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# The Adaptation Study of The Student Engagement in the General Chemistry Laboratory Scale to Turkish

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## Abstract

Chemistry laboratories are an essential and indispensable part of chemistry education; however, the process in the laboratory cannot fully provide the desired gains. Although various scales in the literature address the process in the chemistry laboratory from different perspectives and enable evaluations, a new perspective on the process is student engagement. By determining to what extent and how students engage in the process, the chemistry laboratory can be carried out more effectively, and the efficiency of the teaching process can be increased by making the necessary arrangements. This study aimed to adapt the scale (Smith and Alonso, 2020) from international literature to Turkish and to determine its validity and reliability. For this purpose, the original scale went through the translation phase, and its language validity was checked. The sample of this study consists of 242 students who continue their education in Sakarya University (N= 158) and Gazi University (N=84) Education faculties, Science teaching and Classroom teaching departments. Then its construct validity was ensured by Confirmatory Factor Analysis. Its reliability was studied by determining the internal consistency coefficient. At the same time, the comparison of the data according to some demographic characteristics was also carried out. As a result, The Student Engagement in The General Chemistry Laboratory Scale adapted to our language is a valid and reliable scale consisting of 25 items and six factors.

## Keywords

Chemistry Lab, Scale, Student Engagement.

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## INTRODUCTION

Chemistry laboratories are considered by many researchers (Hofstein & Lunetta, 1982; 2004; Galloway & Bretz, 2015a, 2015b; Bretz, 2019; Reid & Shah, 2007) as an important and integral part of chemistry education. Considering that students often have difficulties in understanding the content of chemistry courses and students have many misconceptions (Canpolat et al., 2004; Johnstone, 1991; Taber, 2001; Sirhan, 2007), the importance and function of chemistry laboratories can be better understood. The functions of laboratories in the teaching process are mostly linked to providing students with a scientific perspective, contributing to the understanding of the theory in practice, helping to learn laboratory techniques, love science and create motivation for a scientific career, helping to develop practical skills, and also contributing the development of skills such as group work and cooperation. (Hofstein & Lunetta, 1982; 2004; Bretz, 2019; Reid & Shah, 2007). However, especially in our country, the use of laboratories in teaching is still limited due to the lack of knowledge and experience of teachers, the lack of materials in the laboratory, the cost of the process, and the dangerous situations that may occur during the process (Özgür, Odabaşı, & Erdoğan, 2017; Güneş et al., 2013; Nakiboğlu and Sarikaya, 2000). In addition, it is frequently mentioned in the literature (Hofstein & Lunetta, 2004) that the desired gains are still not achieved at the end of the laboratory process, and it is expected to design processes aiming to achieve better gains. At this point, the importance of examining the process in the laboratory emerges. In order for the process in the laboratory to reach the desired gains, meaningful learning must take place. Ausubel (1968) states that for meaningful learning to occur, the student should have prior knowledge, present the new material in a meaningful way, and be able to establish relationships between the new material and their prior knowledge. Galloway and Bretz (2015a) developed the Meaningful Learning Scale in the Laboratory based on the theory of meaningful learning to evaluate the process in the laboratory. This measurement tool consists of a total of 31 cognitive and affective (expectation and experience) items. Researchers state that it is possible to compare the pre-experimental and post-experimental experiences of the students in various experiments by using this measurement tool, and that necessary arrangements can be made, and they draw attention to the importance of the affective dimension for meaningful learning to occur. The same researchers (Galloway & Bretz, 2015b) used this measurement tool and conducted in 15 universities and colleges (N=3583) in the United States and found that students' expectations before the experiment shape the experiences and that cognitive expectations are necessary for meaningful learning. However, they stated that it is not enough on its own.

One of the important studies in the literature on the affective dimension of the process in the chemistry laboratory belongs to Bowen (1999). The researcher has developed a measurement tool (Chemistry Laboratory Worry Scale) that aims to measure the concerns of students, which constitute an obstacle to achieving the desired gains in the process in the chemistry laboratory. This scale, which was later adapted into Turkish by Azizoğlu and Uzuntiryaki (2006), can make it possible to determine the concerns of the students in the laboratory process and to redesign/modify the process considering these concerns.

Another factor in not being able to achieve the expected gains from the chemistry laboratory may be that the expectations of the students and instructors, who are the components of the process, from the process do not fully overlap with each other. As a result of the study conducted by Bruck, Towns, and Bretz (2010) on the expectations of faculty members from the chemistry laboratory, although it is different for various laboratory courses (such as general chemistry laboratory, organic chemistry laboratory, research laboratory); it is stated that teaching laboratory techniques and skills, teaching critical thinking skills and experimental design, integrating scientific explanations about the course into the laboratory, providing scientific thinking and group work, and developing written communication skills are common expectations. In a study by DeKorver and Towns (2015), students' expectations from the chemistry laboratory were investigated, and as a result, it was found that expectations such as "finishing the experiment early" and "getting a good score" were at the forefront. Therefore, it is seen that the students, who are the components of the process, have more affective expectations, while the instructors have more cognitive expectations and they do not overlap with each other much.

All these studies, which examine the process in the chemistry laboratory from different perspectives, assume full engagement of the students in the process. According to Fredricks, Blumenfeld, and Paris (2004), school engagement can be expressed in three dimensions as behavioral, affective and cognitive engagement. Behavioral engagement can be defined as the student's involvement in academic tasks and activities and can be understood with the effort, persistence and patience of the student. Affective engagement is the student's affective reactions in the academic environment and can be understood by indicators such as curiosity, interest, boredom, and anxiety. Cognitive engagement, on the other hand, refers to the psychological and physiological participation and involvement of students in academic tasks and can be understood with indicators of learning, understanding, and specialization. For example, the fact that the student attends the lesson to act with his/her friends even though he/she is not interested in the content of the lesson shows his/her behavioral engagement, or being worried about the lesson content helps to understand that lack of emotional engagement. These three dimensions of engagement can also be expressed in response to the three dimensions of meaningful learning, which are affective, cognitive, and psychomotor learning, and just as meaningful learning does not occur when the three dimensions are not together, it cannot be said that there is full engagement in the process without affective, cognitive and behavioral engagement. A study that handles the process in the chemistry laboratory from this perspective was conducted by Smith and Alonso (2020), and as a result of the study, a scale was developed to measure the engagement of students in the general chemistry laboratory. Researchers state that by using Student Engagement in the General Chemistry Laboratory scale, the process in chemistry laboratories can be examined and necessary arrangements can be made according to the data obtained. It is clear that examining the process in the chemistry laboratory and making the necessary arrangements will contribute positively to the improvement of the teaching process. Although there are various scales in the literature (Uzunoğlu & Tiryaki, 2006; Alkan & Erdem, 2012; Galloway & Bretz, 2015a; Sadler et al., 2011) in order to examine the process in the chemistry laboratory, it is useful to examine student engagement in the chemistry laboratory from a different perspective. According to our experience in chemistry laboratories and literature review, no study has been found in our country in which the process in the chemistry laboratory is discussed in this respect, and it is thought that it would be beneficial to adapt Student Engagement in the General Chemistry Laboratory Scale, which originally developed by Smith and Alonso (2020), into Turkish. Therefore, this study aims to adapt the scale to Turkish.

## METHOD

Since a scale adaptation study was carried out in this study, a quantitative research method was adopted in the study.

## Sample

The sample of this study consists of 242 students who continue their education in Sakarya University (N= 158) and Gazi University (N=84) Education faculties, Science teaching and Classroom teaching departments. The sample was determined according to the convenient sampling method, which is one of the non-random sampling methods. The convenient sampling method aims to reduce the loss of time, labor, and mone, and is based on the creation of tasample from people who can be easily reached by the researcher (Büyüköztürk et al., 2016). Demographic characteristics of the sample are presented in Table 1.

**Table 1**

*Demographic Characteristics of the Sample*

| | | f |
|---|---|---|
| Gender | Female | 219 |
| | Male | 23 |
| University | Sakarya University | 158 |
| | Gazi University | 84 |
| Year of education | First year | 31 |
| | Second year | 83 |
| | Third year | 61 |
| | Fourth year | 67 |
| Department | Science Teaching | 209 |
| | Classroom Teaching | 33 |

## Original scale

The scale, which was adapted into Turkish, is the "Student Engagement in the General Chemistry Laboratory Scale" developed by Smith and Alonso (2020). This original scale consists of a total of 25 items and 6 factors and is in a 4-point Likert structure. While developing the scale, students at a public university located in the north-west of the United States were chosen as the sample of the study. First, a 46-item pre-scale was prepared, which constitutes the theoretical foundations of the scale and questions emotional, behavioral, and cognitive student engagement. As a result of the statistical analysis final version of 25 items was reached. The scale consists of 6 factors as cognitive engagement in data collection and general, negative emotional engagement in laboratory procedures, positive emotional engagement in laboratory procedures, behavioral engagement in laboratory procedures, cognitive engagement in laboratory procedures and negative emotional engagement in data collection.

## Research Ethics

All the rules stated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" were complied with in the whole process, from the planning of this research to its implementation, from data collection to data analysis. None of the actions specified under the heading "Actions Contrary to Scientific Research and Publication Ethic,", the second part of the directive, have been taken. Scientific, ethical, and citation rules were followed in the writing process of this study; No falsification was made on the collected data and this study was not sent to any other academic publication medium for evaluation.

### Process

According to the International Test Commission (International Test Commission, 2017), cross-cultural scale adaptation studies consist of stages of: researching the scales related to the feature to be measured, developing a new scale, and comparing the advantage of adapting the existing scale in the international literature, obtaining permission from the original scale developer(s), translating the scale from the original language to the target language, converting the scale from the target language back to the original language, reviewing the translations, making an application to ensure language validity, applying to the target group, performing item analyzes and validity and reliability analyzes. In this study, these steps were carried out as described in detail below.

First, the scales related to the feature to be measured were investigated. The importance of engagement in the chemistry laboratory (cognitive, affective, and behavioral engagement) in gaining achievements in the laboratory has been demonstrated by many studies in the literature. Therefore, the existing scales in the domestic literature on "engagement in the chemistry laboratory", the subject of this study and which is stated to be important in chemistry teaching, were examined. As a result of the examination, it is found that there are some scales in the litearture like the pre-service teachers' anxiety about the chemistry laboratory (Azizoğlu & Uzuntiryaki, 2006), pre-service teachers' attitudes towards laboratory skills (Alkan & Erdem, 2012), pre-service teachers' self-efficacy perceptions towards the chemistry laboratory (Alkan, 2016) and pre-service teachers' perceptions about laboratory practices (Feyzioğlu et al., 2012). However there is no scale for engagement in the chemistry laboratory. But, it has been determined that there is a scale (Smith & Alonso, 2020) to measure this phenomenon in the international literature.

Then, it was decided that adapting this scale would be more advantageous than developing a new scale due to the existence of a valid and reliable scale in the literature regarding the subject to be researched. After that, permission was obtained by contacting the authors of the original scale via e-mail. Then, an application was made to Sakarya University Educational Research and Publication Ethics Committee and the necessary ethics committee document (dated 12.11.2021 and numbered E-61923333-050.99-79435) was obtained.

Then, the scale items were translated from the original language (English) to the target language (Turkish) by 3 different experts (Turkish academics who have given chemistry laboratory courses and who are fluent in English). Three other experts (Turkish academics who have given chemistry laboratory courses and are fluent in English and different from their predecessors) have translated these translations from Turkish to English with the back translation method. Then, the forms in both languages were examined by interviewing two people who are fluent in both languages (Turks with chemistry laboratory experience and fluent in English) and necessary arrangements were made. In order to ensure language validity, application to students who have command of both languages and have experience in the chemistry laboratory (students studying at Boğaziçi University Science Education and Chemistry Teaching programs, n=13) was made (given the scale in the original language first and then the translation scale, not simultaneous) and the correlation between the responses was calculated.

After the language validity was ensured, the translated draft scale was obtained, and the application of this draft to a suitable sample for the target group and item analysis phase was started. For this purpose, since it was desired to reach students who have experience in the chemistry laboratory, this translated draft scale was applied to prospective teachers (n=242) who continue their educationthe in Science and Classroom Teaching programs of Sakarya University and Gazi University. With the obtained data, item analyzes and validity and reliability analyzes were started.

### Data analysis

In order to investigate the language validity of the scale, correlation analysis was carried out between the responses of the students who answered both the original and the translated draft scale. Considering that the number of data at this stage was not very large (n=13) and the need to apply non-parametric tests, the Spearman's rho correlation coefficient was evaluated. The calculated Spearman's rho (r= 0.788, n=13, p<0.001) indicates a high level of correlation (Cohen, 1988). Then, item analyzes and validity and reliability analyzes of the translated draft scale were carried out.

Validity analysis was performed with Confirmatory Factor Analysis, and reliability analysis was performed by calculating the internal consistency coefficient (Cronbach alpha). It was also examined whether the scores obtained from the sample differed by various demographic data (gender, department of education and grade level of education). The findings obtained as a result of the analyzes are presented below.

### Ethical Principles

Ethics committee permission for this study was obtained from Sakarya University Ethics Committee with the decision dated 10.11.2021 and numbered 01/10.

## FINDINGS

After the draft scale was obtained, the data obtained using this scale were first examined in terms of whether they showed normal distribution and whether they contained extreme values. Tests such as Shapiro-Wilk or Kolmogorov-Smirnov, which are used to test the normal distribution, are used when the data is continuous (Uysal & Kılıç, 2022). However, in most of the studies in the field of social sciences, as in this study, the data that can be obtained with a scale cannot fully fulfill this condition since they can only take certain values. According to Tabachnick and Fidell (2013), for a variable to be considered continuous, it must contain at least seven categories. For this reason, it was determined whether the data showed normal distribution or not by examining the kurtosis and skewness values. At the same time, whether there were extreme data was examined by calculating the Mahalanobis distance and 15 data were determined to be extreme data and were excluded from the scope of the analysis. For the remaining 227 data, both the kurtosis and skewness values were between -1.5 and +1.5, and the analysis was continued by accepting that they showed normal distribution (Tabachnick & Fidell, 2013). Thus, the prerequisites of Confirmatory Factor Analysis were checked.

Confirmatory Factor Analysis was used to verify the factor structure of the translated draft scale. For this, AMOS 24 program was used. As a result of the analysis of the path diagram drawn using the factor structure of the original scale, it was determined that the standardized regression coefficient of one item (Item 9) was low (0.462). It is not desirable for standardized regression coefficients to be less than 0.5 (Hair et al., 2006). In addition, the extent to which the item contributes to reliability should also be considered while making the evaluation (Cohen, 1988). The extent to which this item affects reliability was investigated by examining the internal consistency (Cronbach alpha) coefficient. It was seen that if this item was deleted, the coefficient would increase from 0.795 to 0.883, and it was decided to remove this item from the scale. The path diagram of the Confirmatory Factor Analysis of the scale can be seen in Figure 1 and the fit index values obtained as a result of the analysis can be seen in Table 2.

**Figure 1**

Confirmatory Factor Analysis of the scale

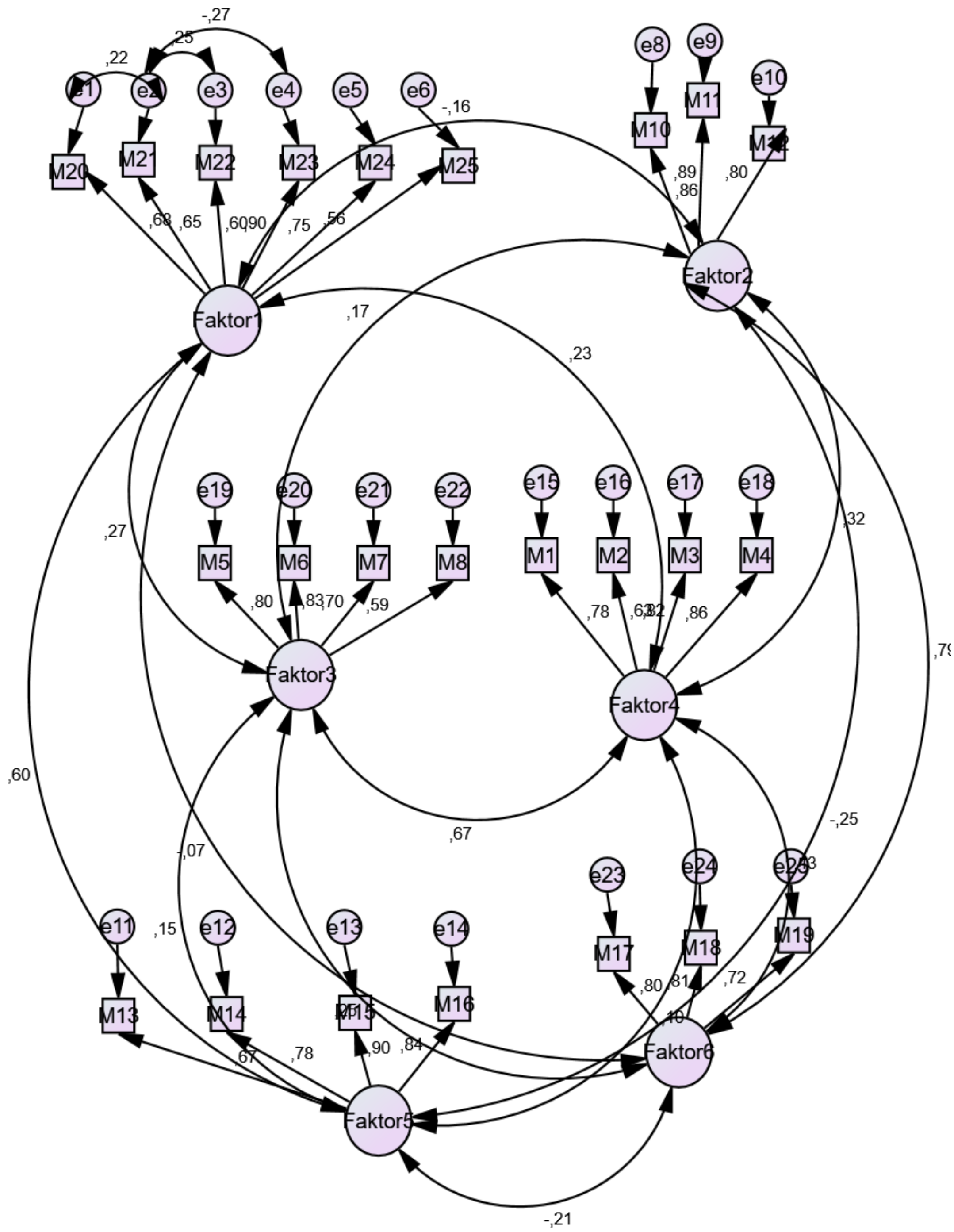

**Table 2**

*Values of Fit Indices obtained by Confirmatory Factor Analysis*

| Fit index | Value | Range of the fit index | Interpretation |
|---|---|---|---|
| $\chi^2/df$ | 1.867 | $\chi^2/df \leq 3$ Perfect fit<br>$\chi^2/df \leq 5$ Acceptable fit | Perfect fit |
| AGFI | 0.862 | AGFI≥0.90 Perfect fit<br>0.85≤AGFI≤0.89 Acceptable fit | Acceptable fit |
| GFI | 0.865 | GFI≥0.90 Perfect fit<br>0.85≤GFI≤0.89 Acceptable fit | Acceptable fit |
| IFI | 0.932 | IFI ≥ 0.95 Perfect fit<br>0.90≤IFI ≤ 0.95 Acceptable fit | Acceptable fit |
| CFI | 0.931 | CFI ≥ 0.95 Perfect fit<br>0.90≤CFI ≤ 0.95 Acceptable fit | Acceptable fit |
| RMSEA | 0.062 | RMSEA≤0.05 Perfect fit<br>0.05≤RMSEA≤0.08 Acceptable fit | Acceptable fit |

As can be seen in Table 2, the fit index values of the adapted scale indicate perfect fit and acceptable fit. Thus, it can be stated that the scale, which consists of 24 items and 6 dimensions, has been confirmed and its construct validity has been ensured.

Then, the internal consistency coefficient (Cronbach alpha) was calculated in the reliability analysis used to investigate the reliability of the scale, and it is given in Table 3 together with the reported coefficients of the original scale.

**Table 3**

*The internal consistency coefficient of adopted and original scales*

| | Original scale | Adopted scale |
|---|---|---|
| Factor 1 | 0.85 | 0.85 |
| Factor 2 | 0.84 | 0.88 |
| Factor 3 | 0.88 | 0.81 |
| Factor 4 | 0.82 | 0.85 |
| Factor 5 | 0.88 | 0.88 |
| Factor 6 | 0.83 | 0.81 |

As can be seen in Table 3, there are high reliability coefficients (George & Mallery, 2003) for all factors. In this case, it can be stated that the adapted scale is a reliable scale. The final version of the adapted scale is presented in Appendix 1.

It was also examined whether the scores obtained with the scale adapted from the sample within the scope of the study varied according to various demographic data, and for this, various analyzes were performed and the findings were presented. When the mean scores taken from the scale are examined, it is seen that the average for the scale is 3.11, when analyzed on the basis of factors, the lowest mean ($\bar{X}$ = 2.61) is in the Cognitive Engagement factor, which is the fifth factor, and the highest mean ($\bar{X}$ = 3.57) is in the Positive Emotional Engagement in Laboratory Procedures factor, which is the third factor. Whether the scores obtained from the scale differ according to gender was examined with the independent sample t-test and as a result, both the overall scale (t=-0.440, p>0.05) and the factors of the scale (t=-0.095, p>0.05 for the first factor; for factor t=-0.353, p>0.05, for third factor t=0.299, p>0.05, for fourth factor t=0.126, p>0.05, for fifth factor t=0.016, p>0.05 and for sixth factor t=0.016 =-0.638, p>0.05), it was found that there was no significant difference between the groups in terms of gender.

The analysis of the scores obtained from the scale according to the variable of the department studied was also analyzed with the independent groups t-test. As a result, it was found that the scores obtained from the scale did not change significantly according to the department (t=0.732, p>0.05), but the Behavioral Engagement in Laboratory Procedures factor (4th factor) was in favor of the students studying in Science Education (averageScience = 3.52 and meanClass = 3.28). ) was found to be a significant difference (t=2.421, p<0.05).

One-Way Analysis of Variance (ANOVA) was used to determine whether the scores obtained from the scale differed significantly according to the level of education. According to the results, there are significant differences for overall scale (F(3,223)=3.636, p<0.05), Positive Emotional Engagement in Laboratory Procedures (third factor) (F(3,223)=5.123, p<0.05) and Behavioral Engagement factor in Laboratory Procedures (fourth factor) (F(3,223)=11.549, p=0.000). The sources of these differences were examined with the Scheffe test, which is one of the post-hoc tests (since the variances are equally distributed and the sample sizes in the groups are different from each other) and are given in Table 4.

**Table 4**

*Post-Hoc Analysis Findings*

| Dependent variable | (I) – (J) | Avg. dif. (I-J) | Std. deviation | Sig. |
|---|---|---|---|---|
| Factor 1 | 1.year-2.year | 0.126 | 0.130 | 0.817 |
| | 1. year -3. year | 0.126 | 0.135 | 0.834 |
| | 1. year -4. year | 0.177 | 0.133 | 0.625 |
| | 2.year-3. year | 0.000 | 0.105 | 1.000 |
| | 2.year-4.year | 0.051 | 0.103 | 0.969 |
| | 3.year-4.year | 0.051 | 0.110 | 0.975 |
| Factor 2 | 1.year-2.year | 0.103 | 0.152 | 0.928 |
| | 1.year-3.year | 0.033 | 0.159 | 0.998 |
| | 1.year-4.year | 0.072 | 0.156 | 0.975 |
| | 2.year-3.year | -0.070 | 0.125 | 0.957 |
| | 2.year-4.year | -0.031 | 0.121 | 0.996 |
| | 3.year-4.year | 0.039 | 0.130 | 0.993 |
| Factor 3 | 1.year-2.year | 0.127 | 0.093 | 0.609 |
| | 1.year-3.year | 0.014 | 0.098 | 0.999 |
| | 1.year-4.year | 0.293* | 0.096 | 0.028 |
| | 2.year-3.year | -0.113 | 0.077 | 0.543 |
| | 2.year-4.year | 0.166 | 0.075 | 0.184 |
| | 3.year-4.year | 0.279* | 0.080 | 0.008 |
| Factor 4 | 1.year-2.year | 0.528* | 0.095 | 0.000 |
| | 1.year-3.year | 0.343* | 0.099 | 0.009 |

| | | | | |
|---|---|---|---|---|
| | 1.year-4.year | 0.490* | 0.098 | 0.000 |
| | 2.year-3.year | -0.185 | 0.078 | 0.136 |
| | 2.year-4.year | -0.038 | 0.076 | 0.969 |
| | 3.year-4.year | 0.147 | 0.082 | 0.358 |
| Factor 5 | 1.year-2.year | 0.128 | 0.161 | 0.890 |
| | 1.year-3.year | 0.125 | 0.170 | 0.910 |
| | 1.year-4.year | 0.218 | 0.166 | 0.634 |
| | 2.year-3.year | -0.003 | 0.134 | 1.000 |
| | 2.year-4.year | 0.090 | 0.129 | 0.922 |
| | 3.year-4.year | 0.093 | 0.139 | 0.930 |
| Factor 6 | 1.year-2.year | 0.227 | 0.136 | 0.430 |
| | 1.year-3.year | 0.222 | 0.143 | 0.489 |
| | 1.year-4.year | 0.313 | 0.140 | 0.176 |
| | 2.year-3.year | -0.004 | 0.112 | 1.000 |
| | 2.year-4.year | 0.086 | 0.109 | 0.890 |
| | 3.year-4.year | 0.091 | 0.117 | 0.895 |
| Whole scale | 1.year-2.year | 0.176 | 0.070 | 0.103 |
| | 1.year-3.year | 0.134 | 0.073 | 0.343 |
| | 1.year-4.year | 0.232* | 0.072 | 0.017 |
| | 2.year-3.year | -0.041 | 0.057 | 0.915 |
| | 2.year-4.year | 0.056 | 0.056 | 0.794 |
| | 3.year-4.year | 0.098 | 0.060 | 0.444 |

Accordingly, the significant difference between the overall scores of the scale is between the students who continue their education in the 1st and 4th grades and in favor of the students who continue their education in the 1st grade (1st grade average score = 3.27 and 4th grade average score = 3.11). The significant difference between the scores obtained from the third factor, Positive Emotional Engagement in Laboratory Procedures factor, is between 1st and 4th year students and 3rd and 4th year students, in favor of 4th year students in both cases (1st year average score = 3.69, 3rd year average score=3.68 and 4th year average score=3.40). Additionally, for the fourth factor, the Behavioral Engagement in Laboratory Procedures factor, 1st grade and 2nd grade (1st grade mean score=3.89, 2nd grade mean score=3.36), 3rd grade (1st grade mean score=3.89, 3 There are significant differences between .class average score=3.54), and 4th grade (1st grade mean score=3.89, 4th grade mean score=3.40), and each time in favor of 1st grade.

## RESULTS, DISCUSSION AND CONCLUSION

In this study, the General Chemistry Laboratory Student Engagement Scale, originally developed by Smith and Alonso (2020), was adapted into Turkish. The Turkish form of the scale, which retains its 6-dimensional structure as in the original, was obtained by removing an item (I felt anxious about using glassware in the laboratory) that did not have a sufficiently high standardized regression coefficient as a result of the Confirmatory Factor Analysis and at the same time caused an increase in reliability if removed from the scale. The remaining 24 items were confirmed as having acceptable and excellent fit index values. The adapted scale has high reliability coefficients in all dimensions. Thus, it can be evaluated that the adapted scale is a valid and reliable measurement tool.

When the averages of the scores obtained from the scale for the sample from which the data were collected were evaluated, it was determined that the scale average was 3.11. This average is an average that can be considered high and indicates that students' engagement in the chemistry laboratory is high. According to the analysis made on the basis of factors, it is seen that the highest average is in Positive Emotional Engagement in Laboratory Procedures, and the lowest average in Cognitive Engagement in Laboratory Procedures. As a result of the original study (Smith & Alonso, 2020), the researchers stated that the lowest average score was in Negative Emotional Engagement in Laboratory Procedures, and the highest score average was in Behavioral Engagement in Laboratory Procedures. Assessments here are highly dependent on the size of the sample as well as its characteristics of course, and the differences between the results of this adapted scale and the original scale are also due to differences in culture and education system. According to the results of this study, in which students continuing their education in two large/important education faculties of our country are the sample, it is pleasing that student engagement in the chemistry laboratory is at a high level. When evaluated together, it can be interpreted that the students have positive emotions such as excitement and curiosity while performing the operations in the chemistry laboratory. Still, they do not learn or understand the procedures in the laboratory sufficiently (cognitive dimension). In this case, it may be suggested to try to use methods and techniques that will allow more cognitive engagement of students. In a study conducted by Cengiz, Karataş, and Aslan (2007), students were asked to create development files consisting of pre-laboratory and post-laboratory products in the general chemistry laboratory, and the effect of this process on student success was investigated, and it was stated that there was a significant increase in student success. In addition, the use of V-diagrams in chemistry laboratory courses (Çeliks et al., 2008; Nakiboğlu & Meriç, 2000), cooperative learning and peer learning (Ding & Harskamp, 2011), and keeping reflective diaries with feedback (Cengiz & Karataş, 2015) studies showed that they lead an increase in success. There are also studies showing that using the case study method in the chemistry laboratory (Seçkin & Yılmaz, 2014) and quizzes being held at the end of the lab instead of at the beginning (Kılınç Alpat & Altun, 2017) increase the success of students by reducing their anxiety. Therefore, by using the General Chemistry Laboratory Student Engagement Scale obtained at the end of this study, it can be investigated how the methods and techniques used in the mentioned studies and reported to increase student achievement in the chemistry laboratory affect student engagement.

When the data obtained with the scale adapted to Turkish within the scope of the study were evaluated in terms of gender, no significant difference was found, while there was a significant difference in favor of the participants studying science teaching in the dimension of Behavioral Engagement in Laboratory Procedures according to the variable of the department. Considering that the students studying in the science teaching department are more familiar with the laboratory, due to the fact that the students in the science teaching department are more familiar with the laboratory, as compared to the students in the classroom teaching department (YÖK, 2018), it can be said that spending more time in the laboratory or being exposed to lab operations has a positive effect on engagement. However, another important point to consider here is that the previous student backgrounds of the students who choose these two departments are also different from each other, and that students who generally prefer science teaching are more inclined to or prefer science courses. According to the variable of the year studied, there was a significant difference between the 1st year students and 4th year students and in favor of the 1st year students throughout the scale. When the curricula of the science teaching and classroom teaching departments of the education faculties, which are the sample, are examined (YÖK, 2018), it is seen that the students use the chemistry laboratory intensively in the 1st year. This situation decreases towards the end of their education life. From this result, it can be deduced that exposure is a factor that increases engagement.

Researchers who developed the original scale state that the scale can be used to evaluate students' experiences after various chemistry experiments and to make necessary adjustments (Smith & Alonso, 2020). The scale adapted to Turkish in this study can be similarly used to evaluate students' experiences in these experiments after various chemistry experiments. At the same time, considering that students' emotional, behavioral and cognitive engagement in the process is necessary for meaningful learning (Fredricks, Blumenfeld, & Paris, 2004), various assessments can be made, and necessary adjustments can be made. Similarly, the adapted scale can be used to examine how changes in laboratory processes affect students' engagement.

## REFERENCES

Alkan, F. (2016). Development of chemistry laboratory self-efficacy beliefs scale. *Journal of Baltic Science Education, 15*(3), 350-359. https://doi.org/10.33225/jbse/16.15.350

Alkan, F., & Erdem, E. (2012). Laboratuvar becerilerine yönelik tutum ölçeği geliştirme çalışması [Development of an attitude scale for laboratory skills]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 1*, 22-31. http://www.efdergi.hacettepe.edu.tr/shw_artcl-605.html

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1968). *Educational psychology: A cognitive view* (6. Baskı). Holt, Rinehart and Winston.

Azizoğlu, N., & Uzuntiryaki, E. (2006). Kimya laboratuvarı endişe ölçeği [Chemistry laboratory anxiety scale]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 30*(30), 55-62. https://hdl.handle.net/20.500.12462/5109

Bowen, C. W. (1999). Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students. *Educational and psychological measurement, 59*(1), 171-185. https://doi.org/10.1177/0013164499591012

Bretz, S. L. (2019). Evidence for the importance of laboratory courses. *Journal of Chemical Education, 96*(2), 193–195. https://doi.org/10.1021/acs.jchemed.8b00874

Bruck, L. B., Towns, M., & Bretz, S. L. (2010). Faculty perspectives of undergraduate chemistry laboratory: Goals and obstacles to success. *Journal of Chemical Education, 87*(12), 1416-1424. https://doi.org/10.1021/ed900002d

Büyüköztürk, Ş., Çakmak, E. K., Özcan, Ö.E., Karadeniz, Ş., & Demirel, F. (2016). Bilimsel araştırma yöntemleri [Scientific research methods] (21. Baskı). Pegem Akademi.

Canpolat, N., Pınarbaşı, T., Bayrakçeken, S., & Geban, Ö. (2004). Kimyadaki bazı yaygın yanlış kavramalar [Some common misconceptions in chemistry]. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 24*(1), 135-146. https://dergipark.org.tr/en/pub/gefad/issue/6760/90936

Cengiz, C., & Karatas, F. O. (2015). Examining the effects of reflective journals on pre-service science teachers’ general chemistry laboratory achievement. *Australian Journal of Teacher Education (Online), 40*(10), 125–146. https://search.informit.org/doi/10.3316/ielapa.557763492058690

Cengiz, C., Karataş, F. Ö., & Aslan, A. (2017). Genel kimya laboratuvarı dersinde öğrenci gelişim dosyalarının kullanımının başarı üzerindeki etkililiğinin belirlenmesi [Determination of the effectiveness of using student progress files on achievement in general chemistry laboratory course]. *Bayburt Eğitim Fakültesi Dergisi, 12(*23), 185-207. https://dergipark.org.tr/en/pub/befdergi/issue/30012/264009

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2. Ed). Lawrence Erlbaum Associates.

Çelikler, D., Güneş, H., Güneş, T., & Şendil, K. (2008). V diyagramı uygulamalarının temel kimya laboratuvarı dersinde öğrenci başarısına etkisi [The effect of V diagram applications on student success in basic chemistry laboratory course]. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 9*(2), 51-58. https://dergipark.org.tr/en/pub/kefad/issue/59525/856030

DeKorver, B. K., & Towns, M. H. (2015). General chemistry students' goals for chemistry laboratory coursework. *Journal of Chemical Education, 92*(12), 2031-2037. https://doi.org/10.1021/acs.jchemed.5b00463

Ding, N., & Harskamp, E. G. (2011). Collaboration and peer tutoring in chemistry laboratory education. *International Journal of Science Education, 33*(6), 839-863. https://doi.org/10.1080/09500693.2010.498842

Feyzioğlu, B., Demirdağ, B., Akyıldız, M., & Altun, E. (2012). Kimya öğretmenlerinin laboratuvar uygulamalarına yönelik algıları ölçeği geliştirilmesi [Developing a scale of chemistry teachers' perceptions towards laboratory practices]. *Türk Fen Eğitimi Dergisi, 9*(4), 44-63. http://88j.76d.mywebsitetransfer.com/index.php/tused/article/view/470

Fredricks, J. A., Blumenfeld, P. C. ve Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Galloway, K. R. ve Bretz, S. L. (2015a). Development of an assessment tool to measure students' meaningful learning in the undergraduate chemistry laboratory. *Journal of Chemical Education, 92*(7), 1149–1158. https://doi.org/10.1021/ed500881y

Galloway, K. R. ve Bretz, S. L. (2015b). Measuring meaningful learning in the undergraduate chemistry laboratory: A national, cross-sectional study. *Journal of Chemical Education, 92*(12), 2006–2018. https://doi.org/10.1021/acs.jchemed.5b00538

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference*. Allyn ve Bacon.

Güneş, M. H., Şener, N., Topal-Germi, N., & Can, N. (2013). Fen ve teknoloji dersinde laboratuvar kullanımına yönelik öğretmen ve öğrenci değerlendirmeleri [Teacher and student evaluations on the use of laboratory in science and technology course]. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 20*, 1-11. https://dergipark.org.tr/en/pub/zgefd/issue/47944/606567

Hair, J. F. Jr., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis* (6. Ed.). Prentice-Hall.

Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected a. aspects of research. *Review of Educational Research, 52*(2), 201–217. https://doi.org/10.3102%2F00346543052002201

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education, 88*(1), 28–54. https://doi.org/10.1002/sce.10106

ITC Guidelines for Translating and Adapting Tests (Second Edition) (2017). Retrieved from www.intestcom.org

Johnstone, A. H. (1991). Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning, 7*(2), 75–83. https://doi.org/10.1111/j.1365-2729.1991.tb00230.x

Kılınç Alpat, S., & Altun, E. (2017). Genel kimya III laboratuarında uygulanan kısa sınavların fen bilgisi öğretmen adaylarının akademik başarısı ve görüşlerine etkisi [The effect of quizzes in general chemistry III laboratory on pre-service science teachers' academic achievement and opinions]. *Education Sciences, 12(*1), 20-39. https://dergipark.org.tr/en/pub/nwsaedu/issue/27296/271093

Nakiboğlu, C., & Sarıkaya, Ş. (2000). Kimya öğretmenlerinin derslerinde laboratuvar kullanımına mezun oldukları programın etkisi [The effect of graduation program on chemistry teachers' use of laboratory in their lessons]. *Kastamonu Eğitim Dergisi, 8*(1), 95-106. https://dergipark.org.tr/en/pub/jotcsc/issue/30533/330311

Nakiboğlu, C., & Meriç, G. (2000). Genel kimya laboratuvarlarında V-diyagramı kullanımı ve uygulamaları [Use and applications of V-diagram in general chemistry laboratories]. *Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 2*(1), 58-75. https://dergipark.org.tr/en/pub/baunfbed/issue/24788/261894

Özgür, S. D., Odabaşı, Z., & Erdoğan, Ü. İ. (2017). Öğretmen adaylarını kimya laboratuvar uygulamaları ile öğretmenlik mesleğine hazırlama [Preparing prospective teachers for teaching profession with chemistry laboratory applications]. *Elektronik Sosyal Bilimler Dergisi, 16*(61), 534-550. https://doi.org/10.17755/esosder.304691

Reid, N., & Shah, I. (2007). The role of laboratory work in university chemistry. *Chemistry Education Research and Practice, 8*(2), 172–185. https://doi.org/10.1039/B5RP90026C

Sadler, T. D., Puig, A., & Trutschel, B. K. (2011). Laboratory instructional practices inventory: A tool for assessing the transformation of undergraduate laboratory instruction. *Journal of College Science Teaching, 41*(1), 25-32. https://mydigitalpublication.com/publication/?i=77830

Seçkin, M., & Yılmaz, S. (2014). Örnek olay yönteminin öğretmen adaylarının kimya laboratuvarı dersine karşı endişelerine etkisi [The effect of case study method on pre-service teachers' anxiety towards chemistry laboratory course]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 29*(2), 215-227. http://www.efdergi.hacettepe.edu.tr/shw_artcl-90.html

Sirhan, G. (2007). Learning difficulties in chemistry: An overview. *Journal of Turkish Science Education, 4*(2), 2–20. https://dspace.alquds.edu/handle/20.500.12213/742

Smith, K. C., & Alonso, V. (2020). Measuring student engagement in the undergraduate general chemistry laboratory. *Chemistry Education Research and Practice, 21*, 399-411. https://doi.org/10.1039/C8RP00167G

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics*. Pearson.

Taber, K. S. (2001). Building the structural concepts of chemistry: Some considerations from educational research. *Chemistry Education Research and Practice, 2*(2), 123–158. https://doi.org/10.1039/B1RP90014E

Uysal, İ., & Kılıç, A. F. (2022). Normal distribution dilemma. *Anadolu Journal of Educational Sciences International, 12*(1), 220-248. https://doi.org/10.18039/ajesi.962653

Yükseköğretim Kurumu (2018). Yeni öğretmen yetiştirme lisans programları [New teacher training undergraduate programs]. https://www.yok.gov.tr/kurumsal/idari-birimler/egitim-ogretim-dairesi/yeni-ogretmen-yetistirme-lisans-programlari

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