yayıncılık
- Fieding, J., & Gilbert, N. (2006). *Understanding social statistics*. London: SAGE Publications.
- Gülgöz, S. (2005). Five factor theory and NEO-PI-R in Turkey. J. Allik & R. R. McCrae (Eds.), *The five-factor model of personality across cultures* (s.175-196). Dordrecht, The Netherlands: Kluwer Academic Publishers
- Hambleton, R. K., Marend, P. F., & Spielberger, C. D. (2005). *Adapting educational and*

- psychological test for cross-cultural assesment*. New Jersey: LEA Publishers.
- Hofer, B., K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.
- Holschuh, J. L. (1998). *Epistemological Beliefs in Introductory Biology: Addressing measurement concerns and exploring the relationships with strategy use*. Yayınlanmamış doktora tezi, The University of Georgia, Athens.
- Jöreskog, K., & Sörbom, D. (2001). *LISREL 8.51*. Mooresville: Scientific Software.
- Kılıç, K., Sungur, S., Çakıroğlu, J., & Tekkaya, C. (2005). Dokuzuncu sınıf öğrencilerinin bilimsel bilginin doğasını anlama düzeyleri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 28, 127-133.
- Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.
- Marsh, H. W., Balla, J. R., & McDonald, R. P. (1988). Goodness-of-fit indexes in confirmatory factory analysis: the effects of sample size. *Psychological Bulletin*, 103(3), 391-410.
- National Research Council. (NRC). (1996) *National science education standards*. Washington, DC: National Academy Press.
- Oksal, A., Şensekeri, E., & Bilgin, A. (2007). Öğretmen adaylarının yaşam teorilerini oluşturan merkezi epistemolojik inançlarının belirlenmesi. *İlköğretim Online*, 6(3), 411-421.
- Pomeroy, D. (1993). Implications of teachers' beliefs about the nature of science: comparison of the beliefs of scientists, secondary science teachers, and elementary teachers. *Science Education*, 77(3), 261-278.
- Rubba, P. A., & Andersen, H. (1978). Development of an instrument to assess secondary school students' understanding of the nature of scientific knowledge. *Science Education*, 62(4), 449-458.
- Saunders, G. L. (1998). *Relationships among epistemological beliefs, implementation of instruction, and approaches to learning in college chemistry*. Yayınlanmamış doktora tezi, University of Oklahoma, Oklahoma.
- Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82(3), 498-504.
- Tosun, Ü., & Karadağ, E. (2008). Yapılandırmacı düşünme envanterinin Türkçe'ye uyarlanması dil geçerliği ve psikometrik incelemesi. *Kuram ve Uygulamada Eğitim Bilimleri*, 8(1), 225–264.
- Tsai, C. C., & Liu, S. Y. (2005). Developing a multi-dimensional instrument for assessing students' epistemological views toward science. *International Journal of Science Education*, 27(13), 1621-1638.
- Turgut, M.F. (1997). *Eğitimde ölçme ve değerlendirme metotları*. Ankara: Gül Yayınevi.
- Yıldırım, C. (1999) *Eğitimde ölçme ve değerlendirme*. Ankara: ÖSYM Yayınları.