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Development of Chemistry Laboratory Anxiety Scale for University Students*

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Abstract

The aim of this study is to develop a measuring tool for measuring the anxiety levels of university students for Chemistry Laboratory course. Sample of the study has been consisted of 685 science teacher candidate including 235 male and 450 female that studying in three different Faculty of Education, enrolling chemistry and chemistry laboratory courses. Chemistry Laboratory Anxiety Scale includes 12 items that supporting anxiety. Content validity was done by taking decisions of different experts. Explanatory Factor Analyses (EFA) was executed for structural validity of the scale. The results of the EFA showed that scale consisted of one factor. The total variance explained was 45% and factor loadings ranged from .52 to .77. It is found that for all the items in the scale Cronbach alpha is .88 and split half test correlation is .84.

Keywords: Chemistry laboratory, anxiety, reliability, validity, university students

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When individuals begin to receive education systematically, skills of individuals related to acquiring knowledge, through education, about concepts, principles, laws, theories and problem-solving processes, realization of change in the concepts related to beliefs, intentions and feelings, and using various organs in education would develop. The role of teaching and learning environment is of great importance in the realization of these changes (Kurbanoğlu, 2014). Science consists of physics, chemistry and biology. One of the most important learning environments in teaching concepts of physics, chemistry and biology is the science laboratory. Science laboratories (Hofstein & Lunetta, 2003) are active learning environments where students interact with each other in the learning environment, create scientific knowledge and develop basic scientific thinking skills as well as comprehend scientific concepts (Kurbanoğlu, 2014). Millar (2004) emphasized the importance of experimental work, which help students establish links between objects and observable properties as well as between events and ideas. Therefore, laboratory activities are employed to support theoretical science education as from the time when science concepts begin to be taught in schools (DeBoer, 1991).

In the science lab, learning takes place in cognitive, affective and psychomotor areas. Attitudes affecting learning, attention, motivation, being motivated, self-efficacy, anxiety comprise affective factors, while critical thinking skills, the use of cognitive strategies and physics knowledge comprise the main cognitive factors (Higbee, 1999; House, 1993; Sönmez, 2001). When the problems in learning environment are addressed in terms of cognitive, affective and psychomotor areas, it is seen that priority is given more to cognitive area and efforts are made to develop suggested solutions to any emerging problems mostly by addressing this aspect only. However, affective characteristics significantly affect an individual's success in the learning environment. For an individual to gain behaviors related to an area, it is of importance that s/he is interested in that area, doesn’t have any negative attitudes toward it, and thinks that the area s/he is interested in is important (Cerit Berber, 2008; Cerit Berber & Sarı, 2010).

In chemistry laboratory, the effects of both cognitive factors and affective factors are important. The most important affective factor affecting the success of the students in the chemistry lab is anxiety. Breslow (1993) and Eddy (2000) define chemistry anxiety, as a concept, as fear of chemicals and chemistry (McCarthy & Widanski, 2009), whereas Turner and Lindsay (2003) define it as feelings such as shyness, timidity towards chemistry and physical symptoms of these feelings. Moreover, Kurbanoğlu (2013) defined organic

chemistry anxiety as students' fear of inability to name organic compounds, learn complicated subjects such as isomers and isomeric relationships in organic compounds and satisfactorily analyze/synthesize reaction problems of organic compounds.

A limited number of measurement tools were developed to determine students' anxiety levels toward chemistry and chemistry laboratory (Bowen, 1999; Eddy, 2000). In his work with college students, Bowen (1999) developed a scale consisting of five subscales to determine students' anxiety levels toward chemistry laboratory. In this scale, it was stated that students' anxiety levels toward chemistry laboratory is associated with working with chemicals, equipment use, data collection, working with friends and good time management (Azizoğlu & Uzuntiryaki, 2006). As tools measuring levels of factors, such as anxiety, affecting learning chemistry concepts in the chemistry lab, desired goal will be reached in chemistry education. Presently, there a few measurement tools that measure students' anxiety in chemistry lab environment.

The purpose of this study was to develop a measurement tool for measuring university students' levels of anxiety toward chemistry laboratory. For this purpose, reliability and validity studies of the chemistry lab anxiety scale were conducted.

Method

Sample

The study sample was a total of 685 pre-service science teachers, including 450 females and 235 males, from three different Faculties of Education, who took chemistry and chemistry lab courses.

Preparation of Scale Items

In this study, the items of Chemistry Laboratory Anxiety Scale (CLAS) were prepared based on the contents of general chemistry and general chemistry laboratory courses. Therefore, while preparing the scale items, attention was paid to using statements that can comprehensively evaluate the contents of General Chemistry course as much as possible, and ultimately a 20-item question pool was created.

In the next step, 3 faculty members from Sakarya University, Faculty of Education were requested to review the questions in the item pool in terms of the extent to which they

measure the students' anxiety levels toward chemistry lab course, they are understood and represent. 8 items which faculty members thought cannot be items of the scale or have nothing to do with the construct were removed from the scale. As a result, a 12-item draft scale was created. All of these items are positive items supporting anxiety. Items were prepared as a 5-point Likert, as was the case for many anxiety scales. Items were rated as "it never worries me", "it sometimes worries me", "it frequently worries me", "it usually worries me" and "it always worries me" (Kurbanoğlu & Yücel, 2014).

Validity and Reliability Studies

One of the most important criterion in assessing the suitability of a measurement tool is the validity score of the tool. The concept of validity is a concept associated with the extent to which an item measures a property it aims to measure or define. For validity study of the CLAS developed, both construct validity and content validity were analyzed.

Content validity is associated with the extent to which items of a test represent, sample the universe of defined behaviors which one wants to measure. Logical ways utilized in content validity are consulting experts and calculating the correlation between scores from the scale and those from another test known to measure the same scope (Büyüköztürk, 2004). The CLAS developed was analyzed in terms of two stages in terms of content validity. In the first stage, 3 faculty members from Sakarya University, Faculty of Education were requested to review the scale.

Construct validity represents links with each other and relationship levels of parts constituting a whole in general. In order to assess construct validity, factor analysis was used. Factor analysis is a statistical technique which aims to measure variables measuring the same construct or quality by bringing them together, and explain them with limited number of factors (Büyüköztürk, 2004). Exploratory factor analysis was used to measure the construct validity of CLAS.

To assess the reliability of the scale, Cronbach's Alpha internal consistency, two half reliability coefficients and item-total correlation and t-test were used to calculate the significance of differences between item averages of groups of 27% from the upper group and of 27% from the subgroup was calculated. The validity and reliability analyses of the scale were performed using SPSS 13.0 program.

Results

Construct Validity

In this study, exploratory factor analysis was performed to determine the factor structure and subscales of CLAS. First of all, the correlation matrix between all items was examined and it was seen that there were correlations which show suitability for factor analysis. Then, sampling adequacy and Barlett Sphericity tests were conducted. Eligibility for factor analysis of data obtained as a result of the application was studied using Kaiser-Mayer-Olkin (KMO) coefficient and Barlett Sphericity test (Büyüköztürk, 2004). Accordingly, KMO should be greater than 0.70 and the result of Bartlett test has to be significant. In this study, KMO sample compliance coefficient was 0.90 and Barlett Sphericity test χ^2 value was 3372.462 ($p < .001$). These results indicate that factor analysis can be applied and correlation exists between the items. Basic components analysis was carried out in such a way that eigen value of 12 items in factor analysis will be 1.

As a result of basic components method by factor analysis and varimax conversion, a construct explaining 45% of the total variance was obtained. This rate was above the criterion of a description ratio of at least 30% (Tabachnick & Fidell, 1996), which is regarded as sufficient for scale development work, so a one-dimensional construct was obtained from the scale. The factor loadings of CLAS consisting of one-dimensional 12 items and total variance percentages they explain are given in Table 1.

Table 1
Factor Analysis Information of CLAS

	Scale Items	n	I
1	Entering the chemistry lab	685	0,673
2	Using chemicals in the chemistry lab	685	0,716
3	Using equipment in the chemistry lab	685	0,744
4	Preparing for the chemistry lab	685	0,713
5	Working with other students in the chemistry lab	685	0,546
6	Making an experimental set-up in the chemistry lab	685	0,774
7	Having little time for doing an experiment	685	0,520
8	Presence of chemicals around me in the chemistry lab	685	0,657
9	Preparing a solution with required concentration in the chemistry lab	685	0,717
10	Identifying equipment and materials required for an experimental setup	685	0,736
11	Recording data in the chemistry lab	685	0,655
12	Interpreting data obtained as a result of chemical experiments	685	0,582
	Total variance explained 45%		

Items in CLAS reflect the students' anxiety levels while they're focusing on developing their levels of knowledge and skills for chemistry laboratory course and respective activities as well as their anxiety levels for learning and using equipment and materials properly while they're performing activities.

Item Analysis and Reliability Findings

For item discrimination of CLAS, item-total correlation as well as upper-lower group comparisons of 27% are included. While calculating item-total correlation, Pearson moments product correlation coefficient was determined by total score, and t-test was used to compare item scores of upper-lower groups of 27%. Corrected item-total correlations of the scale were found to vary between .52 and .77. t values of the scale concerned with differences in item scores of upper and lower groups of 27% determined by total scores are shown in Table 2.

Table 2
Reliability of the Scale and Item-Total Correlations (N=685)

Scale Items	Item-Total Correlations (r_{jx})	t- values
Entering the chemistry lab	,584	14,150
Using chemicals in the chemistry lab	,634	17,861
Using equipment in the chemistry lab	,660	18,944
Preparing for the chemistry lab	,629	19,238
Working with other students in the chemistry lab	,470	13,313
Making an experimental set-up in the chemistry lab	,701	19,305
Having little time for doing an experiment	,453	15,636
Presence of chemicals around me in the chemistry lab	,585	20,662
Preparing a solution with required concentration in the chemistry lab	,649	20,411
Identifying equipment and materials required for an experimental setup	,663	18,354
Recording data in the chemistry lab	,576	15,789
Interpreting data obtained as a result of chemical experiments	,497	14,624

Cronbach's alpha internal consistency coefficient was .88 for CLAS reliability calculations. Two half reliability coefficient was found to be .84.

Conclusion and Discussion

Chemistry Laboratory Anxiety Scale (CLAS) developed for measuring university students' anxiety levels toward chemistry laboratory course was a 5-point Likert-type scale containing 12 items. Chemistry Laboratory Anxiety Scale developed by Bowen (1999) and adapted to Turkish by Azizoğlu and Uzuntiryaki (2006) consists of 20 items and 5 subscales. However, the scale developed under the study showed a one-dimensional construct. The results showed that items in CLAS measured the students' anxiety levels while they're focusing on developing levels of knowledge and skills for experiments they do during chemistry laboratory lessons as well as their anxiety levels for learning and using equipment and materials properly while they're doing experiments.

In conclusion, this 12-item scale with a single factor explains 45% of the total variance. All 12 items supporting anxiety in the scale are positive. Items supporting anxiety were scored 1, 2, 3, 4, 5 in an orderly fashion as from the category of "it never worries me". Internal consistency coefficients were calculated to check reliability of the scale. In reliability

studies of the scale, Cronbach's alpha coefficient was found .88 for the entire scale. Two half reliability coefficients were calculated for the scale and found .84. Consequently, the values obtained from analyses showed that CLAS has high levels of reliability criteria. According to these results, the scale can be said to be ready for use as well as both valid and reliable for measuring the students' levels of anxiety toward chemistry lab course.

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