PERIÓDICO TCHÊ QUÍMICA
ARTIGO

UMA ANÁLISE DAS CRENÇAS DE AUTOEFICÁCIA LABORATORIAL E PERCEPÇÕES SOBRE APLICAÇÕES EM LABORATÓRIO DE ESTUDANTES DO ENSINO MÉDIO

AN ANALYSIS OF HIGH SCHOOL STUDENTS' LABORATORY SELF-EFFICACY BELIEFS AND PERCEPTIONS OF LABORATORY APPLICATIONS

LİSE ÖĞRENCİLERİNİN LABORATUVAR ÖZ-YETERLİLİK İNANÇLARININ VE LABORATUVAR UYGULAMALARINA İLİŞKİN ALGILARININ BELİRLENMESİ

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RESUMO

Introdução: A Química é uma das disciplinas menos preferidas e é considerada um ramo abstrato e difícil da ciência pelos estudantes. Para tornar a química mais significativa e interessante, é de grande importância realizar mais atividades laboratoriais e relacionar a química com o cotidiano. Ao elaborar programas de química, devem ser consideradas as habilidades que os alunos precisam desenvolver. Entre essas habilidades, a percepção laboratorial e a autoeficácia são as mais proeminentes. **Objetivo**: Esta pesquisa foi realizada para determinar as percepções dos estudantes do ensino médio em relação às práticas laboratoriais, revelar sua autoeficácia em laboratórios de química e também determinar as mudanças na percepção e autoeficácia de acordo com o nível escolar e gênero. **Métodos**: O estudo foi projetado utilizando o modelo de pesquisa relacional. A amostra do estudo consiste em 423 estudantes do ensino médio. O teste MANOVA foi realizado para determinar os efeitos do gênero e do nível escolar na percepção laboratorial e autoeficácia dos estudantes. **Resultados**: De acordo com os resultados da MANOVA, o efeito do gênero é significativo, mas o efeito do nível escolar e o efeito gênero*nível escolar não são significativos. No entanto, houve uma diferença em relação ao gênero nas dimensões dos objetivos do laboratório, na eficácia do laboratório e no planejamento da percepção química. Foi determinado que as estudantes do sexo feminino apresentaram percepções mais elevadas dos objetivos laboratoriais, enquanto os estudantes do sexo masculino apresentaram percepções mais elevadas da eficácia e planejamento laboratorial. **Discussão**: Considera-se que examinar as percepções e autoeficácia dos estudantes do ensino médio em relação às atividades laboratoriais antes de iniciarem sua educação universitária e analisar como esses fatores estão relacionados a diversas variáveis pode orientar a educação em nível universitário. **Conclusões**: Estes resultados indicam que as percepções dos estudantes do ensino médio sobre práticas em laboratório de química e sua autoeficácia no laboratório estão em um nível moderado. Para aprimorar as percepções dos alunos sobre química, recomenda-se que atividades práticas sejam incorporadas ao currículo.

Palavras-chave: *autoeficácia em laboratório de química, percepções de aplicações laboratoriais, estudantes do ensino médio.*

ABSTRACT

Background: Chemistry is one of the least preferred courses and is considered an abstract and difficult branch of science by students. In order to make chemistry more meaningful and interesting, it is of great importance to do more laboratory activities and to relate chemistry to daily life. When designing chemistry programs, the skills that students need to develop should be taken into account. Among these skills, laboratory perception and self-efficacy are the most prominent ones. **Aim:** This research was conducted to determine the perceptions of high school students regarding laboratory practices to reveal their self-efficacy in chemistry laboratories and also to determine the changes in perception and self-efficacy according to grade level and gender. **Methods:** The study was designed using the relational survey model. The study sample consists of 423 high school students. MANOVA test was performed to determine the effects of gender and grade level on students' laboratory perception and self-efficacy. **Results:** According to the MANOVA results, the gender effect is significant, but the class level effect and the gender*class level effect are not significant. However, there was a difference with respect to gender in the dimensions of the goals of the laboratory, the effectiveness of the laboratory, and the planning of the chemistry perception. It was determined that female students had higher perceptions of laboratory goals, while male students had higher perceptions of laboratory effectiveness and planning. **Discussion**: It is thought that examining the perceptions and self-efficacy of high school students regarding laboratory activities before they start their undergraduate education and analyzing how these factors are related to various variables can guide university-level education.**Conclusions:** These results indicate that high school students' perceptions of chemistry laboratory practices and their self-efficacy in the lab are at a moderate level. To enhance students' perceptions of chemistry, it is recommended that hands-on activities be incorporated into the curriculum.

Keywords: *chemistry laboratory self-efficacy, perceptions of laboratory applications, high school students.*

ÖZET

Giriş: Kimya dersi, zorunlu olmadığı sürece öğrenciler tarafından en az tercih edilen derslerden biridir ve öğrenciler tarafından soyut ve zor bir bilim dalı olarak nitelendirilmektedir. Kimyayı daha anlamlı ve ilgi çekici hale getirmek için daha fazla laboratuvar etkinliği/pratik çalışma yapmak ve kimyayı günlük yaşamla ilişkilendirmek büyük önem taşır. Kimya programları tasarlanırken, öğrencilerin geliştirmesi gereken beceriler dikkate alınmalıdır. Laboratuvar algısı ve öz yeterlilik inancı, bu beceriler arasında en belirgin olanlardan bazılarıdır. **Amaç:** Bu araştırma, lise öğrencilerinin laboratuvar uygulamalarına ilişkin algılarını belirlemek ve kimya laboratuvarlarında öz-yeterliklerini ortaya koymak, ayrıca algı ve öz-yeterliklerinin sınıf düzeyi ve cinsiyet gibi değişkenlere göre değişimini belirlemek amacıyla yapılmıştır. **Yöntem:** Çalışma ilişkisel tarama modelinde tasarlanmıştır. Çalışmanın örneklemini 423 lise öğrencisi oluşturmaktadır. Cinsiyet ve sınıf düzeyinin öğrencilerin laboratuvar algısı ve öz yeterliliklerine olan etkilerini belirlemek için MANOVA testi yapılmıştır. **Bulgular:** MANOVA sonuçlarına göre cinsiyet etkisi anlamlıdır, sınıf düzeyi etkisi ve cinsiyet*sınıf düzeyi etkisi anlamlı değildir. Ancak kimya algı ölçeğinin laboratuvar hedefleri, laboratuvar etkinliği ve planlama boyutlarında cinsiyete göre bir farklılık gösterdiği belirlenmiştir. Laboratuvar hedefleri konusunda kız öğrencilerin daha yüksek algı düzeyine, laboratuvar etkinliği ve planlama konusunda erkek öğrencilerin daha yüksek algıları olduğu sonucuna ulaşılmıştır. **Tartışma**: Lise öğrencilerinin lisans eğitimlerine başlamadan önce laboratuvar aktivitelerine ilişkin algılarının ve öz yeterliliklerinin incelenmesi ve bu faktörlerin çeşitli değişkenlerle nasıl ilişkili olduğunun analiz edilmesinin üniversite düzeyindeki eğitime rehberlik edebileceği düşünülmektedir. **Sonuç:** Bu bulgular, lise öğrencilerinin kimya laboratuvar uygulamalarına ilişkin algılarının ve laboratuvardaki öz yeterliliklerinin orta düzeyde olduğunu göstermektedir. Öğrencilerin kimyaya ilişkin algılarını geliştirmek için müfredata uygulamalı etkinliklerin dahil edilmesi önerilmektedir.

Keywords: kimya laboratuvar özyeterliği, laboratuvar algısı, lise öğrencileri

1. INTRODUCTION

In high school and university, students choose fewer chemistry and physics courses and more biology courses. In fact, students avoid studying science courses other than compulsory courses (Gatsby, 2018). Although many students claim that chemistry is an interesting branch of science(Höft *et al*., 2019), most of them find chemistry quite boring, difficult, and challenging and think that some topics in chemistry are (Rüschenpöhler & Markic, 2020). Overcoming such negativities can be possible by making chemistry more meaningful and interesting, doing more laboratory activities and practical work, and associating chemistry with daily life (Broman *et al*., 2011). It is suggested that the reason why students have difficulty and anxiety in chemistry is due to calculations and mathematical operations in some subjects (Duncan & Johnstone, 1973; Johnstone *et al*.,1976). The reason for the difficulties students experience in making calculations is due to the components in the nature of these operations (Wheeler & Kass, 1977).

Traditional teaching can create a learning environment characterized by high levels of memorization in some areas. Students remember very little of what they learn and have difficulty applying this information that they do not forget (Saint-Jean, 1994). Therefore, chemistry laboratory practices should be the most fundamental practice to ensure meaningful learning and an important component of chemistry course assessment. If laboratory work is not included in chemistry, failure will occur (Wilson, 1987). When designing chemistry programs, the skills that undergraduate students need to develop should be taken into account. These are application, perception, problem-solving, and self-efficacy. Problem solving is defined as the ability to clearly define a problem, develop testable hypotheses, design and conduct experiments, analyze data, and produce results (American Chemical Society, 2015). It is expected that concepts in chemistry will be combined with laboratory practice in order to be understood. Therefore, chemistry programs should be organized in a way that includes experimental design that will provide opportunities for application and development of self-efficacy (Shadle *et al.*, 2012).

Experiments are very important in chemistry classes at every level of education, such as high school or university. Results are obtained from experiments conducted in the laboratory. Students learn to use these results to think deeply about theoretical knowledge and reach conclusions (Uzuntiryaki-Kondakci *et al.*, 2021). Task-based activities such as laboratory practices enable students to develop skills such as self-assessment and awareness of self-efficacy (Wu *et al.*, 2023). While shifting chemistry teaching to student-centered practices increases students' academic success, it also increases their belief that they can manage their own learning process and develop motivation (Cascolan, 2023). Starting with teachers and teacher candidates, the importance of chemistry should be focused on teaching thought processes in order to ensure sustainability. Teachers trained in this regard can ensure that their students in their classes go through the same process (Delaney *et al.*, 2021). In order to ensure the sustainability of learning, attention should be drawn to increasing students' motivation in learning environments (Bezen, 2023). Teachers have a big responsibility for this. Increasing teacher competencies will contribute positively to the development of students' affective characteristics, such as motivation and self-efficacy.

In order to make chemistry more meaningful and interesting, laboratory activities and experiments should be carried out, and attention should be paid to the association of chemistry topics with daily life (Broman *et al.*, 2011). Real-life context has been previously examined in the principles of model-eliciting activities (Saglam Kaya, 2021). Determining students' knowledge about the laboratory actually reveals what they know and what they do not know about chemistry topics. The instructional plan should also be updated according to students' knowledge and views about the laboratory. Based on the feedback received from students regarding their knowledge and opinions about the laboratory: (1) the difficulty level of experiments conducted in the lab can be reviewed, (2) chemistry lessons can be restructured to better support laboratory practices, or (3) safety considerations during the execution of experiments can be revisited (Triayuni *et al.*, 2023). The information that students have about the laboratory also sheds light on how laboratory teaching should be planned. The selection of materials used in daily life in experiments to be conducted in the laboratory is very important (Hakim *et al.*, 2022). Based on the literature on the importance of chemistry laboratories, it is necessary to determine the laboratory perceptions of high school students and their self-efficacy in chemistry laboratories and to examine these variables, which are important for chemistry courses, in-depth.

Understanding high school students' beliefs and perceptions toward the laboratory serves as a foundational step in designing effective chemistry laboratory environments, preparing experiments and activities tailored to students' needs, and developing lesson plans. During high school, improving students' scientific literacy has been emphasized as a priority, and laboratory activities have been identified as one of the most effective methods for achieving this goal (DeBoer, 2000; Mohapatra & Mohapatra, 2013; Ulu & Bayram, 2014). However, to ensure the success of such practices, it is essential to first identify factors such as students' self-efficacy beliefs and perceptions about the laboratory, which can influence the effectiveness of these applications, ultimately making the process of conducting experiments more impactful.

This study aimed to examine high school students' perceptions of laboratory practices and their self-efficacy in chemistry laboratories. Additionally, the research sought to explore how these perceptions and self-efficacy beliefs varied according to factors such as grade level and gender.

The research question of the study is as follows:

1. Do students' laboratory self-efficacy beliefs and laboratory perception factor scores differ significantly based on gender and grade level?

According to the findings obtained from the research, the points to be considered for laboratory practices in chemistry education have been emphasized.

2. MATERIALS AND METHODS

2.1. Research Design and Participants

The study was designed using the correlational survey model. A correlational survey is a model that enables to examine the relationship of two or more variables with one another (Fraenkel *et al.*, 2012). In this study, the changes in the perceptions and chemistry laboratory self-efficacy beliefs of high school students towards laboratory practices, according to class and gender variables, were investigated. The research was carried out in the 2023-2024 academic year.

The study sample was determined using the convenience sampling method. Sample size has the effect of increasing statistical power. Therefore, this should be taken into account, as statistical errors will decrease in samples of 200 or more (Hair *et al.*, 2010: 75). The sample of the study consists of 423 high school students. Two hundred thirty-three females (55.1%) and 190 males (44.9%). The distribution of students by grade is 107 students in 9th grade, 117 students in 10th grade, 109 students in 11th grade, and 90 students in 12th grade. Demographic characteristics of the sample are shown in Table 1.

2.2. Instrument and Data Collection

Data were collected using the Chemistry Laboratory Self-Efficacy Beliefs Scale (CLSEB) and the Perceptions on Laboratory Applications Scale (PLA).

Chemistry Laboratory Self-Efficacy Beliefs Scale (CLSEB): The scale was developed by Alkan (2016). The scale, which consists of 14 items in a five-point Likert type, has two sub-dimensions. Dimensions are cognitive self-efficacy beliefs (Seb1) and psychomotor self-efficacy beliefs (Seb2). The Cronbach alpha reliability coefficient for the whole scale is 0.885 and 0.818 and 0.847 for the sub-dimensions, respectively.

Validity and reliability analyses of the scale were conducted with the sample group in this study. While the scale was originally developed for high school students, it was administered here to a different group of high school students to assess its validity and reliability in this new sample. To confirm the factor structure of the scale for this group, a confirmatory factor analysis (CFA) was performed, and the two-factor structure was successfully validated. Figure 1 presents the CFA model for the Chemistry Laboratory Self-Efficacy Beliefs Scale, conducted using the AMOS V24 program. Additionally, the suitability of the identified factor structure for this sample group was verified, and the two-factor structure was consistently confirmed. Table 2 provides sample items alongside reliability coefficients from both the original study and the current study for comparison.

Perceptions on Laboratory Applications Scale (PLA): The scale was developed by Feyzioğlu, Demirdağ, Akyıldız, & Altun (2012). The scale, which consists of 20 items, has three sub-dimensions. Sub-dimensions of the scale, the goals of the laboratory (PL1), the effectiveness of the laboratory (PL2), and planning (PL3). The Cronbach alpha reliability coefficient of the 5-point Likert-type scale is 0.92, 0.80, and 0.70, respectively. The reliability coefficient for the overall scale is 0.88.

The validity and reliability of the scale were examined for the sample group of this research. The scale was originally developed for teacher candidates; however, in this study, it was administered to high school students. To adapt the scale for this new sample, an exploratory factor analysis (EFA) was conducted initially to determine its factor structure within the high school context. Following this, a confirmatory factor analysis (CFA) was performed to validate the identified factor structure and assess the scale's reliability and validity for use with high school students.

The suitability of the data for factor analysis was assessed using Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) test. The KMO test provides information about the adequacy of the sample size, with a KMO value of 0.929, which is considered highly sufficient (Field, 2009). Bartlett's Test of Sphericity indicates that the data comes from multivariate normal distributions with a significant value (χ^2 = 4060.366, $p < 0.001$). Based on these results, exploratory factor analysis (EFA) was conducted on a sample of 423 data points. In the EFA, the Varimax rotation technique, an orthogonal rotation method in principal components analysis, was applied. According to Tabachnick and Fidell (2013), items with anti-image correlations below 0.5 should be considered for exclusion from the analysis. Therefore, items with anti-image correlations above 0.5 were retained (Field, 2013). Upon examining the data based on common variance and anti-image correlations, the default values were met. When determining the number of factors, only those with eigenvalues greater than 1 were accepted. Factor loadings between 0.30 and 0.40 are considered minimally acceptable, while values of 0.50 and above are considered more reliable (Hair, Black, Babin, & Anderson, 2010). Accordingly, only items with factor loadings of 0.45

or higher were retained. The factor loadings of the scale items ranged from 0.383 to 0.687. Based on the principal components analysis, a three-factor structure with eigenvalues greater than 1 was obtained.

While the validity of the scale was examined with exploratory factor analysis and confirmatory factor analysis construct validity, reliability was examined with internal consistency, composite reliability, and item-total correlation. As a result of factor analysis, a 3-factor structure with an eigenvalue greater than 1 was obtained. Confirmatory factor analysis (CFA) was performed to test the construct validity of the scale, which was determined by factor analysis (Pituch & Stevens, 2016: 639). Whether the three-factor structure of the scale, determined by EFA, is a valid model was examined by confirmatory factor analysis (CFA) conducted with the AMOS 23 program. The diagram of the factor structure of the scale is given in Figure 2. The distribution of scale items to factors according to calculated values and criteria is the same as those who developed the scale, and the factor structure was confirmed for the sample group of the research. The sample items, along with the reliability coefficients for the original and current study, are presented in Table 2.

2.3. Data Analysis

The analysis of the data obtained from the study was performed using SPSS 23 and AMOS23 programs. First, missing data was checked, and then imputed data was used using the Expectation Maximization algorithm (Tabachnick & Fidell, 2013). The confirmatory factor analysis of the scales was carried out with AMOS, while all other statistical analyses were made with SPSS. Descriptive statistics were calculated for the variables of perceptions on laboratory applications, chemistry laboratory self-efficacy beliefs, and all sub-dimensions. The difference between the perceptions of laboratory applications, chemistry laboratory self-efficacy beliefs, and sub-dimensions according to gender and class variables was examined by "Multivariate Variance Analysis MANOVA". All assumptions required for MANOVA were justified before analyzing data. For this purpose, univariate and multivariate normal distribution, homogeneity of variance-covariance matrices, and multiple collinearity were tested. Univariate normality can be examined descriptively, graphically, and statistically. Descriptively, statistics such as arithmetic mean, mode, median, skewness, and kurtosis coefficients were examined. Then, univariate and multivariate normality assumptions were checked. While examining univariate normality, skewness, and kurtosis value (Tabachnick & Fidell, 2013), graphically standard Q-Q plots (Pallant, 2001) and statistical Kolmogorov-Smirnov test were used. Scatter plots and chi-square Q-Q plots were used for multivariate normality. (Gamma plot) was checked (Burdenski, 2000; Oppong & Agbedra, 2016). The skewness and kurtosis value is between -1.5 and +1.5, and the Kolmogorov-Smirnov test is insignificant. When the data are examined in univariate normality, when the scatter chi-square Q-Q plot is examined, multivariate normality is met because there are no deviations from the straight line. Univariate and multivariate extreme values were examined. Boxplots, the difference between trimmed mean and mean is checked. Based on this review, there are no outliers.

The linearity between the two variables is examined with a bivariate scatter plot. Here, if the variables are normally distributed and linearly related, the scatterplot is oval-shaped (Tabachnick & Fidell, 2013). Accordingly, the data meet the linearity assumption.

Multicollinearity was investigated with a correlation matrix. It is expected that there is no relationship of .90 or more between the variables (Tabachnick & Fidell, 2013). When the table is examined, it is seen that the correlation between the observed variables is not high. The data set meets univariate, multivariate normality assumptions, linearity is provided, and there is no multicollinearity in the data.

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Results regarding the normality assumption on chemistry laboratory self-efficacy and perceptions on laboratory application

In a study, whether the data obtained from the scales of " Chemistry Laboratory Self-Efficacy Beliefs and Perceptions on Laboratory Application" showed normal distribution was first examined using descriptive methods. In this direction, some statistical findings such as arithmetic mean, standard deviation, mode, median, kurtosis, and skewness coefficients were calculated. The results are given in Table 3.

When Table 3 is examined, it is striking that the kurtosis and skewness values of the data are between +1.5 and -1.5. In addition, when the trimmed mean and mean are compared, it is seen that these two values are not very different from each other. These values are within accepted limits, data are normally distributed (Tabachnick &

Fidell, 2013). When all these data are evaluated, the data set shows a normal distribution.

In graphical methods, the normal Q-Q plot and the detrended normal Q-Q plot of the scores were examined, and it was determined that no situation would affect normality. In statistical methods, the results of the Shapiro-Wilks Test and the Kolmogorov-Smirnov Test were examined. In order for the data to meet the normal distribution assumption, this value should not be significant ($p>0.05$). It can be said that the data did not show a significant deviation from the normal distribution, and the univariate normality assumption was met.

In order to observe multivariate normality and whether there are extreme values, the original mean and the trimmed mean were compared (Table 3). If these two mean values are very different from each other, the Q-Q plot was first examined to check the extreme values. If it is determined whether there is an extreme value from here, the Mahalanobis distance value is examined. When Table 3 is examined, it is seen that there are very few differences between the mean and trimmed mean values. The Q-Q plot was examined considering that there may be extreme values. According to the multivariate normal distribution, the data show very little deviation from the normal distribution in the normal Q-Q graph, and it is noted that there are few point clusters around the zero line in the trend-free Normal Q-Q graph. Using the information obtained from the Q-Q plots graph, the multivariate normal distribution was checked using the Mahalanobis distance for the data set. It was determined whether there were extreme values above the critical value for the Mahalanobis distance. Since the number of dependent variables in the study in question is 5, the critical value is 20.52 (Tabachnick & Fidell, 2013). Accordingly, there are 13 extreme values in the data file whose Mahalanobis distance is above the critical value, and these are removed from the data set. The multivariate normality assumption of MANOVA is met.

Levene's test and Box's M test were examined for the assumption of homogeneity of variances and covariances. Accordingly, when the assumption is not met, Pillai's trace value is examined when interpreting the MANOVA analysis (Tabacnik & Fidell, 2013, p-254). Pillai's trace gives acceptable values when the sample size is small, in unequal groups, or when the homogeneity of covariances is violated (Steven, 2009; p.695).

Multiple collinearity was examined by correlation analysis. A correlation of 0.80 and above between dependent variables reveals the problem of multiple collinearity (Pallant, 2005). Obtained findings are presented in Table 4.

In Table 4, the correlations between all variables are given. From this table, we can say that all correlations are significant; some are negative, some are positively related, and others are not significant. Accordingly, there is no multicollinearity among the dependent variables, and the data set meets this assumption.

3.1.2. Findings on chemistry perception and chemistry laboratory self-efficacy

According to the results of the analyses, the hypothetical criteria of MANOVA are met. Accordingly, MANOVA was used to examine whether there were significant differences in the dependent variables of the chemistry laboratory self-efficacy scale (cognitive self-efficacy beliefs, psychomotor self-efficacy beliefs) and the dependent variables of the chemistry perception scale (the goals of the laboratory, the effectiveness of laboratory, planning) according to gender and class. The results are given in Table 5.

When the table 5 is examined, it is seen that according to the MANOVA results, the gender effect is significant (Pillai's Trace = .048, $F_{(5,398)}=4.054$ $\eta^2=.048$, $p<.001$), the class effect (Pillai's Trace = .047, $F_{(15,1200)}=1.269$ $\eta^2=.016$, $p>.001$) is not significant, and the gender and class effects (Pillai's Trace = .046, $F_{(15,1200)}=1.249$ $\eta^2=.015$, $p>.001$) are not significant.

ANOVA test was applied to determine in which sub-dimension or dimensions the significant difference determined according to MANOVA occurred, and Tukey multiple comparison test data were used. The analysis results are given in Table 6.

According to the results of the analysis, it is seen that the independent variable of gender has a significant effect on the dependent variables of the goals of the laboratory, the effectiveness of the laboratory, and planning. When the means are examined, the means of female students in three dimensions of the scale are as follows ($M_{PL1}=4.22$, $M_{PL2}=1.65$, $\bar{X}_{PL3}=1.65$), and those of males are as follows ($M_{PL1}=4.01$, $M_{PL2}=1.95$, $M_{PL3}=1.82$). Females have higher means, and the difference is significant. The effect size eta squared (η^2) value is .021 for the goals of the laboratory (PL1), .035 for the effectiveness of the laboratory (PL2), and .012 for planning (PL3). Eta squared (η^2) ratios below .01 are considered small, between .06-.14 are considered medium, and above .14 are considered large effect values (Cohen, 1988). These eta squared (η2) ratios are small-level effect values. The explanation rate of the goals of laboratory (PL1) sub-dimension of the Chemistry perception scale with the gender-independent variable is 2.1%, the explanation rate of the effectiveness of laboratory (PL2) dimension is 3.5%, and the explanation rate of the planning (PL3) dimension is 1.2%.

3.2. Discussion

As a result of the analysis conducted for the changes in the dependent variables of the chemistry laboratory self-efficacy scale cognitive self-efficacy beliefs, psychomotor self-efficacy beliefs, and the dependent variables of the perceptions on laboratory applications scale, the goals of the laboratory, the effectiveness of laboratory, planning according to gender, class and gender-class interaction variables, it was determined that there was a significant difference only with gender. According to the detailed analysis results, there was no significant difference between male and female students in the cognitive self-efficacy beliefs and psychomotor self-efficacy beliefs. Analysis revealed gender-based differences across multiple dimensions: laboratory goals, laboratory effectiveness, and planning within the chemistry perception scale. The data showed higher perception scores for female students regarding laboratory goals. In contrast, male students demonstrated higher perception scores in both laboratory effectiveness and planning dimensions. Among the gender-independent variables, laboratory effectiveness showed the highest explanation rate, followed by laboratory goals, with planning showing the lowest rate.

The results of this study suggest that gender may play a significant role in shaping students' perceptions and experiences in laboratory practices. Female students' higher perceptions of laboratory goals indicate that they may be more inclined to view laboratory work as a platform for learning and personal development. This aligns with previous studies suggesting that female students often place greater emphasis on goal-oriented learning strategies (Baruch et al., 1983, as cited in Eccles, 1994; Denktaş, 2019; Ethington, 1991). It could be posited that female students' strong motivation toward academic and professional aspirations contributes to their tendency to assign greater meaning to laboratory activities. Conversely, the finding that male students exhibit higher perceptions of laboratory effectiveness and planning suggests that they may prioritize the functional and outcome-driven aspects of laboratory work. This observation resonates with studies indicating that male and female students may conceptualize task requirements differently and attribute varying degrees of value to activities depending on their practical implications (Eccles, 1994; Erkut, 1983).

According to descriptive statistics, the means of female students in the goals of laboratory sub-dimension of the chemistry perception scale were higher than those of male students. While gender is a significant variable for chemistry self-efficacy (Saputra *et al*., 2024), no significant effect was detected in this study. While competition in the learning environment provides a favorable condition for female students, it has the potential to significantly reduce self-efficacy and goals laboratory among male students (Coll *et al*., 2002). The fact that females have a higher mean in the goals of the laboratory dimension is supported by other studies. Female students' more positive perceptions of the learning environment and the purpose of learning reveal stronger general chemistry self-efficacy and perception compared to males (Boz *et al*., 2016). The fact that no significant difference emerged at the class level for self-efficacy is also supported by other studies (Sağlam-Kaya, 2019). In order to achieve a significant increase in self-efficacy, an increase in individuals' knowledge and perceptions should be recorded, and it is thought that progress will be made in self-efficacy in this direction. According to research, there is a positive relationship between success and self-efficacy in learning science, and self-efficacy is an important predictor of success (Bezen, 2023).

Many events in our daily lives are related to chemistry (Özmen, 2004; Özden, 2007). Students are well aware that chemistry is related to various areas of our lives. Chemistry is an experimental science. The most important requirement for being a competent person in the field of chemistry is to associate subjects with experiments. For this reason, it is unacceptable for traditional laboratory programs to have content that provides little training for the development of this skill (Pickering, 1984). Students are also aware that problems will arise when they think that their chemistry knowledge is insufficient to explain the relationship in other areas (Rüschenpöhler & Markic, 2020). Students are more interested in science during middle school and can even gain science knowledge. It is very important to ensure that students at other levels also acquire this knowledge (Sheldrake & Mujtaba, 2019). For this reason, it is thought that interacting with extracurricular activities will create a positive attitude and desire towards science (Archer *et al*., 2020).

Students' knowledge and attitudes toward the laboratory are also indicators of how they will behave in the laboratory (Galloway & Bretz, 2015). What is recommended for teachers is to determine the students' perceptions of chemistry before starting the lesson in high school and then design activities in the lesson according to this perception (Altundağ *et al*., 2022). For this reason, investigating the laboratory perceptions and chemistry laboratory self-efficacy of students at the high school level before starting undergraduate education and revealing their relationship with various variables will guide the education to be carried out at the university. For example, in the long term, it supports the idea that well-structured laboratory activities for chemistry laboratories can effectively increase cognitive skills in chemistry education (Hofstein, 2004). Activities related to chemistry will enable students to understand that chemistry can be understood and applied (Mujtaba *et al*., 2020). Teaching chemistry topics by relating them to daily life (Mustafaoğlu & Yücel, 2022) and providing a learning environment enriched with experiments will make it easier for students to understand the cause-effect relationship (Aydoğdu, 2000) and will support students in reducing their prejudices and concerns about chemistry (Koçak Altundağ & Yücel, 2022). In addition, activities planned in detail have great potential to improve attitudes and cognitive development (Hofstein & Lunetta, 1982; 2004).

4. CONCLUSIONS:

These findings show that high school students' perceptions of chemistry laboratory practices and their chemistry laboratory self-efficacy are at a moderate level. However, students' perception levels in different dimensions of laboratory practices vary according to gender. In this context, it is essential to adopt balanced strategies that address the learning needs of both female and male students in the design of laboratory activities. For instance, providing instructions that explicitly outline laboratory goals and incorporating practices that focus on developing individual skills could foster more positive engagement with laboratory experiences for all students. Moreover, creating learning environments that promote gender equality and implementing interventions to enhance collaboration may support equal success among students in laboratory practices. In addition, more course activities for laboratory experiments can be added to the curriculum to increase students' perception levels of chemistry. Future research could explore how these distinct perceptions influence learning outcomes and how laboratory practices can be tailored to address diverse motivational and cognitive approaches across genders.

5. DECLARATIONS

5.1. Study Limitations

1. The study was conducted with high school students in Ankara, Turkey, due to the availability of the sample. The limited geographic and demographic scope may limit the applicability of the findings to larger populations or students in different regions or educational contexts.
2. This study was structured in a way that would allow for experimental studies to be conducted as a result of the data obtained by directly obtaining opinions from students at certain scales within a certain period of time.
3. There may also be external variables that affect students' perceptions and self-efficacy that were not taken into account in this study.
4. Data on students' perceptions were collected only through quantitative data collection tools.

5.2. Acknowledgements

We would like to thank all the students who volunteered to contribute to the data collection process for the research.

5.3. Funding source

The research was founded by the authors.

5.4. Competing Interests

The authors declare no potential conflict of interest in this publication.

5.5. Open Access

6. HUMAN AND ANIMAL-RELATED STUDIES

6.1. Ethical Approval

The ethical approval authority was obtained from the Hacettepe University Institute of Education Sciences Research Ethics Committee, Türkiye (Approval No: E-51944218-050-00003773818).

6.1. Informed Consent

The students who participated in the study filled out the voluntary participation form. We would like to thank the high school students who participated in this research.

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Table 1. *Characteristics of sampling*

		N	%
Gender	Female	233	55,1
	Male	190	44,9
Class	9. class	107	25,3
	10. class	117	27,7
	11. class	109	25,8
	12. class	90	21,3

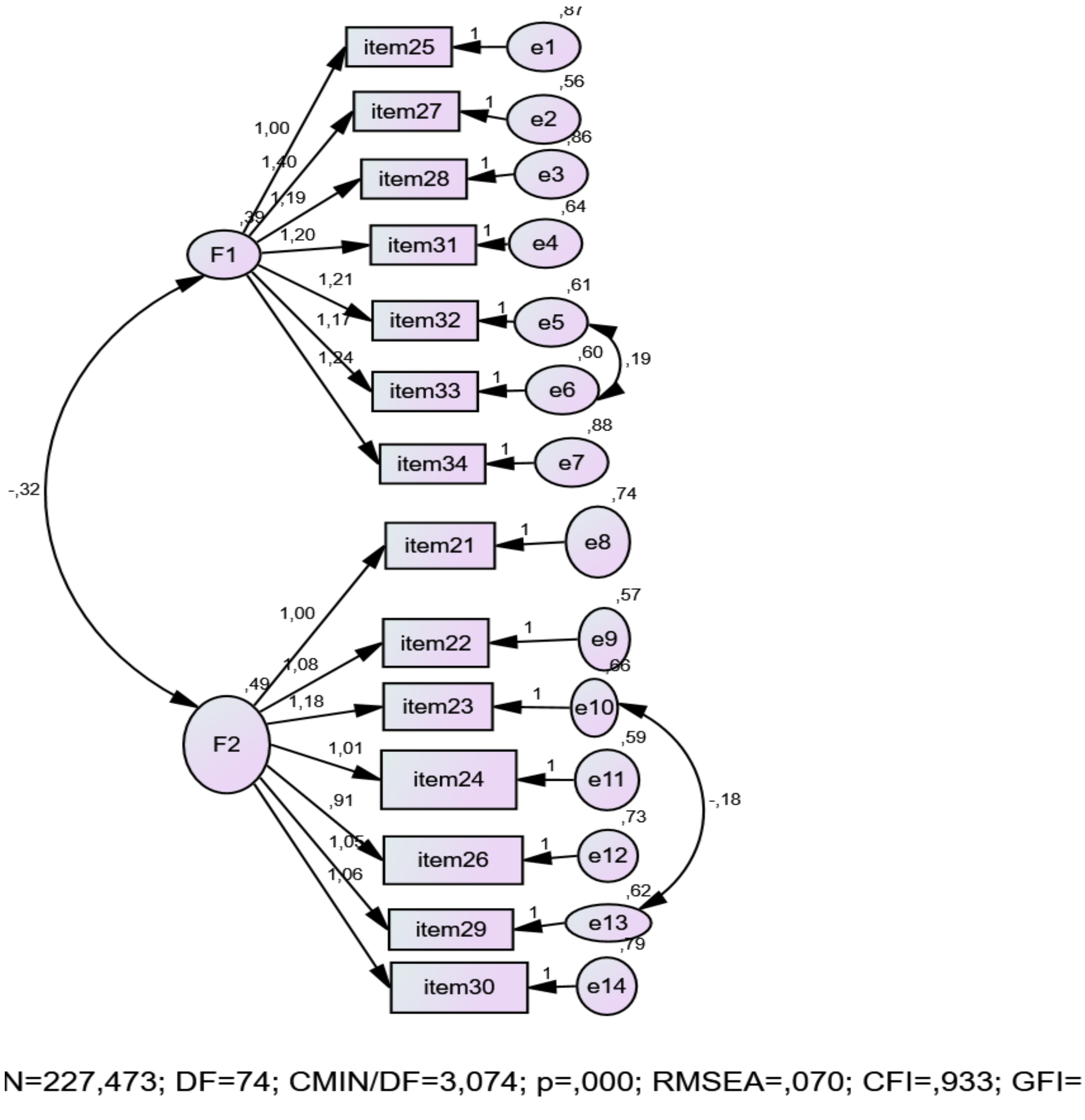

Figure 1. *Confirmatory factor analysis diagram for chemistry laboratory self-efficacy beliefs scale*

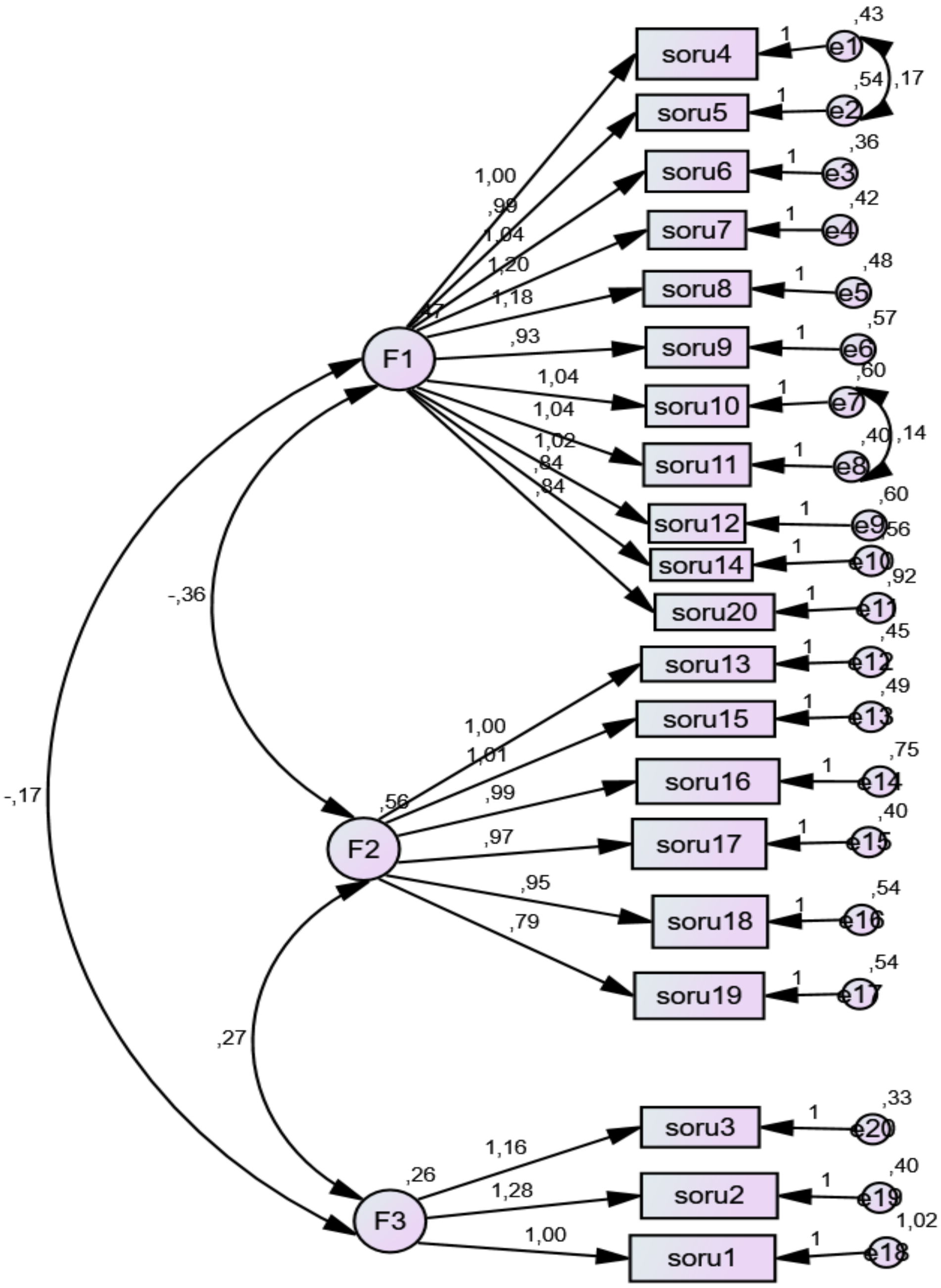

Figure 2. *Confirmatory factor analysis diagram for perceptions on laboratory applications scale*

Table 2. *Sample items and reliability coefficients for each subscale of the scales.*

Scale	Subscale	Sample item	Number of item	Cronbach's α in the original study	Cronbach's α in the current study
CLSEB	Cognitive self-efficacy beliefs (Seb1)	I have problems in converting the units used in the chemistry into each other in the laboratory	7	0.82	0.85
	Psychomotor self-efficacy beliefs (Seb2)	I can record the data that I obtain from the experiments in the laboratory.	7	0.85	0.84
PLA	Goals of laboratory (PL1)	Abstract concepts are embodied by experiments in the laboratory.	11	0.92	0.91
	Effectiveness of laboratory (PL2)	Laboratory work disrupts classroom discipline.	6	0.80	0.85
	Planning (PL3)	Laboratory studies reduce the time devoted to chemistry class.	3	0.70	0.71

Table 3. *Descriptive statistics for the observed variables.*

Observed variables	Mean	5% Trimmed mean	SD	Min	Max	Skew.	Kurt.
The goals of laboratory (PL1)	4.08	4.13	.72	1.00	5.00	-.994	1.378
The effectiveness of laboratory (PL2)	1.74	1.68	.73	1.00	5.00	1.069	.562
Planning (PL3)	1.87	1.81	.76	1.00	5.00	1.017	1.241
Cognitive self-efficacy beliefs (Seb1)	2.26	2.23	.79	1.00	5.00	.527	.205
Psychomotor self-efficacy beliefs (Seb2)	3.51	3.53	.82	1.00	5.00	-.181	.052

Note: Skew. = Skewness; Kurt. = kurtosis.

Table 4. *Correlation between sub-dimensions.*

	PL1	PL2	PL3	Seb1	Seb2	Gender	Class
PL1	1	-,618(**)	-,362(**)	-,445(**)	,543(**)	-,178(**)	-,129(**)
PL2		1	,497(**)	,583(**)	-,369(**)	,212(**)	,119(*)
PL3			1	,338(**)	-,228(**)	,127(**)	,084
Seb1				1	-,613(**)	,100(*)	,109(*)
Seb2					1	-,031	-,077
Gender						1	,308(**)
Class							1

**Correlation is significant at the 0.01 level (2-tailed)

Table 5. *MANOVA Analysis of Dependent Variables*

	Interaction	Value	F	Hypothesis Sd	Error Sd	p*	η^2
Gender	Pillai's Trace	.048	4.054	5	398	.001*	.048
Class	Pillai's Trace	.047	1.269	15	1200	.214	.016
Gender*Class	Pillai's Trace	.046	1.249	15	1200	.228	.015

*p<0.001

Table 6. *Sub-Dimensions Variance Analysis Results*

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	p	η^2
Grup	Seb1	.643	1	.643	1.193	.275	.003
	Seb2	.002	1	.002	.004	.950	.000
	PL1	3.757	1	3.757	8.508	.004	.021
	PL2	7.594	1	7.594	14.633	.000	.035
	PL3	2.357	1	2.357	4.892	.028	.012