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Perceptions and Attitudes of Secondary School Students towards Engineers and Engineering

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Abstract
The aim of this research is to determine the perceptions and attitudes of fifth and sixth grade secondary school students towards engineers and engineering. The study group consists of fifty four students receiving education in the fifth and sixth grades of a state secondary school in Turkey. Convergent parallel design, as a mixed methods research design, was used during the research. The research data were obtained using the questionnaire on attitudes towards engineers and a draw-an-engineer form. Descriptive and predictive statistical techniques and content analysis were used during data analysis. The research results indicate that, students perceive engineers as qualified construction workers, repairers, managers or designers; and that they have stereotypical opinions about their gender. Despite their positive attitudes towards engineering, students were found to prefer engineering as a profession at a low level. The research was carried out with a view to contribute to the related literature, educators and researchers with research results obtained from Turkish education system in which STEM education has an increasing importance.
Keywords: STEM education, engineering, perception, attitude, stereotypical opinions

1. Introduction

To complete its digital transformation, Turkey needs adequate number of workforce with STEM (Science, Technology, Engineering and Mathematics) capabilities. In today's world, the presence of a productive, enterprising and innovation-oriented educational system holds great importance for countries to complete their technological transformation. As a result of the tendency towards STEM education in Turkey, the curriculum of the science course was updated in 2017 so as to include subject areas of science and engineering applications as well as engineering design skills (MoNE, 2017). The expectations from STEM education involve acquisition of an interdisciplinary point of view, facilitated transformation of theoretical information into practice, and provision of twenty first century skills, in addition to meeting the expectations of the business world (Turkish Industrialists' and Businessmen's Association - TUSIAD, 2017).

Equipping students with insight into the four different disciplines of STEM and the skills involved in these disciplines depends upon a good integration. The increasing importance of engineering and technology among these disciplines brings about the requirement for educating individuals that know the relationship between these concepts, science and mathematics, and have the capability to use new technologies (Katehi, Pearson, & Feder, 2009). Engineering is a profession that has the capability and potential to change the life quality of human beings in a positive or negative way. Although our daily lives are covered with all sorts of engineering products, students mainly fail to understand what engineers do (Frehill, 1997). Engineering education is involved in both formal and informal environments with a view to draw students' attention to engineering careers and increase engineering and technology literacy (Brophy, Klein, Portsmore, & Rogers, 2008).

1.1 Problem of Research, Previous Findings, Research Questions

Determination of students' perceptions towards engineers and their opinions as to what engineers do holds great importance; since such perceptions are likely to have an important impact on student perceptions and beliefs about the profession in addition to their tendency to have a career with that profession (Knight & Cunningham, 2004). The performed studies so far have revealed that, most students think of engineers as repairers or constructors of something, they are mostly engaged in works that require physical effort, and that engineering is a boring field that only draw nerdy students' attention (Aswad, Vidican, & Samulewicz, 2011; Cunningham, Lachapelle, & Lindgren-Streicher, 2005; Gibbons, Hirsch, Kimmel, Rockland, & Bloom, 2004; Karatas, Micklos, & Bodner, 2011; Oware, 2008; Oware, Capobianco, & Diefes-Dux, 2007a; Powell, Dainty, & Bagilhole, 2012).

The drawings in the literature were used as an effective pre-post evaluation tool (Bowker, 2007) and as a means for determining the differences in students' ways of perceiving a given subject or concept (Barraza, 1999). The drawings were also used to evaluate the perceptions, attitudes and misconceptions of students about scientists and engineers (Chambers, 1983; Knight & Cunningham, 2004). Draw an Engineer Test (DAET), is a tool used to determine students' perceptions regarding engineers and engineering. This tool was developed on the basis of Draw a Scientist Test (DAST) (Chambers, 1983) which is used to determine students' perceptions of scientists. DAET was originally developed by researchers in Museum of Science in Boston. In addition to

drawings, DAET involves questions with short answers about engineers and engineering (Knight & Cunningham, 2004). The research which was carried out to develop DAET involved three hundred eighty four third-twelfth grade students which were asked to draw an engineer and reply the question "what does an engineer do" in written. Engineering works and their statement frequency were as follows: construction (30%), repair (28%), production (17%) and design (12%). Four main themes, namely *construct/repair* (tools, goggles, construction equipment); *design* (plans, technical drawings, pencils, tables); *mechanical products* (bridges, roads, buildings, houses) and *laboratory works* (test tubes) were specified in the research (Knight & Cunningham, 2004).

In the next step, the researchers used the results of their previous work on DAET to establish an evaluation-measurement tool titled "What is an Engineer?" which consisted of sixteen visuals and then they asked the students to choose between the visuals that represented the perceived engineering works. Afterwards, the participating students were asked to complete the sentence "an engineer is a ……. person". The results of the research performed with more than five hundred students showed that, the majority of the students had a tendency to think of engineers as automobile mechanics (repairers) or construction workers. The researchers attributed the tendency of students to confuse engines with engineers to the phonetic resemblance between these two words (Cunningham et al. 2005).

In another research, primary school students perceived engineering as repairing, constructing or operating something, and in their drawings they depicted engineers as workers. In this research, the students were of the opinion that engineers need materials such as plans, computers and helmets so as to perform their works (Oware et al., 2007a). In a research in which DAET was used during interviews, the perceptions of students about engineers mainly involved an image of a *mechanic (repairer)* who used vehicles or repaired engines; *a worker* who constructed buildings, roads or made construction or repair works; *a technician* who repaired computers; and *a designer.* In this research only 17% of the participating students could state that engineers were occupied with designing (Capobianco, Diefes-Dux, Mena, & Weller, 2011).

In a research on investigation of perceptions of second, third and fourth grade students about engineers by use of DAET, engineers were associated with works such as hand-workmanship (constructing buildings), repairing things and driving vehicles. In the post-test stage which was performed after an engineering-based curriculum application, nearly half of the students were found to change their perceptions from hand-workmanship to engineering design (Carr, Diefes-Dux, & Horstman, 2012). In a research which was performed to determine secondary school students' perceptions of engineering using drawing and engineering test, the majority of the students were found to have no perception of engineering, and some were found to perceive engineers as individuals who worked outdoors and performed heavy works (Fralick, Kearn, Thompson, & Lyons, 2009). In another research, seventh and eighth grade students were asked the question *"What is the meaning of the word "engineering" for you?",* and the answers including "design", "production" and "invention" were found to be more frequent during the post-test stage after engineering-based applications as compared to those received during the pre-test stage, thus indicating the reduced level of misconceptions about the concept of "engineer" (Welty, & Stricker, 2012).

Gibbons et al. reported that, the majority of the secondary school students had positive attitudes towards the skills related to mathematics, science and engineering. For instance, 80% of the students stated that they enjoyed having the grasp of how things work as well as thinking about new and better ways of doing something. Despite their positive attitudes, only few students could correctly express five different types of engineering. In addition, none of the students could provide a completely correct exemplification of what a specific type of engineer does, which was ascribed to the fact that students did not hear or learn much from adults such as their parents and teachers about engineering (Gibbons et al., 2004).

Karatas et al. used DAET to determine sixth grade students' opinions on the nature of engineering by interviewing. The research results showed that, the majority of the students imagined engineers as individuals that construct or produce things. However, some of the students stated that they were aware of engineers' role in the design and planning stages of production, and a minority group further stated that engineers test products' reliability or operability prior to their use. In the research, the majority of the students were found to imagine the process of engineering as assembling things and constructing buildings, and both in their drawings and interviews; they depicted engineering as a set of works performed by a handful of master builders or mechanics. Although no illustration of women were found among the drawings, students stated that engineering was not a male-oriented profession. This was mainly ascribed to the opinion stated by female participants as: *"this can be managed by women other than me"* (Karatas et al., 2011).

In Turkey, seventy two gifted secondary school students' perceptions of engineers were investigated using DAET. During the research, the majority were found to draw civil engineers and mention the design aspect of engineering. The participants were found to perceive engineering as a male-oriented profession (Ünlü & Dökme, 2017). The results of another study on determination of secondary school students' perceptions of engineers revealed that, as compared to female students, male students thought of engineers as people that perform multiple tasks, earn a lot of money as good problem solvers, at a higher rate. As compared to male students,

female students stated at a higher rate that engineers used a variety of ways to express their opinions. 50.20% of the students stated that they did not want to be an engineer in the future, 38% stated that they wanted, and 10.70% stated that they were indecisive as to being an engineer. In the research, 43.80% of the male students stated that they wanted to be an engineer in the future, 43.80% stated that they did not, and 58.20% of the female students stated that they did not wanted to be an engineer (Balçın & Ergün, 2017).

There is no systematic study on children's engineering gender stereotypes, nevertheless the studies performed using DAET show that, students mostly imagine engineers as male individuals (Capobianco et al. 2011; Fralick et al. 2009; Karatas et al. 2011; Knight and Cunningham 2004; Ünlü & Dökme, 2017). Female students' perception of engineering as a male-oriented profession may affect their future tendencies about engineering. For instance, female students who are of the stereotypical opinion regarding mathematics and science that *"I believe males are better than females in science and mathematics"* were found to have lower success in these fields (Chatard, Guimond, & Selimbegovic 2007; Guimond & Roussel 2001). Likewise, acceptance of social engineering gender stereotypes may affect the desire of females to be an engineer and their success.

A few possible reasons for engineering's not being preferred as a career by students were stated in previous studies (Besterfield-Sacre, & Atman 1994; Besterfield-Sacre, Moreno, Shuman, & Atman, 2001). The majority of students had negative stereotypes regarding engineers (such as nerdy students become engineers) or they had exaggerated perceptions about engineers (such as, all engineers must be genius). Students' lack of knowledge as to what engineers do can be another underlying reason for their reluctance for making a career in the field of engineering. As opposed to law and medicine careers, engineering career is seldomly shown on television, also parents and teachers do not generally discuss engineering as a possible career.

All previous studies show that, in general, primary and secondary school students do not know what engineers do, regard them as qualified or heavy-duty workers, few students have a grasp of the design aspect of engineering, civil engineers are depicted in drawings at higher rates, and engineering is mainly associated with construction and repair works. It was also found that, students have stereotypes about engineers' gender, they depict engineers as male and asocial individuals, and engineering is not a commonly preferred profession. The number of studies carried out in Turkey on secondary school students' perception of engineering was also found to be significantly lower than those performed in other countries.

The use of DAET involves some limitations since this tool only requires students to draw what they think. Such limitations may be encountered both by students in application stage and by researchers in analysis stage. For instance students with high drawing skills could adequately reflect their imaginations; whereas data obtained from those with low drawing skills may not be sufficient for determining perceptions. Student drawings are considered to not go beyond a physical point of view by use of DAET. Accordingly, in the literature DAET has been supported with interviews or likert-type scales as a means for gaining a more detailed insight into children's perception of engineering (Capobianco et al. 2011; Fralick et al. 2009; Karatas et al., 2011).

The present research aims to determine the perceptions and attitudes of fifth and sixth grade students, since the first years of secondary school are regarded as the period in which students' perceptions and attitudes towards their career take a shape. In the research, a likert-type scale adopted into Turkish by the researchers was used in addition to DAET. This study was carried out as a result of Turkey's focus on STEM education as of year 2017 and the scarce number of studies regarding secondary school students' perceptions and attitudes towards engineers and engineering in Turkish literature. The research aims to contribute to the literature on nature of engineering through determination of perceptions and attitudes of students in their first years in the secondary school. The problem statement of the research was specified as "*what is the level and extent of fifth and sixth grade students' perceptions and attitudes towards engineers and engineering".* The sub-problems of the research are as follows:

1. To what extent do students prefer to embark on a career in the field of engineering?
2. Do student tendencies towards choosing engineering as a career vary by gender?
3. Do student tendencies towards choosing engineering as a career vary by grade level?
4. Do student attitudes towards engineering vary by gender?
5. Do student attitudes towards engineering vary by grade level?
6. What is the general attitude level of the students towards engineers?
7. How do students perceive engineers' gender?
8. Do student perceptions of engineers' gender vary by students' gender?
9. How is the general perception of students about engineers?

2. Methodology of Research

2.1. General Background

Mixed methods design in which qualitative and quantitative methods are collectively used was used in the research. Creswell and Plano Clark (2007) defined mixed methods research as a method that provides a better

understanding of the research problem by collective use of quantitative and qualitative methods as compared to any method that uses a single approach. Convergent parallel design among mixed methods research techniques was used in the research. Convergent parallel design aims to collect different and complementary data on a specific subject to articulate the research problem in the best possible way (Morse, 1991). In this design, researcher does not favor a specific method over another through giving the same priority to qualitative and quantitative research stages; separates these stages from each other during data analysis; and recombines them while interpreting the research data (Creswell and Plano Clark, 2015).

2.2. Study Group

Convenience sampling among purposive sampling methods was used during the research (Yıldırım & Şimşek, 2013). As stated by Yıldırım and Şimşek (2013), in this sampling method, researcher facilitates the research through bringing practicability and speed by choosing a situation which is close and accessible. The study group consists of fifty four students receiving education in a state school of Turkey's Eastern Anatolia Region as of 2016-2017 academic period. The gender and grade-based distribution of the study group is given in Table 1.

Table 1. Gender and grade-based distribution of the study group

Grade level	**Gender**		**Total**
	Male	**Female**	
5	13	8	21
6	15	18	33
Total	28	26	54

2.3. Instrument and Procedures

2.3.1. Questionnaire on Attitudes towards Engineers

The "questionnaire on attitudes towards engineers and scientists" developed by Lyons, Fralick ve Kearn (2009) and adopted into Turkish by Ergün and Balçın (2017) was used during the research. The Turkish version of the questionnaire is in likert-5 type involving 22 items and 2 factors. 11 of 22 items constitute factor 1 and involve the items related to attitudes towards scientists, and the remaining 11 items constitute factor 2, involving the items related to attitudes towards engineers. 11 items constituting the second factor related to attitudes towards engineers were used in this research. Cronbach's Alpha reliability coefficient of these 11 items is .84. The questionnaire also involves the question *"Do you want to be engineer in the future"* to determine students' tendency to prefer an engineering career in their lives.

2.3.2. Worksheet

The worksheet used is the "Draw an Engineer (DAE)" form used by Fralick, Kearn, Thompson and Lyons (2009) in their research. The front page of the form includes a large framed area which is allocated for students to draw a working engineer, and an area right below the frame to write the name of the depicted engineer. The back side of the form includes questions such as *"what are the personal attributes of an engineer?", "how is the working environment of an engineer?", "what kinds of work does an engineer do?",* and *"what is the engineer that you drew doing?"* for students to explain their drawings. The structural validity of open-ended questions was ensured by consulting two professionals in the field of science teaching, and a linguist.

2.4. Application Period

During the application period, the researcher used the two evaluation tools independently from each other. The students were given forty five minutes to make the drawings on the front page and answer the open-ended questions on the back page. Also, the use of colored pencils was suggested while drawing. The period for answering the questionnaire items was specified as twenty five minutes.

2.5. Data Analysis

2.5.1. Analysis of data obtained from the questionnaire on attitudes towards engineers

SPSS (Statistical Package for the Social Sciences) 18.0 software package was used during the analysis of quantitative data obtained from the questionnaire. The questionnaire involves 11 positive attitude items and no negative item. The answers to the questionnaire items were; "absolutely agree" (5) points, "agree" (4) points, "indecisive" (3) points, "disagree" (2) points, and "absolutely disagree" (1) point. The highest and lowest possible scores for a student to receive from the questionnaire were 55 and 11, respectively. The score range was found by subtracting the lowest score from the highest score. Score intervals were established by dividing the obtained range value by three. The attitude levels towards engineers and questionnaire score intervals are given in Table 2.

Table 2. Attitude levels towards engineers and score intervals

	Attitude level towards engineers		
	Low	**Medium**	**High**
Total attitude score	11.00-25.66	25.67-40.33	40.34-55.00

Firstly, it was determined whether the total attitude scores received by students from the "attitudes towards engineers" questionnaire exhibited a normal distribution. The normal distribution characteristic of scores obtained from a continuous variable can be examined by using coefficient of skewness, arithmetic mean, median and mode by means of graphs and normality tests (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, Demirel, 2016). In this research, Kolmogorov-Smirnov normality test was used, since the study group was larger than fifty individuals. The findings on total attitude scores of students investigated by Kolmogorov-Smirnov normality test are given in Table 3, and the findings as to average, median, standard deviation, coefficients of kurtosis and skewness are given in Table 4.

Table 3. Normality test results related to total attitude scores

	Kolmogorov-Smirnov		
	Statistics	**sd**	**p**
Total attitude score	.108	54	.172

Table 4. Average, median, standard deviation, coefficients of skewness and kurtosis values of total attitude scores

Total attitude score				
$\bar{X}$	μ_e	**S**	**Coefficient of skewness**	**Coefficient of kurtosis**
41.13	43.00	8.30	-1.048	1.196

Büyüköztürk (2015) reported that, the p value higher than α = .05 was an indication of insignificant deviation from normal distribution in this significance level, since the statistical null hypothesis is established on the grounds that "distribution of scores do not significantly differ from normal distribution". George and Mallery (2003) also stated that, data sets in which coefficients of skewness-kurtosis are below the interval of ± 2 show normal distribution. As shown in Table 3, p is higher than .05; and in Table 4 skewness-kurtosis coefficients are within -2,+2 interval. Based on these values, total attitude scores of the students were found to exhibit a normal distribution. Independent samples t test was used during the evaluation of the questionnaire data, since total attitude scores displayed normal distribution and the research involved two groups based on grade level (fifth-sixth) and gender (female-male).

2.5.2. Analysis of worksheet data

The students were coded as 1, 2, … during the analysis of data obtained from worksheets. Content analysis was used during the evaluation students' drawings and their answers to the open-ended questions. By use of content analysis, similar data are gathered within the frame of specific concepts and themes, and these are then reorganized to provide the user with an understandable content (Yıldırım & Şimşek, 2013). The data obtained from student answers to open-ended questions in the worksheet were transferred into digital environment and a fifty four pages document was prepared accordingly. The findings obtained from the opinions in this document were evaluated and coded by the researchers. The prepared codes were then categorized to establish the themes.

Coding, categorization and theme preparation processes were separately performed by two researchers. In the next stage, two researchers collaborated to review the themes and eliminate inconsistencies. Statement frequencies of the codes in the themes by students and statement percentages were calculated in accordance with the agreed results. Total frequency was found to exceed the study group since the answer of a single student could be covered by multiple themes. Statement percentage was found by dividing the number of statements in a given theme by the total number of statements.

Data reliability was calculated using the formula proposed by Miles and Huberman (1994) ([Consensus / (Consensus + Dissensus)] x 100). By use of this formula, the matching percentages of coding were found as 0.87 for question 1, 0.86 for question 2, 0.90 for question 3, 0.92 for question 4 and 0.89 for all questions. Yıldırım and Şimşek (2013) proposed that, reliability percentage is achieved when matching percentage reaches 70%. Accordingly, the obtained values show that the researchers provided adequate coding reliability.

3. Research Results

3.1. Findings on the First Sub-problem

The questionnaire involved the question "*Do you want to be an engineer in the future"* to determine the student tendencies to have an engineering career. The frequencies and percentage values related to student tendencies to become an engineer were evaluated and the results are presented in Table 5.

Table 5. Findings on student tendencies to become an engineer

Tendency to become an engineer	N	%
Yes	26	48.10
No	28	51.90
Total	54	100.00

As indicated by the findings in Table 5, 48.10% (f=26) of students want to have an engineering career, and 51.90% (f=28) do not want to have an engineering career.

3.2. Findings on the Second Sub-problem

Students' tendency to prefer an engineering career was evaluated to determine whether this tendency varied by their gender. Analysis results are given in Table 6.

Table 6. Findings related to the gender based distribution of tendency towards choosing engineering as a career

		Tendency to become an engineer		Total (N)
		Yes	No	
Gender	Male (N) %	16 57.14	12 42.86	28
	Female (N) %	10 38.46	16 61.54	26
Total (N)		26	28	54

As shown in Table 6, the percentage of the male students that want to be an engineer in the future (%57.14) is higher than the male students that do not want to be an engineer of (%42.86). In the case of female students, the percentage of those that want to be an engineer (%38.46) is significantly lower than those that do not (%61.54).

3.3. Findings on the Third Sub-problem

Distribution of the tendency towards being an engineer was evaluated to determine whether this tendency varied by grade level. The analysis results are shown in Table 7.

Table 7. Findings related to the grade-based distribution of tendency to choose engineering as a career

		Tendency to be an engineer		Total
		Yes	No	
Grade level	5 (N) %	12 57.14	9 42.86	21
	6 (N) %	14 42.42	19 57.58	33
Total (N)		26	28	54

As indicated in Table 7, 57.14% of the fifth grade students and 42.42% of the sixth grade students stated that they wanted to be an engineer in the future. The percentage of fifth and sixth grade students that do not want to be an engineer in the future are 42.86% and 57.58% respectively.

3.4. Findings on the Fourth Sub-problem

The total scores received from the attitude questionnaire were evaluated using independent samples t-test to determine whether student attitudes towards engineers varied by gender. Analysis results are shown in Table 8.

Table 8. Gender-based independent samples t-test results of the total scores obtained from the questionnaire

Scale	Gender	N	$\bar{X}$	S	t	p
Overall questionnaire total attitude score	Male	28	40.07	10.05	-.967	.338
	Female	26	42.26	5.85		

As indicated by the results in Table 8, there is no significant relationship between student attitudes towards engineering and their gender ($p > .05$).

3.5. Findings on the Fifth Sub-problem

The total scores obtained from the attitude questionnaire were evaluated using independent samples t-test to determine whether student attitudes towards engineers varied by their grade level. Analysis results are given in Table 9.

Table 9. Grade-based independent samples t-test results of the total scores obtained from the questionnaire

Scale	Grade level	N	$\bar{X}$	S	t	p
Overall questionnaire total attitude score	5	21	41.62	10.23	.347	.730
	6	33	40.81	6.95		

As indicated by the results in Table 8, there is no significant relationship between student attitudes towards

engineering and their grade level ($p > .05$).

3.6. Findings on the Sixth Sub-Problem

Students' attitudes towards engineers and their characteristics were evaluated using questionnaire data. The arithmetic mean of student answers to each of the questionnaire items are separately given based on gender and grade level in Table 10. Also, the mean values of the scores received by students from the questionnaire are given in the bottom line of the table.

Table 10. Arithmetic means of the answers to questionnaire items

Questionnaire item	$\bar{X}$	**Male**	**Female**	**5. grade**	**6. grade**
Engineers are occupied with several different works.	3.57	3.75	3.37	4.05	3.26
Engineers are creative people.	3.50	3.39	3.62	3.81	3.30
Engineers earn a lot of money.	3.67	3.68	3.65	3.76	3.61
Engineers make other people's lives easier.	3.63	3.54	3.73	3.67	3.61
Engineers are supposed to be good problem solvers.	3.89	3.93	3.85	4.10	3.76
Engineers always adopt the best way of solving a problem.	3.89	3.75	4.04	4.05	3.79
Engineers use several different ways to express their opinions.	3.61	3.39	3.85	3.71	3.55
Engineers are supposed to be good in mathematics.	3.82	3.71	3.92	3.81	3.82
Engineers do most of their work using their brain.	3.89	3.75	4.04	3.33	4.24
Engineers explore new information.	3.80	3.46	4.15	3.71	3.82
Engineers design new stuff.	3.81	3.71	4.04	3.62	4.03
Mean values of total attitude scores	41.12	40.07	42.26	41.62	40.81

The mean scores presented in Table 10 indicate that students in general agree with the statements related to engineers in a gender and grade basis evaluation. The statements with relatively lower mean scores are *"Engineers are creative people"* and *"Engineers are occupied with several different works"*. The statements with relatively higher mean scores are *"Engineers are supposed to be good problem solvers", "Engineers always adopt the best way of solving a problem"* and *"engineers do most of their work using their brain"*. The mean value of students' total mean score ($\bar{X} = 41.12$) indicates that they have a good attitude towards engineers. The findings in Table 10 indicate that, female students have a higher mean attitude score ($\bar{X} = 42.26$), as compared to that of male students ($\bar{X} = 40.07$). The mean values show that, female students' attitudes towards engineers is at a good level, whereas that of the male students is at a medium level. Fifth grade students were found to have a higher attitude score ($\bar{X} = 41.62$) than that of the sixth grade students ($\bar{X} = 40.81$), both having a good attitude towards engineers. However, the findings in Tables 8 and 9 indicate that, this difference between the gender and grade based total attitude scores, is not statistically significant.

3.7. Findings on the Seventh Sub-problem

The students were asked to name their drawings in the worksheet to determine how they generally perceive the gender of engineers. The name of no well-known engineer was encountered among the names given by students. The descriptive analysis results as to the gender of students' engineer drawings are given in Table 11.

Table 11. Frequency and percentage values related to the gender of drawn engineers

Gender of drawn engineer	**N**	**%**
Female	7	12.96
Male	47	87.04
Total	54	100.00

The findings in Table 11 show that, 12.96% of the students perceived engineers' gender as female, and 87.04% of the students perceived engineers' gender as male. The findings in the table indicate that the majority of students perceive the gender of engineers as male.

3.8. Findings on the Eighth Sub-problem

The gender of drawn engineers were evaluated by use of the drawings and the names given by students as a means to determine whether students' perception of engineers' gender varied by their own gender. The analysis results related to students' perception of engineers' gender are given in Table 12.

Table 12. Frequency and percentage values related to the gender of drawn engineers based on students' gender

Gender of the drawn engineer	Student's gender			
	Male		Female	
	N	%	N	%
Male	27	96.43	20	76.92
Female	1	3.57	6	23.08
Total	28	100.00	26	100.00

As indicated by the findings in Table 12, 96.43% of the male students drew male engineers, whereas 76.92% of the female students drew male engineers. The percentage of students that drew female engineers is 3.57% among male students and 23.08% among female students. This finding shows that, female students drew female engineers at higher rates than male students.

3.9. Findings on the Ninth Sub-problem

Engineer illustrations depicted by students in their drawings and their answers to the open ended questions were evaluated to determine the general perceptions of students about engineers. The drawings and the answers of students to four open-ended questions were evaluated using content analysis. The findings related to each question are presented in the below tables. The findings related to the student answers to question "what are the personal characteristics of an engineer" are given in Table 13.

Table 13. Findings related to the perceptions about engineers' personal characteristics

Theme	Code	Student code	Statement frequency (f)	Frequency-dependent percentage (%)	Percentage (%)
Cognitive characteristics	Intelligent, smart	1, 8, 12, 13, 20, 21, 24, 31, 32, 39, 41, 46, 52	13	10.16	25.78
	Hardworking	2, 3, 5, 7, 10, 11, 12, 16, 17, 20, 21, 25, 26, 50	14	10.94	
	Creative	25, 54	2	1.56	
	Successful	28, 33, 35, 43	4	3.13	
Affective characteristics	Calm	2, 4, 6, 9, 13, 15, 20, 43, 45, 46	10	7.81	32.81
	Self-confident	2	1	0.78	
	Reliable	2, 5, 11, 18, 29	5	3.91	
	Stubborn	3	1	0.78	
	Ambitious	3	1	0.78	
	Shy	11	1	0.78	
	Merciful	16, 17, 18, 32	4	3.13	
	Affectionate	19	1	0.78	
	Respectful	19, 31	2	1.56	
	Sensitive	12, 20	2	1.56	
	Emotional	45	1	0.78	
	Imaginative	53	1	0.78	
	Helpful	19, 29	2	1.56	
	Sympathetic	19, 47, 50	3	2.34	
	Angry	19, 28, 42, 48, 49	5	3.91	
	Honest	6, 18	2	1.56	
Psychomotor characteristic	Skillful	21	1	0.78	0.78
Socialness	Spending much time at computer	1	1	0.78	5.47
	Loving to read books	22, 25, 32	3	2.34	
	Watching Tv	22	1	0.78	
	Team-working	24, 30	2	1.56	

Theme	Code	Student code	Statement frequency (f)	Frequency-dependent percentage (%)	Percentage (%)
Attitude towards working	Punctual	17	1	0.78	7.81
	Meticulous	51	1	0.78	
	Loving the job	15, 17, 18, 25, 31, 44, 50	7	5.47	
	Not working	4	1	0.78	
Self-care skills	Being clean	7, 26, 28	3	2.34	2.34
Entrepreneurship	Management	4	1	0.78	0.78
Research skills	Improved general culture	30	1	0.78	1.56
	Loving to invent	32	1	0.78	
Appearance Characteristics	Crazy hairstyle	6, 54	2	1.56	22.66
	Protective goggles/glasses	22, 24, 25, 50, 51, 54	6	4.69	
	Work-wear	24, 25	2	1.56	
	Helmet/barette	3, 7, 10, 11, 12, 15, 16, 19, 24, 25, 26, 28, 29, 30, 33, 34, 42, 44, 47	19	14.84	
Total		54	128*	100	100

*Frequency of student statements.

As shown in Table 13, the statement frequencies of the themes related to engineers' personal characteristics are: cognitive characteristics (25.78%), affective characteristics (32.81%), psychomotor characteristics (0.78%), socialness (5.47%), attitude towards working (7.81%), self-care skills (2.34%), entrepreneurship (0.78%), research skills (1.56%), and appearance characteristics (22.66%). The majority of students defined engineers with cognitive characteristics such as being intelligent, smart and hardworking; affective characteristics such as being calm, reliable and angry, and appearance-related characteristics such as wearing helmet/barette, protective goggles/glasses.

Some of the direct quotations from students' opinions are as follows: the statement of student coded 1 in cognitive characteristics theme, smart, intelligent code; socialness theme, spending much time at computer code: *"He/she is very interested in computers, smart with intelligent opinions"*. The statement of student coded 2 in cognitive characteristics theme, hardworking code; affective characteristics theme, calm, self-confident, reliable codes: "*He/she is a very hardworking, calm, and self-confident person and gains everybody's trust"*. The drawings of students coded 24 and 25 related to the personal characteristics of engineers are given in Figure 1. In these drawings, illustrations involve engineers wearing glasses, helmets/barettes and work-wears.

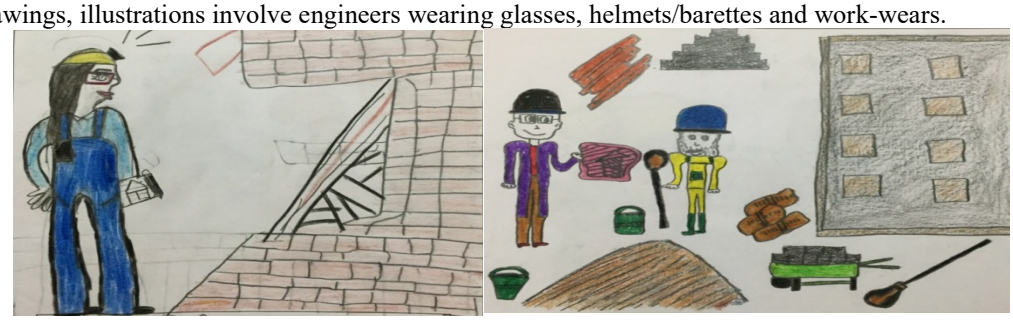

Figure 1. Drawings of students 24 and 25

The findings related to the answers of students to the question "how is the working environment of an engineer" are given in Table 14.

Table 14. Findings related to the perceptions about the working environment of engineers

Theme	Code	Student Code	Statement frequency (f)	Frequency-dependent percentage (%)	Percentage (%)
Human-effect on the environment	Crowded	1, 4, 7, 24, 32, 37, 45	7	9.09	38.96
	Silent	1, 2, 5, 8, 13, 18, 20, 28, 30, 31, 38, 40, 43, 46, 49, 50	16	20.78	
	Active	4	1	1.30	
	Noisy	4, 7, 23, 36, 45, 52	6	7.79	
Order of environment	Dirty	4, 27	2	2.60	28.57
	Clean	8, 14, 17, 44	4	5.20	
	Tidy	3, 14, 18, 26, 38, 39, 40, 44, 46	9	11.69	
	Untidy	9, 16, 21, 27, 29	5	6.49	
	Safe	3	1	1.30	
	Healthy	17	1	1.30	
Air condition	Hot	16	1	1.30	3.90
	Shady	2, 30	2	2.60	
Indoor Environments	Tent	6	1	1.30	15.58
	Factory	51	1	1.30	
	Laboratory	51	1	1.30	
	Somewhere full of dossiers	39, 48	2	2.60	
	Lone-working environment	47	1	1.30	
	Construction site	15, 23, 24, 25, 35, 53	6	7.79	
Outdoor Environments	Wide area	10	1	1.30	6.49
	Empty area	11	1	1.30	
	Seaside	12, 15	2	2.60	
	Somewhere with trees/garden	26	1	1.30	
Equipment status	Too many equipment	18	1	1.30	6.49
	Somewhere with TV	22	1	1.30	
	Somewhere with a chair	22	1	1.30	
	Somewhere with computers	39	1	1.30	
	A comfortable room	30	1	1.30	
Total		54	77*	100	100

*Students' statement frequency

As indicated in Table 14, statement frequencies for the themes about working environments of engineers are specified as; human effect on the environment (38.96%), order of environment (28.57%), indoor environments (15.58%), air condition of environment (3.90%), equipment status of environment (6.49%), and outdoor environments (6.49%). According to the majority of students, working environment of engineers can be both silent- tidy and dirty-untidy places. They also stated that, working environment of engineers can be crowded places or construction sites.

Some of the direct quotations from students' opinions are as follows: The statement of the student coded 45 about "human effect on the environment" theme, "crowded" and "noisy" codes: *"Crowded and noisy"*. The statement of the student coded 38 about "human effect on the environment" theme, "silent" code; "order of environment" theme, "tidy" code: *"Silent, tidy"*. The drawings of students coded 35 and 51 as to the working environment of engineers are given in Figure 2. In these figures, the engineers were depicted in a laboratory environment and a construction site.

Figure 2. The drawings of students coded 35 and 51

The findings as to the answers of the students to the question "What kinds of work does an engineer do?" are given in Table 15.

Table 15. Findings on the perceptions about the works that engineers do

Theme	Code	Student code	Statement frequency (f)	Frequency dependent percentage (%)	Percentage (%)
Construction related works	Construction	3, 10, 11, 16, 18, 21, 22, 23, 27, 28, 33, 34, 36, 42, 43, 44, 45, 46, 48, 50, 52, 53	22	30.14	45.21
	Sand-dumping	9	1	1.37	
	Stone-tile-brick carrying	9, 16	2	2.74	
	House painting	16, 18, 32	3	4.11	
	Wood carrying	29	1	1.37	
	Walling	29, 32	2	2.74	
	Construction repair-works	25	1	1.37	
	Construction inspection	37	1	1.37	
Works that require productiveness	Project-drawing	6, 7, 13, 19	4	5.48	31.51
	Project-design	13, 28	2	2.74	
	Design-drawing	2, 5, 6, 12, 22, 30, 35, 46	8	10.96	
	Outfit design	2	1	1.37	
	Hair design	2	1	1.37	
	Contracting projects	7	1	1.37	
	New product design	14	1	1.37	
	Making inventions	51, 54	2	2.74	
	Making research	38	1	1.37	
	Reading books	20	1	1.37	
	Dealing with Mathematics	39	1	1.37	
Environmental works	Agricultural-field survey	15, 17	2	2.74	5.48
	Working on sea creatures	15	1	1.37	
	Familiarizing with environment	26	1	1.37	
Repair-works	Computer repair	1, 8, 14, 20, 31	5	6.85	9.59
	Repair-work	40	1	1.37	
	Electric appliance repair	36	1	1.37	
Works that require entrepreneurship	Management	4, 19, 24, 30	4	5.48	8.22
	Charity	49	1	1.37	
	Doing diverse works in different environments	15	1	1.37	
Total		54	73*	100	100

*Statement frequency of students.

As shown in Table 15, the statement frequencies as to the works carried out by engineers are specified as: Construction related works (%45.21), works that require productiveness (31.51%), repair-works (9.59%), works that require entrepreneurship (8.22%) and environmental works (5.48%). The majority of students are of the opinion that an engineer is occupied with construction works and design-drawings, in addition to repair-works.

Some of the direct quotations from student opinions are as follows: The statement of student coded 30 about "works that require entrepreneurship" theme, "design-drawing" code; "works that require entrepreneurship" theme, "management" code: "*They design houses and manage constructions".* The statement of student coded 16 about "construction-related works" theme, "construction", "stone-tile-brick carriage", "house painting" codes is as follows: "*They paint houses, make constructions, carry stones".* The drawings of students coded 2 and 14 regarding the works carried out by engineers are given in Figure 3. In these drawings engineers are depicted as individuals that make designs in office-places and make new products.

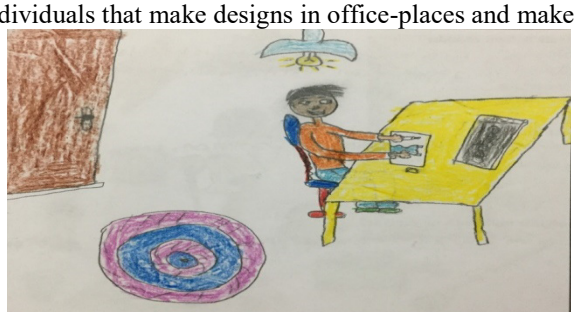
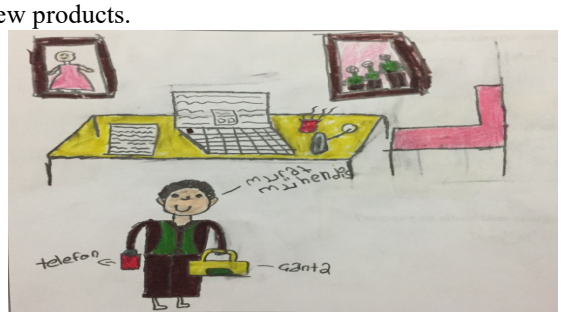

Figure 3. Drawings of students coded 2 and 14

The findings related to the students' answers to the question "what is the engineer that you drew doing?" are given in Table 16.

Table 16. Findings related to the works that the drawn engineers do

Theme	**Code**	**Student code**	**Statement frequency (f)**	**Frequency dependent percentage (%)**	**Percentage (%)**
Works related with company or institution management	Communication	1, 10, 49	3	5.09	33.90
	Taking care of his/her works	3, 14, 23, 34	4	6.78	
	Management	4, 15, 16, 21, 24, 27, 32	7	11.86	
	Making employees do their jobs	21, 24	2	3.39	
	Providing workers with their rights	36	1	1.70	
	Paper-works	39, 45, 48	3	5.09	
Works related with productiveness	Project-drawing	12, 13, 19	3	5.09	23.73
	Design-drawing	2, 5, 6, 7, 11, 28, 30, 35, 46, 52, 53	11	18.64	
Construction related works	Construction-works	11, 18, 28, 29, 33, 42, 44	7	11.86	18.64
	Inspection of constructions	25, 37	2	3.39	
	Sand-dumping	9	1	1.70	
	Walling	9	1	1.70	
Ecological works	Earthwork-agriculture	15, 17	2	3.39	6.78
	Working on sea creatures	15	1	1.70	
	Protecting environment	26	1	1.70	
Electronic works	Dealing with computers	8, 20, 31	3	5.09	5.09
Works related with research and development	Making inventions	22, 54	2	3.39	8.48
	Making research	38, 40, 43	3	5.09	
Repair-works	Chair-repair	50	1	1.70	3.39
	Electric-repair	47	1	1.70	
Total		54	59*	100	100

*Statement frequencies of students

The findings in Table 16 show that, the statement frequencies related to the works carried out by the drawn engineers are as follows: works related with company or institution management (%33.90), works that require productiveness (%23.73), construction-related works (%18.64), research and development related works (%8.48), ecological works (%6.78), electronic works (%5.09) and repair-works (%3.39). The majority of students depicted engineers as individuals that do management and construction related works in addition to making designs and drawings.

Some of the direct quotations from students' opinions are as follows: the statement of student coded 46 about "works that require productiveness" theme, "design-drawing" code: "*He/she is designing stuff. He/she is drawing a house."* The statement of student coded 32 about "works related with company or institution management" theme, "management" code: "*He/she manages workers".* The drawings of students coded 1 and 30 about the works carried out by engineers are given in Figure 4. In these drawings, engineers are depicted as individuals that establish communication and make designs-drawings.

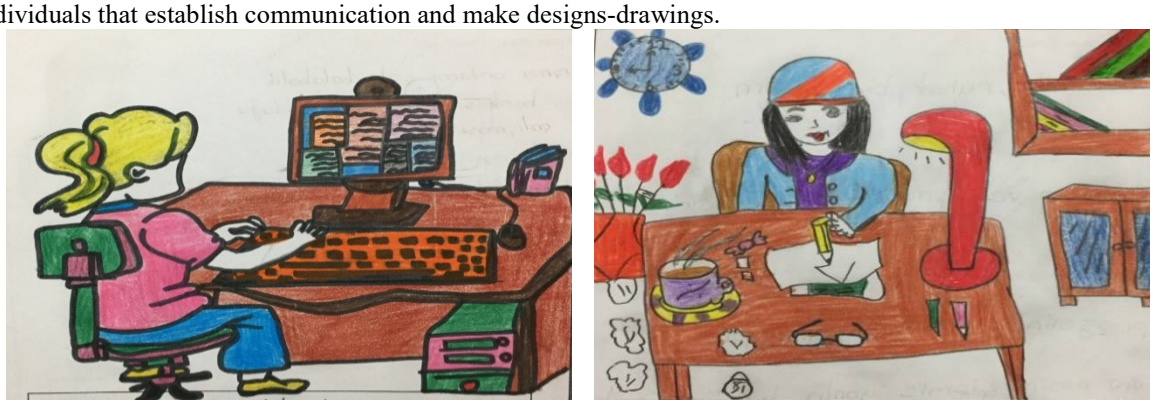

Figure 4. Drawings of the students coded 1 and 30.

4. Discussion

The results of this research, performed to determine the perceptions and attitudes of fifth and sixth grade students towards engineers and engineering, show that the ratio of students that do not intend to choose engineering as a career in the future (%51.90) is higher than that of the students that want to choose this profession as a career (%48.10). Likewise, in another research, 50.20% of the students stated that, they did not consider engineering as their future career, whereas 38.00% stated the opposite and 10.70% stated that they were indecisive on the subject (Balçın & Ergün, 2017). In this research, students' gender based opinions as to choosing engineering as a career indicate that, 57.14% of the male students want to be an engineer, while 38.46% of the female students want to be an engineer. Similarly, the results of another research on determination of the interests of sixteen years old students in the fields of mathematics, science or medicine showed that, the ratio of male students that wanted to be an engineer was 21.10%, while this ratio remained at 0.20% for female students. In the research, the determinant attributes for the profession of engineering were stated to be being male, being skillful in the fields of mathematics and science and being an angry individual (Schoon, 2001). Likewise, women's representation rate in the profession of engineering was reported to be significantly lower than that of males in other researches (Nauta, & Kokaly, 2001; Yurtseven, 2002).

In this research, the ratio of students with the intention to choose engineering as a career shows that, 57.14% of the fifth grade students and 42.42% of the sixth grade students want to be an engineer in the future. In another research, the ratio of students that wanted to be an engineer was found as 38.20% in the fifth grade, 44.90% in the sixth grade, 34.10% in the seventh grade, and 40.70% in the eighth grade (Balçın & Ergün, 2017). Gender-based evaluation of the tendency to choose engineering as a career was also addressed in other works (Pearson & Miller, 2012; Sadler, Sonnert, Hazari, & Tai, 2012; Schoon, 2001), however, no other study on grade-level (classroom)-based evaluation of the same subject was encountered.

The results of this research, performed to determine the attitudes towards engineers on the bases of gender and grade level show that, students have a good attitude towards engineers in general. Female students were found to have a good attitude, whereas male students' attitude was found to be at a medium level. Fifth and sixth grade students were also found to have a good attitude. In the research, no significant relationship was detected between the students' attitudes towards engineers, and their genders and grade levels. In general, the participating students agreed with the statements included in the questionnaire on attitudes towards engineers. Students mostly agreed with the statements that, engineers are supposed to be good problem solvers, they always adopt the best way of solving a problem, and they do most of their works using their brain. The students that agreed with these statements a high rate, however, included in their drawings the depictions of construction and repair-works that require physical force, which constitutes an interesting result of the research. On the other hand, the participating students were found to agree with the statements that engineers are creative people and they are

occupied with several different works, at a lower rate. Likewise, in another research, most of the secondary school students were found to have a positive attitude towards mathematics, science and engineering-related skills. In the research, 80% of the students stated that they enjoyed knowing how things work as well as thinking about newer and better ways of doing something. Despite their positive attitudes, only few students could correctly define five different engineering fields and none could provide a completely correct exemplification of what these engineers do (Gibbons et al. 2004).

In their drawings, 12.96% of the participants depicted engineers as female individuals and 87.04% depicted engineers as male individuals. These results show that, students perceive engineers as male individuals at a high rate. A variety of other literature results also show that, students in general have adopted this stereotypical opinion on the gender of engineers (Capobianco et al. 2011; Fralick et al. 2009; Karatas et al. 2011; Knight and Cunningham 2004; Ünlü & Dökme, 2017). In the research, 96.43% of male students and 76.92% of female students drew male engineers. Similarly, sixth grade students drew no female engineer (Karatas et al., 2011), secondary school students were found to perceive engineering as a male-oriented profession (Ünlü & Dökme, 2017) and young students perceived engineers as male individuals (Capobianco et al. 2011; Fralick et al. 2009; Knight & Cunningham 2004), as reported in other studies.

The most frequently stated personal characteristics specific to engineers were determined as; intelligent, smart (%10.96), hardworking (%10.94), wearing helmet and barette (%14.84) Similarly, primary school students were found to think that, engineers needed helmets and similar equipment to carry out their works (Oware et al., 2007a; Oware, 2008). In this research, students stated with 1.56% frequency that, engineers are occupied with teamwork. As reported in another study, students were indecisive on the statement "engineers work alone" (Lyons, 2011).

The most frequently stated attributes of engineers as to their working environment were determined as: silent (%20.78), tidy (%11.69), crowded (%9.09), construction site (%7.79) and noisy (%7.79). These results show that, students mostly imagine engineers as people doing construction works or office-works. The results of other studies also show that, students imagine engineers as people doing heavy construction works at outdoor environments (Capobianco et al., 2011; Cunningham et al., 2005; Fralick et al., 2009; Knight & Cunningham, 2004; Oware et al., 2007a; Oware, 2008).

The statement frequencies of students as to the works of engineers were determined as; construction works (45.21%), design-drawing (10.96%) and repairworks (9.59%) The majority of students were found to perceive engineers as qualified and heavy-duty workers occupied with construction works. The statement frequency for making designs or drawings was only 10.96%. Similarly, the results of related works showed that, primary school students had a tendency to think of engineers as car repairers and construction workers (Cunningham et al. 2005); third-twelveth grade students' statement frequencies were: construction (30%), repair-works (28%), production (17%) and design (12%) (Knight & Cunningham, 2004); primary school students perceived engineering as repairing, constructing and operating stuff and depicted engineers as workers (Oware, 2008); students perceived engineers as repairers, workers, technicians and designers (only 17%) (Capobianco et al., 2011); and students perceived engineers as people working outdoors in heavy works (Fralick et al., 2009).

In the research, the statement frequencies as to the works carried out by the drawn engineers were; works related to company or institution management (33.90%), designworks-drawings (18.64%), construction-related works (18.64%) and repair-works (3.39%). Students stated with 10.96% frequency that engineers make designs-drawings, however, in their drawings they depicted engineers as designers-technical drawers with 5.48% frequency. Likewise, management was stated with 5.48% frequency, whereas the works related with company-institution management were depicted with 33.90% frequency. Students stated construction-works with 45.21% frequency, whereas in their drawings they depicted engineers doing construction-works with 18.64% frequency. Literature results showed that, primary and secondary school students depicted engineers mostly as individuals doing construction, repair and design-works, and the drawings included no depictions of company or institution management related works (Capobianco et al., 2011; Cunningham et al. 2005; Fralick et al., 2009; Knight & Cunningham, 2004; Oware et al., 2007a; Oware, 2008). The results of another research revealed that, 56% of students were indecisive as to engineers' potential to become a boss in the future (Lyons, 2011).

5. Conclusion

In this research, fifth and sixth grade students were found to perceive engineers as construction workers, repairers, managers and designers. The drawings of students mostly involved depictions of qualified workers doing construction-works, and managers doing office-works. Therefore, it can be inferred that, students in general do not have a clear perception of engineering. The research results revealed that, students have stereotypical opinions as to the gender of engineers and 12.96% drew female engineers whereas 87.04% drew male engineers. 96.43% of male students drew male engineers, while 76.92% of female students drew male engineers. This gender stereotype of students in their drawings was found to reflect upon their tendency to prefer engineering as a career. In the research, 57.14% of male students stated that they would prefer engineering

as a career, while 38.46% of female students stated to choose engineering as their future career. This is attributable to students' perception of engineers as heavy-duty workers doing construction-works, in addition to the gender of role model engineers and society's general perception of engineering as a male-oriented profession. In the research, students were found to have a good attitude level towards engineers in general. Students' attitudes towards engineers did not vary depending on the gender and grade variables. Despite their positive attitude towards engineers, students stated to prefer this profession as a career at a low rate and their perception of engineers remained at an inadequate level. Particularly, female students were found to have a lower tendency towards choosing engineering as a career, as compared to male students. STEM constitutes the basis of the Science Curriculum of Turkey which was updated in 2017. In this research, participating students were found to have stereotypical opinions on engineering which is involved as a discipline in STEM education, and they were found to be uninformed about engineers' working field and what they do. Early years of secondary school are important for establishment of a career awareness, thus arises the necessity to provide students with accurate and adequate information about engineering in learning environments to clarify their perception of engineering. For this purpose, integrated STEM education is regarded as an important opportunity in Turkey.

6. Recommendations

6.1. Recommendations for Educators

The results of the present research have revealed that students have misconceptions regarding the works that engineers do. Students' perception of engineers as construction workers, repairers or managers prevent female students from regarding engineering as a potential career for their future. Informing students of the fact that engineering does not merely involve heavy construction, repair or management-related works will likely cause female students to regard this profession as a potential career for their future. For this purpose, programs about the engineering design process targeting primary and secondary school students can be organized at out-of-school learning environments or summer camps (Oware et al., 2007a; Oware et al., 2007b). Therefore, educating teachers with the capability to organize and implement such programs holds particular importance. Applied trainings and seminars about in-class application of integrated STEM education, which was included in the updated science curriculum of Turkey in 2017, and about design-based science teaching and engineering design process, can also be organized. Teachers with the ability to improve themselves about STEM education are supposed to determine the preliminary knowledge and misconceptions of students about engineers and engineering, and improve the career awareness of students through implementing the engineering design process during science courses at classrooms or out-of-school environments.

6.2. Recommendations for Researchers

Students' perceptions and attitudes towards engineering are also reflected upon their perceptions and attitudes towards technology since these two concepts are inseparably interconnected (Knight, & Cunningham, 2004). All students may not be inclined to prefer technical professions such as engineering as a career. Additionally, being a "technology literate", i.e., understanding and appreciating technology, has become a necessity for students as a result of increasing dependence on technology in today's world. Technology literacy involves basic skills and information related to understanding and using new technologies (Pearson, & Young, 2002). Gaining insight into the relationship between engineering and the development of technology is an important constituent of technology literacy. In this regard, further research can be conducted on determination of the effect of students' perceptions and attitudes towards engineering on their perceptions of technology and technology literacy.

In general, the participants of this research were found to have an inadequate perception of engineering and tendency to prefer this profession as a career. Students were also found to have stereotypical opinions about engineers. Early years of secondary school hold importance for establishing career awareness, discovering skills and learning about professions. Students' inadequate perception of engineers and engineering at fifth and sixth grades and relatively lower rates of choosing engineering as a profession in these ages do not necessarily mean that their perceptions and preferences will not change in the future. Students' opinions related to career selection in the future may vary depending on their developmental periods and experiences. Therefore, long-term longitudinal studies can be performed to determine their tendencies towards choosing engineering as a profession. Also, qualitative researches can be conducted to support quantitative research results related to determination of the factors that affect the perceptions about engineers and tendencies to choose engineering as a profession.

Although the study group of this research can be considered inadequate within the context of quantity and grade level with the low representability of overall population, the obtained results are valuable as they provide insight into the opinions of fifth and sixth grade students on engineers and engineering. Reapplication of similar research with different study groups is also deemed necessary as a means for determination of the grade-dependent changes in the findings obtained from a specific study group.

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