A CONFIRMATORY FACTOR ANALYSIS ON THE ATTITUDE SCALE OF CONSTRUCTIVIST APPROACH FOR SCIENCE TEACHERS

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Abstract. Underlining the importance of teachers for the constructivist approach, the present study attempts to develop "Attitude Scale of Constructivist Approach for Science Teachers (ASCAST)". The pre-applications of the scale were administered to a total of 210 science teachers; however, the data obtained from 5 teachers were excluded from the analysis. As a result of the analysis of the data obtained from the pre-applications, it was found that the scale could have a single factor structure, which was tested using the confirmatory factor analysis. As a result of the initial confirmatory factor analysis, the values of fit were examined and found to be low. Subsequently, by examining the modification indices, error covariance was added between items 23 and 24 and the model was tested once again. The added error covariance led to a significant improvement in the model, producing values of fit suitable for limit values. Thus, it was concluded that the scale could be employed with a single factor. The explained variance value for the scale developed with a single factor structure was calculated to be 50.43% and its reliability was found to be .93. The results obtained suggest that the scale possesses reliable-valid characteristics and could be used in further studies.

Keywords: constructivist approach, science and technology teachers, confirmatory factor analysis

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Introduction

Instead of the behaviorist approach which considers the minds of students as blank slates and reserves for teachers the role of transmitting knowledge, contemporary learning environments are now increasingly being dominated by the constructivist approach which maintains that students filter through mental processes and structure new information on the basis of their previous knowledge and experiences through an active participation in the process. Although interpretations of the constructivist approach do differ according to varying perspectives, in the most general sense it rests upon the underlying argument that students structure new information on their previous knowledge through the social and cognitive processes they actively participate in, and learn by establishing mental relationships among the information in question. The approach assigns an active role to students in learning process, while teachers abandon the role of transmitting knowledge and assume the role of guiding students in structuring knowledge and facilitating the process. To put it differently, teachers are entrusted with facilitating the learning of students, helping them have access to information, guiding them, and controlling their learning process as a whole. Thus, by student-centered education one should not assume that teachers have now reduced roles. On the contrary, teachers are supposed to be more investigative in the constructivist approach (Köseoğlu & Kavak, 2001). This requires that teachers assume a very active role in learning environments in which the constructivist approach is used

(Selley, 1999). In this approach, teachers are charged with crucial responsibilities such as revealing the previous knowledge of students, providing them with appropriate learning environments, encouraging them to test their ideas and compare them with scientific knowledge, and helping them get into interaction with people and sources of information (Watts et al.,1997; Bağcı-Kılıç, 2001).

Therefore, teachers take a crucial part in helping student structure new information on the basis of their previous knowledge (Watson, 2001). Given the qualities that teachers need to possess, in constructivist learning environments, it is evident that teachers are not to undertake a passive role, but on the contrary are supposed to dominate the process in many respects. Therefore, classroom environments organized in line with the constructivist approach place greater duties and responsibilities on teachers. According to Rosenfeld & Rosenfeld (2006), in creating classroom environments based on the constructivist approach, teacher opinions concerning the difficulties with creating such environments are of considerable importance. Thus, it could be suggested that affective attributes are among the principal components that affect teachers' performance of their duties and responsibilities. It is believed that one of these affective attributes is teacher attitudes toward the constructivist approach.

Taking into consideration the importance of teachers in creating learning environments based on the constructivist approach which recently gained prominence in science and technology instruction, the study was dedicated to developing the scale in question. To Tezbaşaran (1997), attitude refers to the tendency to display positive or negative learned reactions towards a certain object, situation, institution, concept or person. Therefore, the study aims to develop a scale that could be used to identify and assess the attitudes of science and technology teachers towards the constructivist approach. A review of the relevant literature did not reveal any study on scale development intended to identify the attitudes of science and technology teachers towards the constructivist approach, which was the motive for conducting the present study.

Method and participants

The study is concerned with developing a scale. The pre-applications at the development stage of the ASCAST were carried out with Science Teachers exercising the teaching profession in cities randomly selected from seven geographical regions of Turkey, 30 teachers from each region. However, five teachers were excluded from the research as they left most of the scale items blank. Thus, the analyses were based on the responses of 205 teachers to the pre-application form. In the view of Harrington (2009), although researchers agree that greater samples yield better results for confirmatory factor analysis, there is no consensus as to which sample size would be sufficient. Kelloway (1998) suggests that pre-applications with 200 observations usually constitute a suitable threshold for sample size. Concerning sample size, Kline (1998), on the other hand, refers to sample sizes lower than 100 as small, those between 100 and 200 as medium and those higher than 300 as large samples. Furthermore, Kline (1998) argues that the statistical invariance of the results could be precarious if the respondent/variable ratio is lower than 5/1, while the same ratio is lower than 3/1 according to Harvey et al. (2005). While relatively smaller samples may well suffice under certain conditions, other conditions might require extremely large samples for factor analysis (MacCallum et al., 1999). Consequently, given the literature in question and the studies conducted, the pre-application sample could be considered to be at a sufficient level.

The study also considered the voluntariness of teachers in participating in the research. The demographic characteristics of the participant prospective teachers are as follows: (a) 4.9% (n=10) of the teachers are in the age range of 20-25, 17.6% (n=36) in the age range of 26-30, 23.4% (n=48) in the age range of 31-35, 22.9% (n=47) in the age range of 36-40 and 31.2% (n=64) are of 41 years of age or above; (b) 31.2% (n=64) of the teachers are male, and 68.8% (n=141) are female. Furthermore, 13.2% (n=27) of the teachers stated that they have professional experience of 1 to 5 years, 24.4% (n=50) 6 to 10 years, 35.6% (n=73) 11 to 15 years, 13.7% (n=28) 16 to 20 years, 2.4% (n=5) 21 to 25 years, 10.7% (n=22) 26 years and above; (c) 55.6% (n=114) of the teachers stated that they are graduates of faculties of education, 30.7% (n=63) of colleges, 0.6% (n=1) of the faculty of letters, 10.2% (n=21) of the institutes of education, while 2.9% (n=6) marked the option “other”; (d) 1.5% (n=3) of the participant teachers stated that they are holders of two-year program degrees, 87.8% (n=180) of undergraduate degrees, 8.8% (n=18) of master degrees and 0.5% (n=1) of PhD degrees, while 1.5% (n=3) marked the option “other”.

An examination of the participating teachers’ responses to the demographic characteristics question about graduation fields revealed that 25.9% (n=53) of the teachers held diplomas in the field of science, %18.5 (n=38) in Physics, 25.4% (n=52) in Chemistry, 20.5% (n=42) in Biology, and 9.8% (n=20) in other fields.

Results and interpretation

This section of the study deals with the processes of validity, reliability, and item analyses on the “Attitude Scale of Constructivist Approach for Science and Technology Teachers”. For analysis, SPSS 12 and LISREL 8.51 were used.

Generating the item pool and obtaining expert opinion

The process of generating an item pool for the scale made use of the study on attitude scale development for prospective teachers, which was conducted in parallel to the research, the interviews with the teachers, and relevant studies on scale development (Berberoğlu, 1990; Ekici, 2002; Nuhoğlu &

Yalçın, 2004; Kan & Akbaş, 2005; Çetin, 2006). Ten open-ended questions about the constructivist approach were addressed to the prospective teachers to identify the scale items and some items were added to the scale in accordance with prospective teachers' responses. Furthermore, some other items were also added to the scale on the basis of teachers' opinions about applications on the constructivist approach and their use in science instruction, which were obtained through semi-structured interviews with teachers in the workshops performed under a TUBITAK project. Finally, the attitude items obtained from the relevant literature were adjusted to the constructivist approach and included in the scale. Subsequently, five expert instructors and two Science and Technology Teachers were asked to state their opinions about 80 items in the scale. On the basis of expert opinion, the scale items were subjected to necessary arrangements and 41 items were removed from the scale in accordance with experts' suggestions on the ground that they did not assess attitude.

Exploratory and confirmatory factor analysis

The first analyses following the pre-applications of the scale attempted to ensure structure validity for the scale. Therefore, exploratory factor analysis was first performed, which was followed by confirmatory factor analysis to test the validity of the structure obtained from the exploratory factor analysis. Exploratory factor analysis is used to identify the latent variables or factors of priority for a set of variables (Harrington, 2009). Confirmatory factor analysis mainly aims to test the fit of a model obtained from exploratory factor analysis or a previously existing theoretical model with the data obtained from a given sample. Factor analysis requires a normal distribution in the universe (Tavşancıl, 2005). To the view of Şencan (2005), multivariate normal distribution of variables is particularly important if the "maximum likelihood" method is used; yet, principal component analysis and common component analysis do not involve an assumption directly related to distribution. Kelloway (1998) and Harrington (2009) suggests that one precondition for the "maximum likelihood" method particularly used in confirmatory factor analysis is that observed variables should have multivariate normal distribution. Bartlett's test is used to test whether the data have a multivariate normal distribution, while the KMO (Kaiser-Mayer-Olkin) value is employed to test the sufficiency of the data obtained from a sample (Tavşancıl, 2005). Besides, according to Harrington (2009), a non-normal distribution can be determined by skewness and kurtosis values for each variable. At this stage, Kline (1998) argues that for each item, skewness values should be lower than 3 and kurtosis values should be lower than 10 and values higher than these are problematic. Consequently, the first stage involved an examination of the correlation table, anti-image matrix, KMO-Bartlett values concerning the data, as well as the skewness and kurtosis values for each item. Analyses of the tables revealed high correlation for the 11th and 12th items, which were identified as items that assess similar characteristics given the items' characteristics. Therefore, the 12th item was removed from the scale. Moreover, the KMO value of the data was found to be .90 and the Bartlett's test was significant (χ^2=3666.167; df=703; p=.000<.05). Marshall et al. (2007) considers a KMO value above .50 as sufficient for factor analysis, while Barco et al. (2007) argues that perfect conformity is achieved for factor analysis with a KMO value equal to or above .90. Furthermore, an examination of the anti-image matrix showed that the values of sample sufficiency for all items were above .50 (Şencan, 2005; Marshall et al., 2007). What is more, the skewness and kurtosis values of each item were found to have a normal distribution by examining them on the basis of Kline's (1998) threshold values.

Factor analyses first made use of different rotational methods besides principal component analysis and correlation matrices. The most distinctive results concerning the factor items were obtained with the varimax technique of orthogonal rotation and initial analyses were carried out by this technique. An examination of the rotated factor loadings revealed that the items in the scale loaded on nine factors with eigen values higher than 1. The items under each factor were examined and it was shown that there was no meaningful coherence among the factor items, except for those under the first factor. Therefore, developing a single-factor scale was decided. For the evaluating of the model, χ^2/df, RMSEA, RMR, SRMR, NFI, NNFI, CFI, GFI and AGFI values were taken into consideration.

In the process of factor analysis of the scale, the varimax technique of orthogonal rotation was employed to examine the obtained factors and all items with loadings above .40 in the first factor were taken into account. Items without a meaningful coherence in other factors were removed from the scale (17-16-11-14-13-20-19-5-22-38-36-42-10-8-7-3-4-2-15-9-1-18).

After removal of such items, factor analysis was repeated with 16 items in the first factor with loadings higher than .40 by taking the number of factors as one. The repeated factor analysis revealed a factor loading below .50 for the 35th item, which was thus removed from the single-factor structure. This single-factor structure subjected to exploratory factor analysis was determined to include items that can assess general attitude toward the constructivist approach. The data in the single-factor structure identified by exploratory factor analysis was subjected to confirmatory factor analysis to test compatibility with a single-factor structure. In confirmatory factor analysis, covariance matrixes was used and fit indexes was calculated. In the first analysis, χ^2 value is significance at .05 level, χ^2/df =2,94, RMSEA= .097, RMR= .054, SRMR= .028, GFI= .85, CFI =.91, NFI = .87, NNFI =.90 and AGFI = .80 are founded out. The analyses yielded low values of fit. Thus, the suggested modifications were examined for the model and a relationship was detected between the error variances of the 23rd and 24th items. Suggestions for modification are offered by software packages and serve as determiners that guide the data in accordance with a new model that will most probably improve model fit (Harrington, 2009). Moreover, when a modification is suggested and there is a great decrease in χ^2, it usually means a real improvement in the model (Child, 1990). To Harrington (2009), suggestions for modification are in parallel with the simple χ^2 difference test. Therefore, a decrease in χ^2 in a suggestion for modification that is higher than 3.84 (p=.05; df=1) indicates a possible meaningful improvement in the model. However, it is not regarded as acceptable to add every modification into the model in confirmatory factor analysis. A modification to be added to the model should possess a certain theoretical background (Şimşek, 2007). In this context, this could be argued to be performed usually between meaningfully close items in the same factor when error covariance is added between the observed variables in a model. Since the 23rd and 24th items have a similar meaning, the model was tested again by adding error covariance between the items in the model. In the second CFA results showed that χ^2 value was significance at .05 level χ^2/df =2.32, RMSEA =.081, RMR = .049, SRMR =.025, GFI =.88, CFI =.94, NFI =.89, NNFI =.93 and AGFI = .84. As a result of interpretation of the obtained data, the new fit indices displayed a relatively better fit when compared to the previous analysis. It is also significant that the number of individuals in the study group was 205. Some studies have reported better results with certain CFA goodness-of-fit indices depending on sample size. Marsh et al.(1988) demonstrated in their study that the RMR, GFI, and AGFI values were positively affected by sample size. Similarly, Fan & Sivo (2007) also stated in their study that the NFI, GFI, and AGFI fit values had high sensitivity toward sample size. Widaman & Thompson (2003) argue that RMSEA value is relatively independent from sample size. As a result, the single-factor structure in question is clearly an acceptable structure. Figure 1 presents the path diagram concerning the standardized results obtained from CFA.

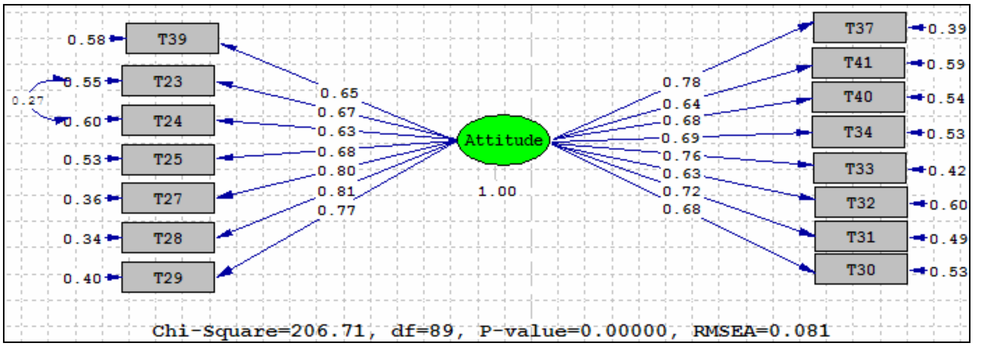

Fig. 1. Path diagram for the single-factor structure

Table 1 shows the items and item loadings, item-total score correlations, and upper and lower groups' discriminatory power in the single-factor structure following the exploratory and confirmatory factor analyses. For the items in the single-factor structure, the item total correlations vary between .759 and .567, while their factor loadings vary from .805 to .625. Moreover, for all items, the discriminatory results of the upper 27% group– lower 27% group t test were found to be significant at a significance level of .001. The variance explained by the single-group structure was calculated as 50.43% and its eigenvalue as 7.56.

Table 1. Factor loadings, item-total correlations, and upper-lower group discrimination for the items in the single-factor structure

No	Eigen value: 7.56 Cronbach alpha: .93 Explained Variance: % 50,43	Factor loads	Item-Total	Mean %27 upper	 %27 lower	t
29	I would do anything to learn about the constructivist approach.	.783	.736	4.45	3.07	12.00
27	Constructivism is an approach that deserves much emphasis.	.803	.759	4.58	3.29	10.29
28	The constructivist approach is suitable for my learning approach.	.805	.757	4.49	3.24	9.90
33	I like the constructivist approach.	.763	.711	4.51	3.44	9.58
37	I like using the constructivist approach in my classes.	.794	.748	4.55	3.65	8.32
34	I like reading books about the constructivist approach.	.696	.638	4.47	3.51	8.16

31	I would like to use the constructivist approach in teaching all my life.	.693	.639	4.44	3.20	8.98
32	I like informing others around me about the constructivist approach.	.625	.567	4.42	3.55	6.19
40	Constructivism is a useful approach.	.660	.607	4.47	3.49	7.77
25	I believe that I can benefit much from the constructivist approach.	.666	.612	4.67	3.35	9.30
41	I would like to conduct research on the constructivist approach.	.641	.584	4.45	3.18	8.30
30	I would not use the constructivist approach in teaching if I did not have to.	.699	.647	4.75	3.55	9.24
39	I am not interested in the constructivist approach.	.647	.595	4.75	3.58	10.31
23	I do not enjoy performing activities concerning the constructivist approach.	.668	.612	4.85	3.44	11.60
24	The constructivist approach is not interesting for me in any way.	.667	.615	4.85	3.62	10.42

p<.oo1 (in any cases)

The structure validation study was followed by the reliability process. In this process, the Cronbach alpha value was calculated to be .93. In their study, Spooren et al., (2007) suggested that a Cronbach alpha value above .70 is sufficient. The single-factor structure consists of a total of 15 items – 4 negative and 11 positive. Given its characteristics, it is clear that the scale can be used with its single-factor structure.

The development stage of the ASCAST involved the processes of exploratory and confirmatory factor analyses and the model with a single-factor structure produced in the exploratory factor analysis was tested by a confirmatory factor analysis. Table 2 shows the values of fit for the model with a single-factor structure produced as a result of exploratory factor analysis and the single-factor-corrected model.

Table 2 Comparison of the CFA indices of fit for different factor structures

Fit indexes / Models	$\chi2$	df	$\chi2$/ df	CFI	NFI	NNFI	GFI	AGFI	RMR	SRMR	RMSEA
One factor (1a)	264,31	90	2,94	.91	.87	.90	.85	.80	.054	.028	.097
One factor-Corrected (1b)	206,71	89	2,32	.94	.89	.93	.88	.84	.049	.025	.081

Studies often employ χ^2 difference test to compare the level of fit between models (Cramer, 2003; Kahn, 2006). According to Harrington (2009) and Kline (1998), the χ^2 difference test is a method that can be used to test the significance level of model improvement. This test is performed by subtracting from the χ^2 and df values of a given parent model the χ^2 and df values of an alternative child model and determining the significance level of this χ^2 value (Harvey et al., 2005). Table 2 presents the results obtained from a comparison of the single-factor model and the single-factor-corrected model. The results of the χ^2 difference test demonstrated that the single-factor-corrected model (1b) exhibited a significantly better fit than the single-factor model (1a) ($\Delta\chi^2$=57,60, Δdf=1, $p<.001$). In other words, error covariance added between the 23rd and 24th item in the single-factor model resulted in a significantly better fit for the model.

Discussion and conclusion

The study discussed the qualities that teachers should possess in learning environments that use the constructivist approach and the importance of teachers in learning process, and highlighted the need for determining teachers' attitudes toward the constructivist approach. Thus, the study dealt with an attempt to develop an attitude scale of constructivist approach for science and technology teachers. A general literature review revealed similar studies, though not exactly the same. Kesercioğlu et al. (2009) conducted a study on developing a scale on teachers' opinions about the constructivist approach. In a similar study, the same authors developed a scale on prospective teachers' opinions (Balım et al., 2009). In a study, Karadağ (2007) developed the "Scale on Teacher Competency about the Constructivist Approach". Fer & Cırık (2006) investigated in their study the language equivalency, validity, and reliability of the Turkish version of the "Constructivist Learning Environment" scale. Considering these studies, no other study was detected with the same characteristics as attitude scale of constructivist approach for science and technology teachers developed in the present study. Thus, the study is believed to have an original value.

The pre-applications for the development of the attitude scale were carried out with science and technology teachers employed in different provinces, each province being in a different region in Turkey. The analyses on the data obtained from the pre-applications showed that the scale can be developed with a single-factor structure and thus, the single-factor structure in question was tested by confirmatory factor analysis. The results of the confirmatory factor analysis demonstrated that the single-factor-corrected model for the scale had a better fit with the data when compared to the single-factor model. In the light of the results of the study, it is believed that: (1) The scale could be used by researchers in experimental and descriptive studies with different factor structures; (2) Further studies that will employ the scale might deal with testing its factor structure and its compatibility to the obtained structure, as well as its use in different samples; (3) Different studies on scale development should be conducted to identify teachers' affective qualities in and out of classroom environment by considering teachers' role in the constructivist approach.

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