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Development Of an Anxiety Scale for Chemistry

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ABSTRACT
Chemistry is regarded as a difficult subject by many; but at the same time, it takes an important place in middle and high school curriculum and many college degree programs require chemistry courses. Therefore, researchers have attempted to develop instruments to assess the levels of chemistry anxiety. This study aimed to develop an "Anxiety Scale for Chemistry", which is essential to setting an alternative for existing tools to determine anxiety for chemistry of students. This study has been carried out to develop a tool to measure the level of anxiety of students studying in the high schools in Turkey. The scale was developed as a result of the following processes: (1) Literature scan and creation of the item pool, (2) Taking expert opinions, (3) Item-total correlations, (4) Item distinctiveness features (5) Exploratory factor analysis (6), Cronbach's Alpha internal consistency reliability, (7) Examination of correlations between sub dimensions, (8) Confirmatory factor analysis. According to the results obtained, the scale is acceptably reliable for the research in social sciences.

Keywords: Anxiety scale for chemistry, reliability, validity, factor analysis.

A. INTRODUCTION

The chemistry is seen by many students as an abstract and difficult lesson that bears no relation to life (Gilbert, 2006; Reid, 2000). Many interrelated reasons that cause students to dislike chemistry lesson were revealed as a result of the studies (Gilbert, 2006; Gilbert, Bulte & Pilot, 2011; Laugksch, 2000; Roberts, 1982). Subject presentation techniques and the teacher's point of view about the contents of the lesson can be stated as source of anxiety developed against chemistry. Chemistry should be presented by the teacher "Not as the implantation of unquestionable facts as readymade information to minds but as a questioning technique that asks, enquires, creates answers, corrects mistakes, rechecks and makes the necessary corrections after each checking within the main framework", which means running towards what is more correct with an ever more careful approach (Alkan, 2013; Alkan, 2016; Herron, 1971; Hurd, Bybee, Kahle, & Yager, 1980; Tamir, 1983, Yücel, 2008).

Chemistry is regarded as a difficult subject by many; but at the same time, it takes an important place in middle and high school curriculum and many college degree programs require chemistry courses. Therefore, researchers have attempted to develop instruments to assess the levels of chemistry anxiety (Abendroth and Friedman, 1983; Baloğlu &Şenocak, 2014; Eddy, 1996; Wells, 2003; Yucel, 2008). Spielberg (1972) has defined these fear and stress situations as anxiety and asserted that these are observable reactions. Izard and Tomkins (1971) explained that anxiety is an affective feature and has effects on human behavior. Anxiety can be expressed as fear and tension felt in the existence of a threat (Buyukozturk, 1997). If students are asked not only to learn chemistry but also to live it, it is extremely important to correctly determine the anxiety about the chemistry. Therefore, it is necessary to determine the anxiety of the students in the school and to investigate the relationship of anxiety with other variables that will have a direct impact on the learning and teaching processes.

In this study, it is aimed to develop an "Anxiety Scale for Chemistry", which is essential to setting an alternative for existing tools to determine anxiety for chemistry of students. The sample of the different schools in turkey research was created by the high school students. The study is also important in terms of guiding the students by emphasizing the importance of the determining the anxiety situation for students. This developed anxiety scale has a feature that can be used for many purposes in teaching processes. Through this scale, chemistry teachers, who want to conduct their lessons, can benefit from the advantage of having preliminary knowledge about student profiles at the beginning of the academic year, by evaluating their students' anxiety about chemistry. In addition, it is thought that chemistry teachers can make more accurate decisions regarding the approaches, methods and techniques to be applied in the course depending on the

results of this scale.

B. METHOD

This study aimed to develop an "Anxiety Scale for Chemistry", which is essential to setting an alternative for existing tools to determine anxiety for chemistry of students. A total of 1007 students (647 female and 360 male) studying in the high schools in Turkey participated in the study. Process "Anxiety Scale for Chemistry's" was developed as a result of the following processes (Figure 1)

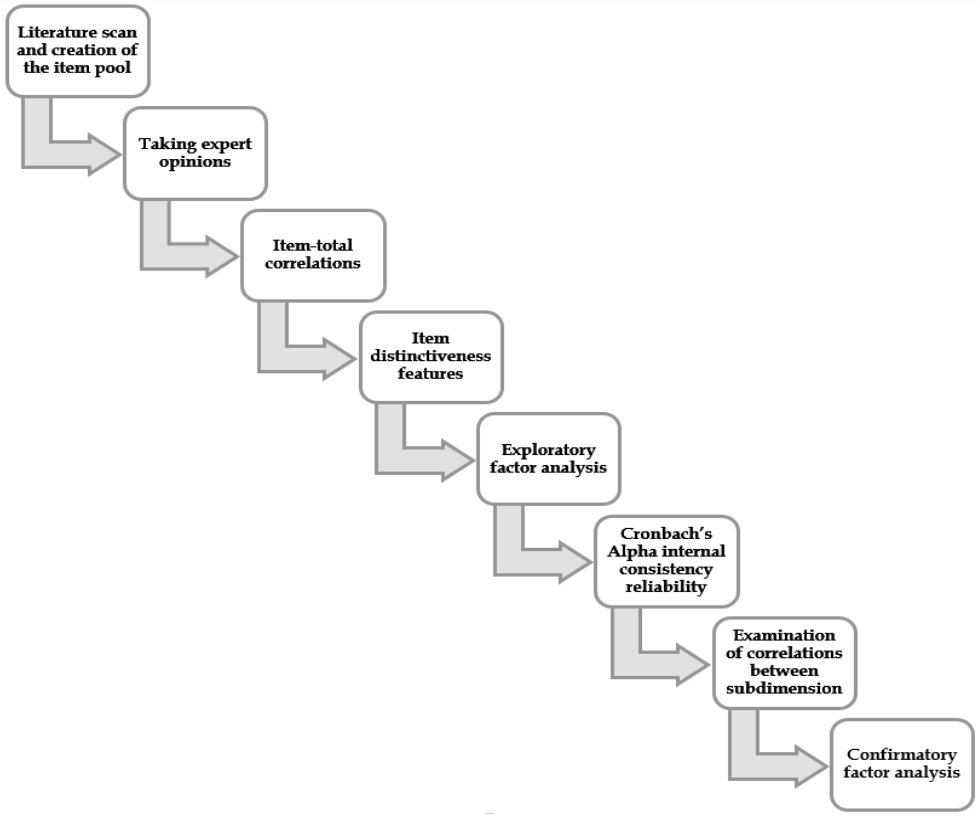

Fig.1: Process

1. Literature Scan, Creation of the Item Pool and Taking Expert Opinions

In a study, Yucel (2008) created by the application of a pool of items consisting of 45 sentences based on student opinions and expert advice to students and the branching of the results with the "Classification Trees" method to prepare a tree. The prepared scale is called the Anxiety Tree and is a suggested guidance tool to identify existing anxieties about chemistry. It has features to be used as a tool to measure performance. This study is carried out to identify the anxieties for the chemistry lesson of a total of 365 volunteer students within the 15- 17 age group, randomly selected from among the students studying in various educational institutions in Turkey. The statistical evaluation of the results of the study was carried out with the Classification Trees technique. As a result of the application of this technique, the 45 item scale was reduced to 23 statements and the comments made were based on 23 statements. The Anxiety Tree was the first step in the development of the "Anxiety Scale for Chemistry". To determine items of the scale, the anxiety tree were made use of and various ıtems were revised. A draft scale was created after the expert opinions. Draft scale was administered to 1010 students. The data obtained at the end of the application were analyzed according to students' responses to all of the choices or a single choice as a part of the preliminary elimination. At the end of the review, 1007 pieces of data were obtained for further analysis.

2. Item-total Correlations

Data obtained from the pilot study were applied item analysis based on item-total correlation. The item-total correlation of "Anxiety Scale for Chemistry" was calculated with Pearson Correlation Coefficient (Table1).

Table 1: Item-total correlations values

No.	Item	No	Item
I1	.450	I18	.398
I2	.512	I19	.382
I3	.551	I20	.559
I4	.603	I21	.488
I5	.624	I22	.543
I6	.533	I23	.514
I7	.613	I24	.595
I8	.573	I25	.184
I9	.453	I26	.545
I10	.541	I27	.571
I11	.589	I28	.468
I12	.477	I29	.524
I13	.462	I30	.509
I14	.531	I31	.575
I15	.443	I32	.560
I16	.548	I33	.587
I17	.238		

As seen in Table 1, item-total correlation coefficient values vary between 0.184 and 0.624. According to Özdamar (1997), in item analysis, item-total correlations should not be negative and should be higher than 0.25 in order to keep the summability feature of the scale intact. In addition, the fact that the item-total correlation is positive and high indicates that the items yield similar behaviors (Büyüköztürk, 2004). However, it was determined that the total correlations of the items of 17th and 25th items were less than 0.25.

3. Item Distinctiveness Features

To determine the distinctive validity of the "Anxiety Scale for Chemistry", a 27% top-bottom group comparison was carried out.

Table 2: Independent group t-test values

Item	(n2-n1)*	Mean	t	Item	(n2-n1)*	Mean	t
I1	n1	2.549	-11.11	I17	n1	3.756	-.99
	n2	3.808			n2	1.926	
I2	n1	3.077	18.38	I18	n1	2.918	16.68
	n2	1.332			n2	3.036	
I3	n1	3.675	21.55	I19	n1	3.605	-3.16
	n2	1.708			n2	1.922	
I4	n1	3.911	24.57	I20	n1	2.896	20.15
	n2	1.708			n2	3.265	
I5	n1	3.822	28.43	I21	n1	3.726	
	n2	1.405			n2	1.867	13.91
I6	n1	3.867	22.95	I22	n1	3.833	
	n2	1.797			n2	1.833	15.10
I7	n1	3.782	26.23	I23	n1	3.645	
	n2	1.597			n2	1.830	19.470
I8	n1	3.760	21.75	I24	n1	3.597	
	n2	1.830			n2	2.188	13.64
I9	n1	2.808	-3.58	I25	n1	2.848	
	n2	3.232			n2	3.321	-4.35
I10	n1	3.619	24.34	I26	n1	3.660	
	n2	1.546			n2	1.774	20.61
I11	n1	3.911	16.07	I27	n1	3.808	
	n2	2.302			n2	2.110	16.6
I12	n1	3.911	21.509	I28	n1	3.597	
	n2	2.302			n2	1.782	18.81
I13	n1	3.656	23.348	I29	n1	3.269	

	n2	1.723			n2	1.560	17.46
I14	n1	3.619	-1.465	I30	n1	2.560	
	n2	1.631			n2	2.944	-3.13
I15	n1	2.915	20.498	I31	n1	3.284	
	n2				n2	1.701	16.07
I16	n1	3.726	19.294	I32	n1	2.774	
	n2				n2	3.413	-5.702
*27% top-bottom group				I33	n1	3.516	16.69
					n2	3.789	

For each item in the draft scale applied, Independent Group t-test was administered in order to determine the significance of the difference between the item scores of the sampling in the top (n=271) and bottom (n=271) groups. The t-test concluded that the average scores of students in the top and bottom groups had significant differences. The averages of the bottom group studens at the Item No. 11,14,17,19,21,27 and 28 were found to be higher than that of the students in the top group. In addition, the t-values of Items 1, 9, 25, 30 and 32 were significantly lower than those of the other items. Therefore, items 1 ,9, 11, 14, 17, 19, 21, 25, 27, 28, 30 and 32 were removed from the draft scale as they affected the internal consistency of the scale on the negative. To determine the structural validity of "Anxiety Scale for Chemistry", factor analysis was carried out as a multivariate statistical technique, where a small number of many variables related to each other are used to form independent factors (Büyüköztürk, 2004).

4. Exploratory Factor Analysis

As a first step of the exploratory factor analysis study, Barlett Sphericity Test has been conducted. The Kaiser-Meyer-Olkin sampling value was calculated to be 0.95 and the Barlett Globalization Test result was found to be significant [$\chi 2 = 8668$; $p < .01$] (Table 3).

Table 3: The results of The Kaiser-Meyer-Olkin and the Barlett Globalization Test

Tests	**Values**	
The Kaiser-Meyer-Olkin	0.95	
The Barlett Globalization	$\chi 2$	.8668
	p	

Kaiser-This is described as "good" in the literature (Hair et al, 2006; Tavsancil, 2010) and the appropriateness of the data structure were proven. Statistical analysis of the "Anxiety Scale for Chemistry" was made through Principal Components Analysis with Varimax Rotation, which aims to obtain variable reduction and significant conceptual structures in large sampling groups. Rotation process, which was carried out through Varimax Vertical Rotation technique as a technique widely used in social sciences, three factors emerged with eigenvalues over 1.00.

Table 4: The results of exploratory factor analysis

Factor1	**Factor Loadings**	**Factor2**	**Factor Loadings**	**Factor3**	**Factor Loadings**
Initial Eigenvalues % of Variance	8.175	Initial Eigenvalues % of Variance	1.83	Initial Eigenvalues % of Variance	1.08
	37.16		8.32		4.91
	.90		.87		-85
I7	.759	I34	.724	I22	.723
I5	.745	I33	.722	I29	.680
I8	.731	I31	.612	I20	.537
I4	.724	I26	.542	I23	.505
I6	.702	I24	.480	I18	.467
I3	.670	I16	.498		
I10	.654				
I12	.562				
I2	.514				
I13	.529				
I15	.522				
I7	.759				

I5	.745				
I8	.731				
I4	.724				
I6	.702				
I3	.670				
I10	.654				
I12	.562				
I2	.514				
I13	.529				
I15	.522				

The values of the three factors obtained at the end of the factor analysis were analyzed and the contributions of the factors to the total variance were calculated to be 37,16 % for the first factor, 8,32 % for the second factor, and 4,91 % for the third factor. The contribution of the three factors to the total variance together was calculated to be 50,39 %. According to Scherer, Wiebe, Luther, and Adams (1988 cited in Tavşancıl, 2010), explained variance shall be between 40% and 60% in social sciences to be considered as adequate. Therefore, the high proportion of explained variance means that the "Anxiety Scale for Chemistry" has a strong factor structure.

As a result of the factor analysis, variables collected under the three factors were determined. Naming of these factors was carried out as follows: The first factor was named as the "Pathological anxiety". The second factor was named as "Emotional Anxiety". The third factor was named as "Behavioral Anxiety". In order to prove that the three sub dimensions of the "Anxiety Scale for Chemistry" assessed the same feature, Pearson Multiplied Moments Correlation Coefficients were calculated. As a result of the correlation analysis, a positive relationship was found between the scale factors ($r = .592$, $r = .662$, $r = .593$, $p = 0.0001$). The consistent factor structure of the scale developed supports its validity as well. In other words, the factor variables could be evaluated as complementary to each other.

5. Cronbach's Alpha Internal Consistency Reliability

For demonstrating the internal consistency of the draft scale Cronbach Alpha reliability coefficients and item-total correlations were calculated separately for the entire scale and each sub dimension. As a result of the statistical analysis made in order to question the consistency of the draft scale Cronbach's alpha (α) reliability coefficient was determined to be 0.91. In addition, Cronbach Alpha (α) reliability coefficients of the "Anxiety Scale for Chemistry" was calculated to be 0.90 for the first subdimension, 0.87 for the second dimension, and 0.85 for the third dimension. Nunnally (1967), reports that depending on the alpha (α) coefficient, if the reliability of a scale is $80 \leq \alpha < .100$ of the scale then this indicates that the scale is highly reliable. In this case, the items of the "Anxiety Scale for Chemistry" could be considered as consistent with each other and they have the same characteristics. According to the results obtained, "Anxiety Scale for Chemistry" is acceptably reliable for the research in social sciences. An exploratory factor analysis was used to determine the validity of the scale developed in this study; however, the scale development process was not limited to that.

Confirmatory factor analysis was carried out in order to determine whether the model obtained as a result of the exploratory factor analysis would support the expected theoretical structure. The number of data obtained in this study is equal to the suggested size in terms of structural equation modeling (Kline, 2005). This data collection tool developed in order to determine students' anxiety for chemistry has items with three dimensions. Confirmatory factor analysis performed over the three factors concluded that the difference observed between the expected covariance matrix and the observed matrix was significant at the .01 level.

C. CONCLUSION AND DISCUSSION

According to Izard and Tomkins (1971), anxiety is an affective feature and has effects on human behaviour. Studies on chemistry anxiety mainly focus on fear and stress situations. As Buyukozturk (1997) reports, Spielberg (1972) defines anxiety as unpleasant emotional and observable reactions stimulated by stress causing situations such as sorrow, perception, and tension. Spielberg (1972) has defined these fear and stress situations as anxiety and asserted that these are observable reactions (Yücel, 2008). According to Bowen (1999), given the multidimensional nature of the chemistry anxiety construct, it makes sense to ask the question: Are the anxieties of each dimensions experienced to the same degree? To answer this research question, the researchers tried to develop a tool to measure chemistry anxiety levels. The researchers have attempted to develop a tool to measure the levels of chemistry anxiety. For example, The Chemistry Anxiety Instruments measures the following dimensions of chemistry anxiety: working with chemicals, using

equipment and procedures, collecting data, working with other students, having adequate time (Abendroth and Friedman, 1983; Eddy, 1996; Wells, 2003;Yucel, 2008).

There are almost no studies on pathological, Emotional and Behavioral dimensions of chemistry anxieties. Anxiety about chemistry influences students' career studies (Udo, Ramsey & Mallow, 2004), science anxiety (Daniels, 1983; George, 2006), performance (Reece & Gable 1982;Wynstra & Cummings, 1993; Hakkinen, 1994; Brosnan, 1998; Chua, Chen, & Wong, 1999; Mikkelsen & Ogaard et al. 2002; Eddy, 2000), learning (Klausmeier & Goodwin, 1971) and statistical success grade (Pretorius & Norman, 1992). In this study, in order to determine how students' an anxiety was, "Anxiety Scale for Chemistry" was developed. Additionally, the data were collected using the descriptive research method. A total of 1007 students participated in the study. Data obtained from the pilot study were applied item analysis based on item-total correlation. To determine the distinctive validity of the "Anxiety Scale for Chemistry", t-test concluded that the average scores of students in the top and bottom groups had significant differences. In addition, the some items were removed from the draft scale as they affected the internal consistency of the scale on the negative. To determine the structural validity of "Anxiety Scale for Chemistry", factor analysis was carried out as a multivariate statistical technique. As a result of the factor analysis, variables collected under the three factors were determined. Naming of these factors was carried out as follows: The first factor was named as the "Pathological anxiety". The second factor was named as "Emotional Anxiety". The third factor was named as "Behavioral Anxiety". In order to prove that the three subdimensions of the "Anxiety Scale for Chemistry" assessed the same feature, Pearson Multiplied Moments Correlation Coefficients were calculated (r = .592., r = .662, r = .593, p = 0.0001). The Cronbach Alpha reliability coefficients and item-total correlations were calculated separately for the entire scale and each subdimension. As a result of the statistical analysis made in order to question the consistency of the draft scale Cronbach's alpha (α) reliability coefficient was determined to be 0.91 In addition, Cronbach Alpha (α) reliability coefficients of the "Anxiety Scale for Chemistry" was calculated to be 0.90 for the first subdimension, 0.87 for the second dimension, and 0.85 for the third dimension.

Confirmatory factor analysis performed over the three factors concluded that the difference observed between the expected covariance matrix and the observed matrix was significant at the .01 level. The results show that, the prepared "Anxiety Scale for Chemistry" is asuggested guidance tool to identify existing anxieties about chemistry for chemistry teachers. It has features to be used as a tool to measure performance. Pathological anxiety is defined that can be experinced by everyone and accepted normal worry situations are becoming uncontrollable anxiety and causing distortions in functioning of people. Starcevic and Berle (2006) proposed that the relationship between pathological anxiety and obsessive thoughts may be better conceptualized in dimensional terms. Despite that, it seems that the dimensions that we investigated are representative enough to allow us to draw certain conclusions, point to conceptual implications, and make suggestions for future research. One limitation of this scale is that it did not include all dimensions that have been implicated in the anxiety of chemistry. Findings of validity and reliability studies indicate that the Anxiety Scale for Chemistry sets a reliable and valid tool for determining students' anxiety for chemistry.The next step is to determine more precisely the dimensions of chemistry anxiety, and to compare the students with degree of chemistry anxiety dimensions. It is suggested that the Anxiety Scale for Chemistry should be administered to students of other fields and program types to serve better to the scale itself and the field of research.

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