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MÜHENDİSLİK ÖĞRENCİLERİNİN İSTATİSTİĞE KARŞI TUTUMLARI: ÇOKLU DURUM ÇALIŞMASI

Kadir SARIKAYA* **Esma EMMİOĞLU SARIKAYA****

ÖZ: Bu çalışma Türkiye'de bir üniversitede elektrik-elektronik ve harita mühendisliği alanlarında eğitim alan öğrencilerinin istatistiğe karşı tutumunu araştırmaktadır. Veri toplamak için İstatistiğe Yönelik Tutum Anketi-36 (İYTA-36) kullanılmıştır. Çalışma, 62 mühendislik öğrencisi (38 Erkek ve 24 Kadın) ile yapılmıştır. Öğrenciler, elektrik-elektronik veya harita mühendisliği bölümü ikinci sınıfında kayıtlı olup daha önce üniversite seviyesinde istatistik dersi almamıştır. Hem elektrik-elektronik hem de harita mühendisliği öğrencilerinin genellikle istatistiğe karşı olumlu tutumları bulunmakla birlikte, dönem sonunda harita mühendisliği öğrencilerinin elektrik elektronik mühendisliği öğrencilerine göre göre daha fazla nötr olma eğilimi gösterdiği tespit edilmiştir.

Anahtar Kelimeler: Yüksek Eğitim, Mühendislik Eğitimi, İstatistik Eğitimi, İstatistiğe Yönelik Tutum
Jel Sınıflandırması: I21, I23
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ENGINEERING STUDENTS' ATTITUDES TOWARD STATISTICS: A MULTI-CASE STUDY

ABSTRACT: This study investigated the attitudes toward statistics of the electrical & electronics engineering and geomatic engineering students who were enrolled in a Turkish university. Survey of Attitudes toward Statistics-36 (SATS) was used to collect data. The participants of the study were 62 Engineering students (38 male and 24 female). They were sophomore students enrolled in either electrical & electronics engineering (n=28) or geomatic engineering (n=34) departments and had not taken a university level statistics course before. Both electrical & electronics engineering students and geomatic engineering students generally had positive attitudes toward statistics; however, geomatic students tended to have more neutral attitudes at the end of the semester.

Key Words: *Higher Education, Engineering Education, Statistics Education, Attitudes Toward Statistics.*
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1. INTRODUCTION

The field of statistics deals with the collection, presentation, analysis, and use of data to make decisions, solve problems, and design products and processes (Montgomery, 2003). Statistics is the main means for gaining insights of the data and its variability. Accordingly, for understanding the source of variability in data and for exploiting it to make decisions, statistics is a must have.

Engineers make use of data to alleviate everyday life of humans. For example, before designing a new product and/or a process, data must be collected and presented. Every engineering system has inputs, outputs, and processes. The outputs' quality and quantity depend mostly on inputs' quality and quantity. There may also be controlled variables and the uncontrollable variables in the system. To understand the system at hand and its variability caused by uncontrolled variables, the engineer should have a statistical thinking mindset. Statistics is also used for forecasting purposes in engineering. In order to design new products and processes, engineers should predict the future by using trends in the data. Thus, statistics can be named as a common language among different engineering fields and engineers must know this language: statistics.

As statistics is an important tool for engineers, an introductory statistics course is a must course for undergraduate level engineering students. Accordingly, it is expected that these students succeed in statistics and have positive attitudes toward statistics at the end of their education (Ramirez, Schau, & Emmioglu, 2012). This study investigated electrical & electronics engineering and geomatics engineering students' attitudes toward statistics in the context of a mid-size Turkish university located in Black Sea region.

2. LITERATURE REVIEW

Attitudes toward statistics is defined as a multidimensional construct representing students' learned predispositions to respond positively or negatively to statistics (Emmioglu & Capa-Aydin, 2012). Many studies have shown that there is a statistically significant relationship between achievement and attitudes toward statistics (e.g., Chiesi & Primi, 2009; Milic et al., 2016; Stanisavljevic et al., 2014; Zimprich, 2012). Students' attitudes are also accepted as equally or even more important as achievement in statistics. For example, Ramirez, Schau, & Emmioglu (2012) state that students might forget what they learn but they do not forget their attitudes, and attitudes help them to keep using what they have learned and to keep them learning.

Studies investigating students' attitudes toward statistics were mostly collected data from different disciplines other than engineering such as business, psychology, and health sciences (e.g., Carlson & Winquist, 2011, Chiesi & Primi, 2009; Gundlach et al 2015; Griffith et al., 2012). These studies showed that using technology (Huynh, Buglin, & Bedford, 2014; Loux, Varner, & VanNatta, 2016) and use of real examples related to students' field or life (Kiekkas et al., 2015; Neumann, Hood, & Neumann, 2013); use of classroom workbooks (Carlson & Winquest, 2011), and use of alternative assessment methods (Posner, 2011) might help students to have more positive attitudes toward statistics. However, some studies showed that students' attitudes toward statistics generally declines throughout the semester (Schau & Emmioglu, 2012); even though, interventions have been made (Carnell, 2008).

There is an abundance of research on engineering students' achievement; however, studies investigating engineering students' statistics attitudes are limited in number. For example, as of October 2019, using "engineering education" and "achievement" as keywords in databases (i.e., ERIC, SSCI, JSTOR, SCI) revealed 3501 studies, when using "engineering" and "attitudes toward statistics" in keywords in same databases revealed only seven studies. Studies conducted with engineering students showed that engineering students' attitudes toward statistics were correlated with their achievement in statistics (Rhoads and Hubele, 2000), students from different engineering fields might differ in terms of their attitudes toward statistics (Rhoads and Hubele, 2000), use of real examples related to students' field (Rhoads and Hubele, 2000), and use of active learning approach and technology might help students to have more positive attitudes toward statistics (Adair, Jaeger, & Price, 2018; Moskal, 2015); however, decline in students' attitudes toward statistics throughout the semester is also expected (Lauriski-Karriker, Nicoletti & Moskal, 2013).

3. MATERIAL AND METHODS

3.1. Data Collection Instrument

Survey of Attitudes toward Statistics (SATS) that was developed by Schau et al. (1995) and translated to Turkish culture by Emmioglu et al. (2018) was used to collect data. SATS-36 is the most current and widely used survey that measures attitudes toward statistics. It has been translated into many languages. Both the adapted and the original versions of SATS have yielded good psychometric properties (e.g., Barkatsas, Gialamas, & Bechrakis, 2009; Chiesi & Primi, 2009; Hilton, Schau, Olsen, 2004; Tempelaar, Schim Van der Loeff, & Gijselaers, 2007).

SATS includes a 7-point Likert type scale that measures attitudes toward statistics in 6 dimensions: Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort. Scores higher than the neutral value of 4.5 on SATS components indicate positive attitudes toward statistics. Therefore, it is important to note here that higher scores on difficulty component indicate that students think that statistics is not a difficult subject. Affect measures students' feelings toward statistics and has six items (e.g., I like statistics), cognitive competence measures "students' attitudes about their intellectual knowledge and skills when applied to statistics" (e.g., I can learn statistics.), value measures "students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life" (e.g., I use statistics in my everyday life.), difficulty measures "students' attitudes about the difficulty of statistics as a subject" (e.g., Statistics formulas are easy to understand), interest measures "students' level of individual interest in statistics" (e.g., I am interested in using statistics.), and effort measures the "amount of work the student expends to learn statistics" (e.g., I plan to work hard in my statistics course.) (Millar & Schau, 2011, p.77). SATS-36 also includes additional items such as achievement in mathematics and hours of studying statistics out of class. In the current study, we also included an open-ended item to original post-SATS-36, which is "Do you think your attitudes toward statistics change throughout the semester? If so, why, please explain your answer".

3.2. Participants

The participants of the study were 62 Engineering students (38 male and 24 female) enrolled in either electrical & electronics engineering (n=28) or geomatic engineering (n=34) departments and taking Introductory Statistics course in autumn semester of 2018/2019 academic year. These students started their programs at the university in 2017. In 2007, in Turkey, students needed to pass a two-stage exam for university entrance. According to the higher education council's (Higher Education Council of Turkey, 2019) database, geomatic engineering and electrical & electronics engineering students' average correct answers in mathematics from the university entrance first stage exam were 11.9/12.8 out of 40 questions, respectively. In the second stage of the university entrance exam, the average numbers of the correct answers were 18.4/19.8 out of 80 questions respectively; indicating that, in general, participants' previous mathematics achievement were low.

3.3. Course

The Introductory Statistics course is a must course for both electrical & electronics engineering and geomatic engineering students. Students must attend 70% of the classes. One semester is 15 weeks long and includes a midterm exam at the 8th week of the semester. Every meeting has three hours lessons and each lesson takes 45-minutes followed up with a 15 minutes-break. Both midterm and final exams took place as open-book-exams and took 90 minutes. There were 4 -5 problems on the exams, and it was free to use calculator but no other electronical device.

During the lessons, the course materials were written on the board while explaining the details. Before erasing the board, instructor asked whether it was all clear or not for the students. After giving theoretical backgrounds and/or definitions for each subject, at least one problem was solved and explained thoroughly. The problems were carefully selected from real life or engineering applications of the subject. The students were encouraged to take notes during classes and requested to ask their questions during the classes or afterwards by sending e-mails to the professor or in person during office hours. Also, the textbook (Walpole et al., 2016) were suggested for further reading, which includes more exercises and problems with solutions provided.

There were 148 students enrolled in geomatic engineering class and 152 students in electrical & electronics engineering class. Out of the 148 students in geomatic engineering class only 77 were required to attend the classes when the remaining 71 students were not required to attend the class as they had already attended this course when they took it previously; but they had to take the exams to pass the course. Likewise, out of the 152 students from electrical & electronics engineering class, 81 students were obligated to attend the classes when the remaining 71 were only needed to take the exams. The instructor could not assign weekly assignments because there were many students in the classroom and the course does not have a Teaching Assistant to help with the reading of the assignments.

At the end of the semester, 23 students (29.87 %) from geomatic engineering did not to attend to the required amount of class hours and failed. Likewise, from 81 students of electrical & electronics engineering 31(31.27%) were directly failed for not attending the classes. The number of students' who attended the geomatic engineering class was between 50-60 and for electrical & electronics engineering it was between 60-70.

For the evaluation, 40% of midterm exam scores and 60% of final exam scores were taken and computed. If the calculated weighted average was over 60, the student passed the course. 33 students (22.30%) from geomatic engineering and 46 students (30.26%) from electrical & electronics engineering passed the class. Out of 100, the weighted averages of the all students attending the classes from geomatic engineering and electrical & electronics engineering were 33.81/40.01 respectively; indicating that, in general, statistics achievement of the students were low.

3.4. Data Collection Procedure

In this study, the Introductory Statistics course was taught by the first author of the study. The data collection was made by a third party who was not related to neither this study nor the instructor of the statistics course. The data were collected two times in order to examine whether there was a change in students' attitudes toward statistics throughout the semester. The paper and pencil form of pre and post versions of SATS-36 were administered at the beginning and at the end of the semester to the students in their regular classroom hours. The data collection took approximately 15 minutes. Students participated in the study on a voluntary base that they read and signed a consent form before the data collection.

3.5. Data Analysis

Descriptive statistics were used to present the frequencies and percentages of the students' self-reports of mathematics achievement and study hours for statistics. Mean and standard deviation values were presented for each component of the pre and post SATS-36. Correlations were computed to investigate the relationships among SATS-36 components, self-reports of mathematics achievement and hours students spend studying statistics a week out of class.

Repeated sample t-test was used to examine whether there was a statistically significant change from the beginning to the end of the semester, for electrical & electronics engineering students and for geomatic engineering students. Alpha level was set as .05 for all statistical tests. Assumptions of the repeated samples t-test were examined before running the analysis. Normal distribution for the post minus pre difference scores of the SATS components were checked by Skewness and Kurtosis values. The Skewness values for the component change scores ranged from -.380 to .260 and Kurtosis values ranged from -.776 to 1.048. As Skewness values were lower than 3.0 and Kurtosis values were lower than 10.0, it was assumed that the data distribution was close to normal (Kline, 2016). The potential outliers were inspected using the z-scores of the post-pre difference scores of the SATS components. Z-scores were between -2.89 and +2.55. As z-scores were between -3.0 and +3.0, it was assumed that there was no influential outlier on the dataset (Kline, 2016).

Qualitative data obtained from the open-ended item -Do you think your attitudes toward statistics change throughout the semester? If so, why, please explain your answer- have been analyzed by using descriptive qualitative analysis. Firstly, students' responses were organized in two groups: "yes" and "no". Students reports of why they think that their attitudes have (or not) changed are described and direct quotations from the students were presented.

4. RESULTS

4.1. Descriptive Statistics

4.1.1.Math Achievement

Students were asked how successful they were at mathematics. On a scale of 1 (very unsuccessful) to 7 (very successful), 24.8% of the electrical & electronics engineering students rated their math as unsuccessful (below 4) and 42.8 % of them rated their math success as successful (above 4); whereas, 67.6 % of the geomatic engineering students rated their math as successful , and 11% of them rated their math success as intermediate (rated as 4).

4.1.2.Study Hours

Students are asked how many hours a week they study for statistics out of class. Of all the electrical & electronics engineering students who provided an answer to this question (n=27), 4 (14.3%) students reported that they did not study for statistics at all and 17 (63%) the students reported that they studied for statistics 3 hours or less a week. Of the 33 geomatic students who answered the question, 3 (8.8.%) students reported that they did not study for statistics at all and 22 (66.7%) students reported that they studied for statistics 3 hours or less a week.

4.1.3. Electrical & Electronics Engineering Students' Attitudes Toward Statistics

At the beginning of the semester, electrical & electronics engineering students liked statistics (M=5.13, SD=1.13) but at the end of the semester they tended to have neutral feelings toward statistics (M=4.50, SD=1.05). Likewise, at the beginning of the semester they were interested in statistics (M=4.58, 1.57), when they had neutral interest in statistics at the end of the semester (M=4.46, SD=1.20). Their mean scores indicated positive attitudes both for the pre (M=5.48, SD= .87) and post (M=4.74, SD=1.12) Cognitive Competence, pre (M=5.26, 1.24) and post Value (M=4.83, SD=1.11) , and pre (M=5.60, SD=1.35) and post Effort (M=5.01, SD=1.40). They had neutral attitudes toward the difficulty of statistics both at the beginning (M=3.77, SD=1.07) and at the end of the semester (M=3.64, SD=.57).

4.1.4. Geomatic Engineering Students' Attitudes Toward Statistics

At the beginning of the semester, geomatic engineering students liked statistics (M=4.68, SD=.10), had cognitive competence in statistics (M= 4.98, SD= .98), valued statistics (M=5.20, SD= .89), interested in statistics (M=4.47, SD=1.42) and planned to put effort into learning statistics (M=5.99, SD=.95). However, they had negative attitudes toward the difficulty of statistics that they found statistics as a difficult subject (M=3.28, SD=.77). At the end of the semester these students tended to have neutral feelings about statistics (M=4.47, SD=1.06). Their interest in statistics got more neutral (M=4.23, SD=1.36). They no longer found statistics as a difficult subject but started to have neutral attitudes toward the difficulty of statistics (M=3.55, SD=.80). At the end of the semester, geomatic students kept their positive attitudes in terms of the value (M=4.86, SD= 1.05), effort (M=5.11, SD= 1.37), and cognitive competence (M=4.75, SD=.88) components.

4.2. Correlations

There was a statistically significant, medium relationship between self-reported mathematics achievement and effort (r=.294, p<.05) and cognitive competence (r=.327, p<.05) components. That is, students who think that they are good at mathematics reported that they are also good at statistics and they put effort into learning statistics. Hours students studied for statistics out of class were significantly correlated with affect (r=.264, p<.05, small relationship), value (r=.285, p<.05, small but close to medium relationship), interest (r=..315, p<.05, medium relationship) and effort (r=..330, p<.05, medium relationship) components (Table 1).

Table 1. Correlations Matrix

	postAffect	postCC	postValue	postDiff	postInterest	postEffort	study hours	math ach.
post Affect	1							
post Cognitive Competence	.656*	1						
post Value	.324*	.413*	1					
post Difficulty	.115	-.014	-.385*	1				
post Interest	.293*	.288*	.535*	-.226	1			
post Effort	.483*	.561*	.481*	-.379*	.357*	1		
study hours	.264*	.231	.285*	-.240	.315*	.330*	1	
math achievement	.191	.327*	.156	-.049	-.014	.294*	.062	1

***p<.05**

4.3. Repeated Samples t-Test

The results of the repeated samples t-test revealed that there was a statistically significant decrease in electrical & electronics students' affect, t(27)=2.56, p<.05, Cohen's d =.49,; and cognitive competence, t(27)=3.06, p<.05, Cohen's d=.57, throughout the semester. There was a statistically significant change in geomatic engineering students' attitudes toward the difficulty of statistics, t(33)=2.08, p<.05, Cohen's d=.36; and the effort they put into learning statistics, t(33)= 3.68, p<.05, Cohen's d=.58, throughout the semester. Effect sizes as computed by using Cohen's d formula (1988) indicated medium effect sizes for all statistically significant change, as Cohen's d values were between .2 and .8 (Table 2)

4.4. Qualitative Results

The number of electrical-electronics engineering students who reported that their attitudes have changed during the semester (f=10) were higher than the students who reported that their attitudes have not changed during the semester (f=7). Out of seven students who reported that their attitudes were the same, only two students provided an explanation for their answers. One of them stated that "I still think that statistics can be handled when studied", when other student stated that "statistics was a course I have never been interested in and I still cannot overcome my prejudice about it". Out of ten students who stated that their attitudes had changed, nine students explained the reasons for this change. Of these students, some students (f=2) stated that at the end of the semester they found statistics as a difficult course; when some (f=3) became more confident as they felt they understood statistics, and some students (f=3) came into the realization of the value of statistics in daily life use; for example, one student stated "I now have a different point of view about the news on TV and internet".

The number of geomatic students who reported that their attitudes have changed during the semester (f=15) were higher than the students who reported that their attitudes have not changed during the semester (f=7). Of the students who reported that their attitudes were the same, one students stated that s/he is still neutral about statistics, when two students stated that they "still do not like statistics" and another two students stated that they "do not understand statistics and find it as a difficult subject", whereas one student stated that s/he is "still happy about statistics". From the students who stated that their attitudes had changed, some of them (f=3) stated that at the end of the semester they found statistics as a difficult course; when on the contrary some (f=8) stated that they no longer found statistics as a difficult subject. For example, one student stated "I realized that it is not difficult when you study. I realized that every topic is related and when you understand, it helps you learn the next topic." Some students (f=2) mentioned about their positive feelings at the end of the semester that they liked statistics more. Others (f=2) reported that they came into the realization of the value of statistics. For example, one student stated that "I realized that statistics is everywhere" when another student reported that "it changed the way I think about the things I do".

Table 2. Repeated samples t-test

		Paired Differences						
		M	**SD**	**SEM**	**t**	**df**	**p**	**Cohen's d**
EEE	**Pret-Post Affect**	.63	1.29	.24	2.56	27	.016	.49
	Pre-Post Cognitive Competence	.74	1.29	.24	3.064	27	.005	.57
	Pre-Post Value	.43	1.42	.27	1.593	27	.123	
	Pre-Post Difficulty	.12	1.15	.22	.563	27	.578	
	Pre-Post Interest	.12	1.64	.31	.393	27	.697	
	Pre-Post Effort	.59	1.87	.35	1.664	27	.108	
GE	**Pre-Post Affect**	.22	1.31	.22	.981	33	.334	
	Pre-Post Cognitive Competence	.22	1.08	.19	1.196	33	.240	
	Pre-Post Value	.35	1.13	.19	1.785	33	.083	
	Pre-Post Difficulty	-.27	.76	.13	-2.077	33	.046	.36
	Pre-Post Interest	.24	1.42	.24	.966	33	.341	
	Pre-Post Effort	.88	1.53	.26	3.368	33	.002	.58

Note: EEE: Electrical & Electronics Engineering, GE: Geomatic Engineering

5. DISCUSSION & RECOMMENDATIONS

Previous research found statistically significant relationship between mathematics achievement and students' attitudes toward statistics (e.g., Carmona, Martinez, & Sanchez, 2005; Chiesi & Primi, 2010; Coetzee & van der Merwe, 2010; Sorge and Schau, 2002). In our study, we found statistically significant relationship only between self-reported mathematics achievement and Effort and Cognitive Competence components. That is, students who think that they are good at mathematics reported that they are also good at statistics and they put effort into learning statistics. Although the participants of the study reported intermediate or above level of success in mathematics, the Higher Education Council (2019) statistics show that their mathematics level was actually low. We recommend researchers to use direct measures of mathematics achievement when investigating the relationship between math achievement and attitudes toward statistics.

Effort was the only variable that was significantly correlated with all the other SATS-36 components and with study hours and with self-reported math achievement. That is, students who stated that they studied for statistics were also reported that they liked, valued, interested in, felt cognitive competence in statistics, found statistics as not a difficult subject, thought that they were good at mathematics, and studied statistics for longer hours. However, we find it interesting that study hours and effort had a medium relationship, as higher relationship would have been expected since study hours is an indicator of amount of effort student spend. This result might mean that our participants might have an unrealistic view of effort or study hours that they spent to learn statistics.

Both electrical & electronics engineering students and geomatic engineering students generally had positive attitudes toward statistics. However, geomatic students tended to have more neutral attitudes at the end of the semester. These results were consistent with the literature that students generally start statistics courses with positive attitudes, and they may end up with more neutral attitudes at the end of taking statistics courses (Schau & Emmioglu, 2012). The standard deviation values for both electrical engineering and geomatic students showed that the dispersion of students' responses to cognitive competence and difficulty items were less variant than students' responses to the other components. That is, students were consistently confident in statistics even though they think that statistics was not an easy subject.

This study also showed that engineering students from different departments differed in terms their attitudes toward statistics; although, they had similar math and statistics backgrounds, were taught by the same instructor with the same instructional methods and used same textbooks. The reasons of this difference might be related with the nature of their field and how statistics is used in their field or it might be because of the group culture itself. A limited number of studies have investigated engineering students' attitudes toward statistics and these studies generally have not done field comparations (e.g., Adair, Jaeger, & Price, 2018; Lauriski-Karriker, Nicoletti & Moskal, 2013; Moskal, 2015). We suggest further researchers to investigate the differences (and causes of the differences) in attitudes toward statistics of the students from different fields of engineering.

In this study, several students stated that their attitudes toward the value of statistics was changed that they valued the use of statistics in their life. We believe that instructor's use of real data and use of examples from students' fields were helpful for this positive change. As literature suggest students have more positive attitudes when statistics is taught within the context of students' field and daily life (Kiekkas et al., 2015; Neumann, Hood, & Neumann, 2013).

The qualitative and quantitative results of this study was consistent that some of the statistics attitudes have significantly changed during the semester. Quantitative results showed that these were affect and cognitive competence for electrical & electronic students, and effort and difficulty for geomatic engineering students. Qualitative results showed that students' reports of attitude change took place when electrical-electronics engineering students had different views about the value and difficulty of statistics and when they had more competence in statistics. As for the geomatic engineering students, they reported that their attitudes changed as their attitudes about the difficulty and value of the statistics changed and some liked statistics more at the end of the semester. Although qualitative and quantitative results were consistent in terms of indicating an attitude change, qualitative results provided more information on individual students, as expected. Therefore, we suggest researchers to use mixed method research when investigating students' statistics attitudes.

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