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Abstract. *University students' achievements in biology laboratory do not depend only on cognitive variables, but also on non-cognitive variables such as anxiety levels. The aim of this study was to develop a measurement tool assessing the anxiety levels of university students in a biology laboratory class. In this study, the Biology Laboratory Anxiety Scale (B-LAS) consisting of 15 items was developed, and analysed its validity and reliability. All items are positively worded to indicate increased anxiety. The sample consisted of 685 science teacher candidates (450 female and 235 male) who take Biology and/or Biology laboratory classes at three different Faculties of Education. The validity of the scale was first assessed by expert review. Exploratory factor analysis was performed to assess structural validity, and revealed a one-dimensional structure. The loading values of all 15 items varied between 0.61 and 0.80, and explained 53% of the total variance. Cronbach's alpha coefficient of internal consistency was calculated as 0.93 and the split-half test correlation was 0.85.*

According to these results B-LAS can be used as a valid and reliable instrument in science education.

Key words: *biology laboratory, anxiety, reliability and validity, university students.*

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DEVELOPMENT AND EVALUATION OF AN INSTRUMENT MEASURING ANXIETY TOWARD BIOLOGY LABORATORY CLASSES AMONG UNIVERSITY STUDENTS

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Introduction

Biology is a rapidly advancing science examining living organisms. New information and developments in biology enter our daily lives in the form of new technologies. These advances can affect human life directly and so adequate biology education is crucial (Altunoğlu & Atav, 2005). For this reason, biology has been included in primary and secondary education curriculum as a part of science lesson or in a separate field. Biology laboratory courses can play a role in the effective teaching of biology concepts and the concepts of other sciences.

The importance of using laboratory has been increased in education of teacher candidates. Laboratory studies are the crucial elements of science education, unfortunately in our country, these studies couldn't reach to the importance level in developed countries due to the lack of conceptual and physical conditions (Erökten, 2010). Science laboratories are special learning environments where students learn more efficiently by doing first-hand activities. According to Hofstein and Lunetta (2003), a science laboratory is an active learning environment in which students interact and develop basic scientific thinking abilities and learn scientific concepts. Within this context, science instructors stated that laboratory activities play a crucial role in contributing to students mixing with each other (Hofstein, 2004; Hofstein & Lunetta, 2004; Hodson, 1993; Lazarowitz & Tamir, 1994; Lunetta et al., 2007; Tobin, 1990). Moreover, science laboratory classes help students learn and appreciate the scientific method and improve their abilities to observe, think, produce ideas and interpret data (Ayas, Çepni & Akdeniz, 1994). Some research (Bowen, 1999; Hofstein & Lunetta, 2004) indicated that laboratory activities have a potential to enhance students' conceptual understanding, development of some affective dimensions such as motivation and attitude with respect to science learning, scientific practical skills and problem solving abilities, and understanding of the nature of science (Kaya & Cetin, 2012).

Factors such as school conditions, condition of instruments, laboratory conditions, and classroom size affect learning in laboratory classes (Akaydin,



Güler & Mülayim, 2000; Ekici, 1996; Alpaut, 1993; Ayas, Çepni & Akdeniz, 1994; Erten, 1991; Gürdal, 1991). Of critical importance for this study, affective factors can also influence learning in laboratory classes. One of the most important affective factors is the anxiety experienced by students in the laboratory environment. Anxiety, as a concept, is commonly referred to as an unpleasant emotional state characterized by excessive degrees of fear, worry, and apprehension without a specific object or cause; it is initiated by feelings as a response to a perceived threat (Casbarro, 2005; Putwain, 2008). Skinner, Furrer, Marhcund, and Kindermann (2008) indicated that anxiety is strongly related to perceived control, so that students who are low in perceived control are more at risk of escalating anxiety (Colwell, 2013). Anxiety has been defined differently in various fields. Mallow (1986) defined science anxiety as the disgust or fear of science concepts, scientists, and scientific activities. Breslow (1993) and Eddy (2000) defined chemistry anxiety as a fear of chemicals and chemistry classes (McCarthy & Widanski, 2009). Turner and Lindsay (2003) defined chemistry anxiety as students' emotional reactions to chemistry such as timidity and shyness, and the physical indications of these emotions.

Laboratory lessons in science education are effective in students' development of their researching and problem-solving skills. Also, they are required in order to develop manual skills and observation ability. Determining the situations in which anxiety towards biology laboratory lessons is present, which is extremely important for biology as well as other sciences, and the level of this anxiety, is necessary. These measures can be taken to decrease anxiety and increase attendance to the lesson. Laboratory activities for physics and chemistry include the use of high-level instruments, sometimes requiring great accuracy. Biology laboratories also include activities such as various organ dissections, blood type determination, and growth-development. Students performing these activities may have different thoughts, emotions, anxieties, or fears. For this reason, some students taking biology laboratory classes in higher education feel anxiety that they cannot succeed, and may perform poorly as a result. Currently, there is no valid and reliable measurement instrument for determining a student's anxiety level toward biology laboratories. Such instruments do exist for physics and chemistry laboratory classes (Berber, 2013; Bowen, 1999; Kurbanoğlu & Akın, 2012). This study was performed to develop and assess the validity and reliability of a scale to be used for measuring university students' anxiety toward biology laboratory classes. Accordingly, the validity and reliability of this scale was assessed.

Methodology of Research

This research is a scale development study. Survey design was used to collect data for this study. Participants were asked to complete a survey questionnaire, consisting of a series of questions taken from the biology laboratory anxiety scale. All of the participants were informed as to the purpose of this study prior to completing the survey. The survey was administered in a group format in each biology laboratory course the first semester during the 2013-2014 academic year.

Sample

A convenience sample was recruited from science teacher candidates and a sufficient supply of surveys was distributed to three universities. Six hundred eighty five valid surveys were returned to the researcher. The sample of the study was composed of 750 sophomore science teacher candidates who take biology and biology laboratory classes at three different Faculties of Education in Turkey in the first semester of 2013-14 academic year. The data were examined through control items and 65 samples were eliminated, since these samples were thought to be involuntary responses. The remaining 685 (450 female and 235 male) samples were used as data for this study. Their ages ranged from 19 to 22 years, with a mean age of 20.5 years.

Preparation of Scale Items

Since the scale was intended to determine the anxiety of individuals about biology laboratory, the researcher has searched the literature for similar scales and also accomplished a brainstorm exercise about anxiety can face in the biology laboratory. Items expressing these situations were noted down. An 18-item preliminary question pool was developed based on the content of biology laboratory classes. Items were designed to comprehensively cover the content of biology laboratory classes (microscope, histochemistry, cell fractionation, electrophoresis, enzyme membranes, microsomes, photosynthesis\respiration, tubules\filaments, chromosomes, cell cycles, cell cultures,



and differentiation). Next, questions were reviewed by five content experts who work in the Faculty of Education at Sakarya University for readability, representation of content and how well they are likely to measure student anxiety for biology laboratory classes. Three items were excluded for their inability to scale or irrelevance, leaving a 15-item draft Biology Laboratory Anxiety Scale (B-LAS). Respondents were asked to respond to each item using a 5-point Likert scale regarding how frequently each item makes me anxious: Never, sometimes, often, usually or always (Kurbanoglu & Yücel, 2014).

Procedure

Biology laboratory course (ranging in size from 20 to 25 students) was selected randomly by the on-site data collector at the faculties of education of the three different universities. Prior to administration of the measures, all participants were told about the purposes of the study. Administration typically required 10 to 15 minutes. The students administering the survey, collected and returned the questionnaires to the researcher. Questionnaire responses were anonymous and there was a guarantee of confidentiality.

Validity and Reliability Assessment

Validity is one of the most important criteria for the development and assessment of an instrument. Validity refers to whether an item measures or defines a construct correctly. This study assessed both the content and structural validity of the B-LAS. Scope validity refers to the extent to which the items cover the entire range of the theoretical construct (in this case, the range of possible anxiety toward biology laboratory classes). Scope validity was assessed first by expert review and then by the calculated correlation between the B-LAS and another test known to measure a similar conceptual construct (Büyüköztürk, 2004).

Structural validity refers to whether the items are independent and evenly distributed, covering the intended range of the construct. This was assessed with an exploratory factor analysis, a statistical technique that measures the variance and accounts for it with the fewest number of structural factors (Büyüköztürk, 2004). Cronbach's alpha coefficient of internal consistency was used to assess the significance of the difference in item means between the upper and lower 27th percentiles. Reliability of the instrument was also assessed with the item-total correlation by split-half reliability and t-tests. SPSS 13.0 software was used for statistical analyses.

Results of Research

Analysis of the data took place in three ways: (a) determining structural validity of scale items, (b) calculating item total correlation estimates for item analysis to identify any faulty items, obtaining internal consistency reliability estimates of the scale scores.

Structural Validity

Exploratory factor analysis determined the factor structure and subscales of B-LAS. Firstly, the correlation matrix was examined between all items and found suitable for factor analysis. Sampling adequacy tests and Bartlett's test of sphericity were performed. Adequacy of factor analysis data was examined with the Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett's test of sphericity. The KMO should be higher than 0.70 and Bartlett's test should be significant (Büyüköztürk, 2004). For our B-LAS sample, the KMO coefficient was 0.94 and Bartlett's test was significant ($\chi^2= 5322.6$, $p<0.001$), indicating the validity of the factor analysis. Principal components analysis was performed such that the eigenvalue of the 15 items would be 1 in the factor analysis. The principal components analysis and a varimax rotation with the factor analysis revealed a one-dimensional structure that explained 53% of total variance. This rate is above the minimum of 30% typically considered sufficient for scale development. Factor loadings and total percentages of explained variance are given in Table 1.



Table 1. Factor Analysis Information of B-LAS (N = 685).

Scale Items		Factor Loads
		I
1	Entering biology laboratory	0.614
2	Making a preparation to determine blood types	0.651
3	Observing embryonic development in the zygote	0.743
4	Preparing a culture environment for microorganism reproduction	0.705
5	Making a sample preparation of a plant tissue	0.738
6	Preparing the microscope to take images	0.738
7	Finding the image on the microscope	0.756
8	Recording the image identified on the microscope	0.730
9	Preparing for biology laboratory	0.728
10	Identifying organic substances with chemical reagents at biology laboratory	0.706
11	Identifying features of plant and animal cells on the microscope	0.807
12	Examining organs of a vertebrate	0.752
13	Identifying pigments of plants with microscope	0.762
14	Learning intended use of chemical reagents at biology laboratory	0.764
15	Recording data obtained from biology experiments	0.728
Explained Total Variance 53%		

Items of B-LAS reflect students' anxiety levels during particular activities and using particular instruments during biology laboratory classes.

Item Analysis and Reliability

In the calculation of the item-total correlation, the Pearson product moment correlation coefficient was determined according to the total score, and a t-test was used to compare the scores of the upper and lower 27th percentile. It was found that corrected item-total correlations varied between $r = 0.61$ and 0.80 . The scale's t-values comparing item scores between the upper and lower 27th percentiles were calculated from the total scores. Cronbach's alpha coefficient of internal consistency was found to be 0.93 for the B-LAS. The split-half reliability coefficient was calculated as 0.85 .

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

Scale Items		Item-Total Correlation (r_{ix})	t
1	Entering biology laboratory	0.565	-11.5938
2	Making a preparation to determine blood types	0.606	-12.8391
3	Observing embryonic development in the zygote	0.700	-15.8056
4	Preparing a culture environment for microorganism reproduction	0.657	-16.8867
5	Making a sample preparation of a plant tissue	0.688	-13.6802



	Scale Items	Item-Total Correlation (r_{ix})	t
6	Preparing the microscope to take images	0.687	-13.5193
7	Finding the image on the microscope	0.704	-15.0727
8	Recording the image identified on the microscope	0.681	-16.7067
9	Preparing for biology laboratory	0.680	-14.0865
10	Identifying organic substances with chemical reagents at biology laboratory	0.659	-16.9948
11	Identifying features of plant and animal cells on the microscope	0.766	-15.6928
12	Examining organs of a vertebrate	0.705	-18.3841
13	Identifying pigments of plants with a microscope	0.714	-20.4305
14	Learning intended use of chemical reagents at the biology laboratory	0.719	-18.9216
15	Recording data obtained from biology experiments	0.680	-14.5248

*the highest and lowest values that t - values assumed on $p < .001$ level.

Discussion

Laboratory applications have major importance in science teaching. Students have anxieties about laboratory lessons in science education. Students may have anxieties about science laboratory because it requires skills to apply theoretical knowledge in situations based on practice. Therefore, determination of the laboratory anxieties of students is important. There are few scale development studies in international literature, and they generally have been focused on the determination of physics and chemistry laboratory anxieties of university students (Berber, 2013; Bowen, 1999; Kurbanoğlu & Akın, 2012). Bowen (1999) developed and validated a Chemistry Laboratory Anxiety Instrument (CLAI) and he wrote five items for each of six dimensions. This scale is a 20-item self-report measurement. The Turkish adaptation of this scale had been done by Azizoğlu and Uzuntiryaki (2006). The internal consistency reliability coefficient of the Turkish form was 0.86. Kurbanoğlu and Akın (2012) developed and validated a Physics Laboratory Anxiety Scale (P-LAS). This scale is an 18-item self-report measurement and it is a one-dimensional scale. The internal consistency reliability coefficient of the scale was 0.94. Furthermore, Berber (2013) developed and validated physics laboratory anxiety scale. It is a scale with four sub-dimensions and 16 items. The internal consistency reliability coefficient of the scale, using Cronbach alpha, for was 0.87.

In this study the Biology Laboratory Class Anxiety Scale (B-LAS), which consisted of 15 items, was developed a measurement tool assessing the anxiety levels of university students in a biology laboratory class and each item was rated on a 5-point Likert scale. The items form one factor that explains 53% of the total variance. All items are coded positively.

Internal consistency coefficients were calculated for the reliability of the scale. In the reliability studies of the scale, Cronbach's Alpha coefficient was found to be 0.93 for the entire scale. Split-half reliability coefficient was calculated as 0.85 for the scale. According to these results, items of B-LAS reflect students' anxiety levels during focusing on improving their knowledge and skill levels for the activities of the biology laboratory class and their anxiety levels for learning and using the instruments while performing the activities. The developed biology laboratory scale reveals that the anxiety about the biology laboratory has different dimensions. The anxiety levels of students who experience failure in biology laboratory applications about the biology laboratory and in which situations they feel anxious can be determined through the biology laboratory anxiety scale.



Conclusions

This study aimed to develop a measurement tool assessing the anxiety levels of university students in a biology laboratory class. As a result, the findings obtained from the analyses show that B-LAS has high reliability criteria. Moreover, the fact that the scale has just been developed and has no other example abroad can be considered as both a limitation and advantage. According to the results obtained from this scale developing study, it can be said that the scale is ready to be used and can be validly and reliably used to determine students' anxiety level for the biology laboratory class.

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