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Investigation of Engineering Students' Attitudes Towards Mathematics According to Various Variables

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Abstract: Engineering is a discipline that plays an important role in finding solutions to the complex problems of the modern world by using mathematical structures and principles. On the other hand, mathematics generally stands out as a course where students' attitudes may be negative. Research indicates that students' positive attitudes towards mathematics generally lead to higher academic achievement and professional motivation, while their negative attitudes can lead to experience difficulties in mathematics and related courses. This study aims to determine the level of engineering students' attitudes towards mathematics and to examine whether these attitudes differ according to various variables. The study was conducted with 382 undergraduate students from various departments of the engineering faculty of a foundation university in Türkiye. *Attitudes Towards Mathematics Scale* was used as data collection tool. Statistical analysis of the data revealed that the attitudes of engineering students towards mathematics were positive. Additionally, it was found that there was a low level of difference in favor of females in terms of attitudes towards mathematics, there was no significant difference according to department and grade variables, and students registered in the university with undergraduate placement examination scores had significantly higher averages.

Keywords: Attitude towards mathematics, Engineering students, Gender, Department, University entrance exam

1. Introduction

Attitudes, which are a subject of extensive research in the field of social psychology and education, are considered to be an important factor that directly affects individuals' behavior, learning processes and academic achievement. Attitude is a psychological concept that expresses individuals' tendencies and emotional reactions towards certain objects, people, events or issues. Particularly in the educational context, students' attitudes towards particular courses or disciplines can greatly shape their performance and motivation to learn in these areas (Ajzen, 2005).

Mathematics stands out as a course that is perceived as difficult to learn and where students' attitudes can often be negative. Attitude towards mathematics is a combination of emotional, cognitive and behavioral tendencies that students develop towards mathematics courses (Ma & Kishor, 1997). These attitudes can affect students' interest in mathematics courses, their success in the course, and their mathematics-related career goals (Neale, 1969). While a positive mathematics attitude enables students to be more self-confident in their approach to mathematics problems, a negative attitude may lead to a tendency to avoid mathematics lessons, which may negatively affect academic achievement in the long term (Hannula, 2002).

Engineering is a discipline that plays an important role in the construction and development of civilizations and finding solutions to the complex problems of the modern world. Based on this importance of engineering, Dym, Agogino, Eris, Frey and Leifer (2005) emphasized that engineering education should be in a way that produces engineers who can design effective solutions to meet social needs. In addition, US Department of Labor (2007) defines engineering as the application of science and mathematics principles to develop economic solutions to technical problems. From this definition, we can say that mathematics stands out as one of the basic building blocks of engineering education in training qualified engineers. Engineers use a wide range of mathematical structures and principles, from design to analysis, optimization to problem solving. Therefore, mathematics education is considered a determining factor in the professional success of engineering students. Mathematics is seen not only as a tool in engineering education, but also as a language that facilitates the understanding and application of engineering concepts (Hodge, 2019). Solving engineering problems with an analytical approach, basic skills such as numerical calculations and modeling require a deep understanding of mathematical knowledge (Flegg, Mallet & Lupton, 2012). Indeed, within the scope of a research project on engineering education, many engineers stated that it is important for them to understand the mathematical

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and scientific foundations behind the software tools and techniques they use and the ability to verify the quantitative results of simulations (King, 2008). On the other hand, deficiencies in basic mathematical skills also cause problems for those studying engineering. In addition, engineering students' attitudes towards mathematics also have a significant impact on their overall academic performance and their preparedness for the challenges they will encounter in their engineering careers.

In the literature, there are many studies examining the relationship between attitudes towards mathematics and various demographic factors (gender, age, socioeconomic status, etc.) or such as academic achievement, self-efficacy and problem-solving skills on different samples. For example, some of them state that attitudes towards mathematics do not differ significantly in terms of gender (Çelik & Bindak, 2005; McGraw, Lubienski & Strutchens, 2006; Öztürk & Şahin, 2015; Sarpkaya, Arık & Kaplan, 2011), there is a significant positive relationship between mathematics achievement and attitudes towards mathematics (Ajisuksmo & Saputri, 2017; Cain-Caston, 1993; Karadeniz & Kelleci, 2015; Tapia & Marsh, 2000; Yücel & Koç, 2011), and students who develop positive attitudes towards mathematics also have good problem-solving skills and high motivation (Aşkar, 1986; Nahari, 2014; Norwich & Jaeger, 1989).

Some of the studies examining attitudes towards mathematics in Türkiye are as follows: Akın (2002), in his study conducted with 4th, 5th, 6th, 7th and 8th grade primary school students, found that there was no significant difference in students' attitudes towards mathematics course according to gender and school, but as the grade level increased, their attitude scores towards mathematics course decreased. Çelik and Bindak (2005), in their study with students of the primary school teaching department, determined that students' attitudes towards mathematics were similar according to gender, and that students with high mathematics success in the university exam also had higher mathematics attitude scores. Karadeniz and Kelleci (2015) in their study on students in different departments of a vocational college, found that there was no significant difference between students' attitudes towards mathematics and their ages, but there was a significant difference between their mathematics achievement levels and mathematics attitudes. Sarpkaya, Arık and Kaplan (2011) also revealed that there was a moderate, positive and significant relationship between primary school mathematics teacher candidates' attitudes towards mathematics and their awareness of using metacognitive strategies, and that their attitudes towards mathematics did not differ in terms of gender. Yıldız (2006) also stated in his study that high school seniors or high school graduates who have positive attitudes towards mathematics are more successful in mathematics courses and prefer mathematics-oriented professions.

In studies examining engineering students' attitudes towards mathematics, it is seen that mostly first-year students (freshmen) are used as the sample (Alibraheim, 2021; Giannoulas & Stampoltzis, 2021; Morán-Soto & Benson, 2018; Nahari, 2014; Shaw & Shaw, 1997). In research, the relationship between attitudes towards mathematics and students' academic achievements, motivations for engineering education, general professional expectations and various demographic variables have been examined. Some of these studies and their results are as follows: Nahari (2014), in his study examining the mathematics skills and attitudes of first-year engineering students, did not observe a difference between the attitude scores towards mathematics according to the pre-test and post-test results. The study also determined that students had high levels of positive attitudes towards mathematics, low levels of mathematics anxiety and motivation to be successful. Zsoldos-Marchis and Ciascai (2017) compared the attitudes of pre-school and primary school teaching department students with technical university students towards mathematics and found that there was a small difference between the two groups in favor of technical university students, and half of the students thought they liked and knew mathematics. Alibraheim (2021) examined the factors affecting the attitudes of first-year engineering students towards mathematics. As a result of the research, he stated that the reasons shaping students' attitudes towards mathematics can be divided into two parts such as internal and external. Accordingly, he stated that internal reasons are reasons arising from the students themselves, such as practice, preparation, evaluations, grades and time management, while external reasons can be said to be the characteristics of teachers and parental support. In Türkiye, there is no study examining engineering students' attitudes towards mathematics.

Research shows that students' positive attitudes towards mathematics generally lead to higher academic achievement and professional motivation, while their negative attitudes cause them to experience difficulties in mathematics and related courses. In this regard, examining attitudes towards mathematics is important in terms of providing insight into how mathematics is taught and how it should be taught. This study was conducted to determine the level of engineering students' attitudes towards mathematics and to examine whether these attitudes differ according to various variables. In this context, it is thought that the findings and results of the study will shed light on the measures to be taken and the plans to be made, especially in training engineers who have an important role in the construction and development of civilizations. In addition, the lack of a study examining engineering students' attitudes towards mathematics according to various variables in Türkiye is also important in terms of the contribution of this study to the literature.

Depending on the purpose of the study, answers will be sought to the following problems:

1) What is the level of engineering students' *attitudes towards mathematics*?
2) Is there a significant difference between engineering students' *attitudes towards mathematics* according to *gender* variable?
3) Is there a significant difference between engineering students' *attitudes towards mathematics* according to *department* variable?
4) Is there a significant difference between engineering students' *attitudes towards mathematics* according to *grade* variable?
5) Is there a significant difference between engineering students' *attitudes towards mathematics* according to *exam type* variable?

2. Method

In this study, descriptive comparative research model, one of the quantitative approaches, was used. The purpose of descriptive studies is to describe individuals, events or conditions by examining them as they are in their environment. The researcher simply defines the sample and/or variables without manipulating any variables (Edmonds & Kennedy, 2016). In this study, the independent variables were determined as *gender*, *department*, *grade* and *exam type*.

2.1. Study Group

Although there are differences between universities across Türkiye, in general, as basic mathematics all engineering students takes *Calculus-1* and *Calculus-2* in the 1st year, *Linear Algebra* and *Differential Equations* courses in the 2nd year. In addition to these courses, each department offers additional mathematics courses such as *Discrete Computational Structures*, *Numerical Analysis*, *Applied Engineering Mathematics* or *Probability & Statistics* according to the needs of the department. Basic mathematics courses, defined as service courses, are generally given by instructors who are mathematics experts, and other additional mathematics courses are given by engineering-based instructors in the departments. This is also the case for the university where the study was conducted.

A total of 382 undergraduate students studying in different departments of the engineering faculty of a foundation university in Türkiye and selected by random sampling participated in the study. The distribution of the participants according to the independent variables of *gender*, *department*, *grade* and the *exam type* is given in Table 1, respectively.

Table 1. Distribution of participants according to independent variables

Variable	Category	N	%
Gender	Female	107	28
	Male	275	72
Department	Computer	55	14.4
	Mechanical	45	11.8
	Mechatronics	66	17.3
	Materials and Nano Technology	13	3.4
	Civil	88	23
	Industrial	46	12
	Electrical-Electronics	69	18.1
Grade	1st	122	31.9
	2nd	136	35.6
	3rd	47	12.3
	4th	77	20.2
Exam Type	UPE	327	85.6
	VTE	34	8.9
	FSE	21	5.5
Total		**382**	**100**

Three different exam categories were used for the *exam type* variable. These exam categories can be explained as follows: Undergraduate Placement Exam (UPE) attended by those in their final year of high schools or at least a high school graduate in Türkiye, Vertical Transfer Exam (VTE) attended by those in their final year of vocational colleges or at least a vocational college graduate, and Foreign Student Examination (FSE) attended by students who are studying or graduated in high schools outside Türkiye. According to the results of these exams, students who enroll in universities with UPE and FSE scores continue their education from the 1st year of engineering departments, and those who enroll with VTE scores continue their education from the 3rd year.

2.2. Data Collection Tools

Descriptive methods use scales or surveys to obtain information from participants. In this study, a scale was used as a data collection tool. Scales are useful in situations where the researcher is interested in perceptions, beliefs, attitudes, or opinions (Edmonds & Kennedy, 2016). In addition, a Personal Information Form (PIF) was also used to obtain participants' information about the variables of gender, department, grade and the type of exam taken for university registration.

2.2.1. Attitude Towards Mathematics Scale

In this study, the *Attitude Towards Mathematics Scale* (ATMS) developed by Çelik and Bindak (2005) was used to determine the attitudes of engineering students towards mathematics. The scale has been used in different studies before. 5-point Likert type scale has 20 items, and 10 of the items are negative. Likert scale scores are (1) strongly disagree, (2) disagree, (3) undecided, (4) agree (5) strongly agree. Prior to analyses, reverse coding was performed for negative items. The lowest attitude score that can be obtained from the scale is 20 and the highest attitude score is 100. Accordingly, the agreement level ranges are as follows: 20-35 → strongly disagree, 36-51 → disagree, 52-67 → undecided, 68-83 → agree, 84-100 → strongly agree. Çelik and Bindak (2005) calculated the Cronbach reliability coefficient of the scale as α = 0.882. In this study, the reliability analysis of the scale was conducted again, and the Cronbach reliability coefficient was calculated as α = 0.883. This value is considered “good” according to George and Mallery (2003).

2.3. Data Collection

Research data was collected in written form in face-to-face environments in the fall semester of the 2019-2020 academic year. Participants were allowed to answer PIF and ATMS in a single session. Application time was approximately 15 minutes.

2.4. Data Analysis

The descriptive comparative research model includes both descriptive and inferential statistics. Descriptive statistics include frequencies, arithmetic means and standard deviation values, etc., inferential tests are parametric or non-parametric tests depending on the data level and data distribution. The answers given to PIF and ATMS were entered into the SPSS 27.0 program and analyzed. Before the analysis of the data, *skewness* and *kurtosis* values were examined to determine whether ATMS scores showed a normal distribution according to the independent variables. *Skewness* and *kurtosis* values obtained for ATMS scores are given in Table 2.

Table 2. Skewness and kurtosis values of ATMS scores according to independent variables

Variable		Skewness	Kurtosis
Gender	Female	– 0.574	0.052
	Male	– 0.377	0.199
Department	Computer	– 0.549	0.333
	Mechanical	– 0.700	0.439
	Mechatronics	0.094	– 0.640
	Materials and Nano Technology	– 0.096	– 0.539
	Civil	– 0.345	0.573
	Industrial	– 0.820	0.596
	Electrical-Electronics	– 0.319	– 0.783
Grade	1st	– 0.735	0.487
	2nd	– 0.345	0.096
	3rd	– 0.328	0.687
	4th	0.072	– 0.597
Exam Type	UPE	– 0.530	0.435
	VTE	0.028	– 0.368
	FSE	0.037	– 0.844

Since the *skewness* and *kurtosis* values in the table are between – 1.5 and + 1.5, it can be said that the data has a normal distribution, according to Tabachnick and Fidell (2013). The homogeneity of the variances was examined with the *Levene's test,* and it was seen that the variances of all variables were homogeneous. Due to the fulfillment of assumptions, parametric tests, *independent samples t-test* and *one-way ANOVA* were used in the analysis. In cases where there was a significant difference as a result of the tests, the effect size was determined by calculating *Cohen's d* (for independent samples t-test) and *Eta-square* effect factor values (for one-way ANOVA). Since the group sizes are different from each other, *Gabriel's pairwise test* was used as a post-hoc test for comparisons between groups.

3. Findings

In this section, findings regarding the sub-problems of the research are presented.

3.1. Findings Regarding 1st Sub-Problem

The results of the descriptive analysis related to the sub-problem "What is the level of engineering students' *attitudes towards mathematics*?" are given in Table 3.

Table 3. Descriptive analysis results for engineering students' ATMS scores

	N	min	max	M	Sd	Attitude level
Attitude score	382	31	100	73.82	11.78	Agree

Table 3 shows that the mean of ATMS scores (M = 73.82, Sd = 11.78) of engineering students is at the "Agree" level.

3.2. Findings Regarding 2nd Sub-Problem

The results of the independent samples t-test conducted to answer the sub-problem "Is there a significant difference between engineering students' scores of *attitudes towards mathematics* according to *gender* variable?" are given in Table 4.

Table 4. Independent samples t-test results of ATMS scores according to *gender* variable

Gender	N	min	max	M	Sd	df	t	p
Female	107	41	96	75.96	10.91	380	2, 232	0.026
Male	275	31	100	72.98	12.01			

From Table 4, it can be seen that the mean of ATMS scores of female students is higher than male students (respectively M = 75.96, Sd = 10.91 and M = 72.98, Sd = 12.01) and this difference is statistically significant ($t\ (380) = 2.232$; $p < 0.05$). *Cohen's* effect factor value calculated to determine the level of this difference was found as $d = 0.254$. This value was defined as a "low level" effect according to Cohen (1988).

3.3. Findings Regarding 3rd Sub-Problem

The descriptive analysis and one-way ANOVA results performed to answer the sub-problem "Is there a significant difference between engineering students' *attitudes towards mathematics* according to the *department* variable?" are given in Table 5 and Table 6.

Table 5. Descriptive analysis results of ATMS scores according to *department* variable

Department	N	min	max	M	Sd
Computer	55	31	96	70,78	14,10
Mechanical	45	44	92	72.16	10.72
Mechatronics	66	51	96	74.14	11,13
Materials and Nano Technology	13	55	92	74.85	10.54
Civil	88	42	100	74.59	11,13
Industrial	46	41	95	76.67	11.73
Electrical-Electronics	69	48	94	73.93	11.92
Total	382			73.82	11.78

Table 6. One-way ANOVA results of ATMS scores according to *department* variable

Source	Sum of squares	df	Mean of squares	F	p
intergroup	1080,396	6	180,066	1,303	0.255
within groups	51804,777	375	138,146		
Total	52885,173	381			

From Table 5, it can be seen that the students of the industrial engineering department had the highest mean ATMS score (M = 76.67, Sd = 11.73), and the lowest mean ATMS score (M = 70.78, Sd = 14.10) was obtained by computer engineering students. However, according to the results in Table 6 this difference is not statistically significant ($F (6,375) = 1.303; p > 0.05$).

3.4. Findings Regarding 4th Sub-Problem

The descriptive analysis and one-way ANOVA results performed to answer the sub-problem "Is there a significant difference between of engineering students' *attitudes towards mathematics* according to the *grade* variable?" are given in Table 7 and Table 8.

Table 7. Descriptive analysis results of ATMS scores according to *grade* variable

Grade	N	min	max	M	Sd
1st	122	31	97	74.29	12.94
2nd	136	41	96	75.21	10,13
3rd	47	42	100	72.34	11.62
4th	77	44	96	71.51	12.44
Total	382			73.82	11.78

Table 8. One-way ANOVA results of ATMS scores according to *grade* variable

Source	Sum of squares	df	Mean of squares	F	p
intergroup	805,598	3	268,533	1,949	0.121
within groups	52079,575	378	137,777		
Total	52885,173	381			

From Table 7, it can be seen that the highest mean ATMS score (M = 75.21, Sd = 10.13) was obtained by the 2nd grade students, and the lowest mean ATMS score (M = 71.51, Sd = 12.44) was obtained by students in the 4th grade, and the mean ATMS scores decreased for overall after the 2nd grade. However, according to the results in Table 8, it is understood that this difference is not statistically significant ($F (3,378) = 1.949; p > 0.05$).

3.5. Findings Regarding 5th Sub-Problem

The descriptive analysis and one-way ANOVA results performed to answer the sub-problem "Is there a significant difference between the engineering students' *attitudes towards mathematics* according to *exam type* variable?" are given in Table 9 and Table 10.

Table 9. Descriptive analysis results of ATMS scores according to the *exam type* variable

Exam Type	N	min	max	M	Sd
UPE	327	31	100	74.52	11.68
VTE	34	47	94	69.94	11.56
FSE	21	46	90	69.14	12.03
Total	382			73.82	11.78

Table 10. One-way ANOVA results of ATMS scores according to the *exam type* variable

Source	Sum of squares	df	Mean of squares	F	p
intergroup	1131,098	2	565,549	4,142	0.017
within groups	51754.075	379	136,554		
Total	52885,173	381			

From Table 9, it can be seen that the mean ATMS score (M = 74.52, Sd = 11.68) of the students who enrolled in the university with their UPE scores, is higher than students who registered with their VTE score and FSE score (respectively, M = 69.94, Sd = 11.56 and M = 69.14, Sd = 12.03). From Table 10, it can be seen that this difference is statistically significant ($F (2,379) = 4.142; p < 0.05$). In addition, the *Eta-square* effect value was also calculated as $\eta^2 = 0.021$. This value was defined as a "low level" effect according to Cohen (1988). *Gabriel's pairwise test* was conducted to determine which exam types of this difference was between. According to the test results, it was found that there is a significant difference ($p < 0.05$) between the students enrolled in the university with UPE scores and those of students enrolled with VTE scores.

4. Results

As the results of the findings related to the sub-problems the following can be said: Engineering students' *attitudes towards mathematics* are positive. There is a low level of difference between attitude scores of male and female engineering students towards mathematics in favor of females. There is no significant difference between engineering students' *attitudes towards mathematics* according to the *department* and *grade* variables. In addition, the attitudes towards mathematics of students enrolled in the university with UPE scores are higher than those of students enrolled with VTE scores with a low level of significance.

5. Discussion

This study aimed to examine engineering students' attitudes towards mathematics according to various variables. Accordingly, for the first sub-problem of the study, it was concluded that engineering students' attitudes towards mathematics were positive. This result coincides with the results obtained in the studies of Nahari (2014), Zsoldos-Marchis and Ciascai (2017), and Alibraheim (2021). This may be a result of the fact that students who choose a discipline where mathematics is frequently used, such as engineering, have positive attitudes towards mathematics in their previous school periods. As a matter of fact, Morán-Soto and Benson (2018) stated that engineering students have high mathematics self-efficacy beliefs starting from high school and that they believe that they can perform well in university mathematics courses even if they have some deficiencies in mathematics competencies. Related to this situation, Yıldız (2006) also states that high school seniors or high school graduates who have a positive attitude towards mathematics prefer mathematics-oriented professions.

According to the result obtained for the second sub-problem of the study, it was determined that there was a low level of difference between female and male engineering students' attitudes towards mathematics in favor of females. This may be a result of female engineering students having positive attitudes towards mathematics in their previous school periods. In the literature, different results have been obtained in studies examining the change in attitudes towards mathematics according to gender. However, for example, in their study of first-year engineering students, Giannoulas and Stampoltzis (2021) stated that women received higher mathematics attitude scores than men, depending on the previous experience factor.

As a result of the third sub-problem of the study, it was seen that there was no significant difference between the engineering students' attitudes towards mathematics according to the department variable. This may be due to the fact that the university entrance exam scores as a basis for registration in different engineering departments are similar, that is, students with similar pre-university academic achievements prefer different engineering departments. At the same time, the fact that basic mathematics courses at the faculty are given by the same instructors in mixed classes consisting of students from different departments and the exams are common for all departments may also have an effect on this situation. In the literature, no research has been found that compares the attitudes of engineering students towards mathematics according to departments.

From the result obtained for the fourth sub-problem of the study, it is understood that there is no significant difference between the attitude scores of engineering students towards mathematics according to the grade variable. In other words, it can be said that there is no significant change in the attitudes towards mathematics of students who have just started their engineering education and those who are close to graduation. In addition, it is an interesting finding that the attitudes towards mathematics decrease in the following grades compared to the 1^{st} and 2^{nd} grades. From these results, we can conclude that the courses given during engineering education do not have a positive contribution to the attitude towards mathematics. This situation is consistent with McLeod's (1989) idea that, unlike daily attitudes towards mathematics, which are sensitive to classroom factors and can change frequently, beliefs about mathematics are more deep-rooted and stable and, accordingly, more resistant to change. On the other hand, the lack of a sufficient relationship between engineering and mathematics in the courses given may have caused this situation. As a matter of fact, regarding this situation, Cardella (2007) stated that some practicing engineers believe that the mathematics they learned at university cannot be applied to their daily work.

From the results obtained for the fifth sub-problem of the study, it is understood that the attitudes towards mathematics of the students enrolled in the university with UPE scores are significantly higher than those of the students enrolled with VTE scores. The majority of students who cannot obtain sufficient UPE scores to enroll in 4-year engineering departments in Türkiye enroll in 2-year colleges of relevant fields, and some of the graduates of these colleges can transfer to 4-year departments with VTE. Accordingly, we can say that students enrolled in engineering departments with VTE have fewer positive attitudes towards mathematics because they have lower mathematics achievement than others. In fact, there are studies in the literature (Ajisuksmo & Saputri, 2017; Tapia & Marsh, 2000) showing that mathematics achievement and attitude towards mathematics are positively correlated with each other.

6. Conclusion and Recommendations

As a result of this research, it is desired and expected that engineering students' attitudes towards mathematics are found to be positive. On the other hand, the fact that attitudes towards mathematics declined in the following grades leads us to think that the courses given during engineering education do not have a positive contribution to attitude towards mathematics. In addition, the fact that students enrolled in engineering departments with VTE scores have relatively lower attitudes towards mathematics suggests that the structure and content of this exam should be reviewed. We can make the following suggestions in order to develop attitudes of engineering students towards mathematics positively and to train more qualified engineers:

- Winkelman (2009) states that, mathematics is abstract, and it enters real life only through modelling. Modeling should also be taught along with mathematics, not after it. In other words, mathematics courses in engineering departments should be given in association with engineering applications.
- All faculty members, especially engineering-based instructors, should put mathematical concerns at the center of all their teaching, and in engineering courses other than mathematics courses, they should focus on the relationship of mathematics with the concept and subject explained, instead of using mathematics only as a calculation tool. In this way, the negative beliefs held by some engineers that mathematics cannot be applied in daily work can be prevented.
- Methods such as problem-based learning, multidisciplinary approach, computer-based methods, project-based learning and active learning should be used in teaching mathematics to students of engineering.
- Conducting studies to compare the mathematics self-efficacy, mathematics anxiety, beliefs and attitudes towards mathematics courses of engineering students in different departments and at different grade levels will contribute to shaping engineering education.
- Since similar studies have not been conducted specifically in Türkiye, conducting them with engineering faculty students from different universities will fill the gap in the literature.

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Conflict of Interest

It has been reported by the author that there is no conflict of interest.

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