Analysis of Factors Influencing Interest in STEM Career: Comparison between American and Turkish High School Students with High Ability

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Abstract

The low number of students studying or applying for STEM subjects and workforce demand has been prioritized in almost all countries' policies. This study intended to examine factors that influenced American and Turkish students to pursue a degree or career in STEM related fields. Participants of the study were 86 high-ability students selected from two high schools in the United States (n = 39) and Turkey (n = 47). A five-part survey was used and its original version was administered to American participants while its translated version was conducted to Turkish students. Results revealed that *self-motivation* was found to be the most influential factor of STEM interest for American students while *mother* was for Turkish students. In addition, regarding primary reasons for interest in STEM career, *self-motivation* was the most important reason for interest in STEM career for American students while *income of occupation* was the one for Turkish students. By stimulating needs for STEM fields, this study will help increase the awareness of the gap between growth in graduates and STEM-related vacancies. Academic institutions will potentially use findings of this study to revise their enrollment policies, with the aim of enhancing enrolment for STEM areas.

Keywords: STEM interest and career, high ability, comparative Study, Turkey, United States

Most innovations that enhance the quality of life come from contribution of science, technology, engineering and mathematics (STEM) related fields (Kuenzi, 2008). As the technology advances, leadership, influence, and economy of nations are increasingly determined by effective practice of STEM-related skills. STEM education is beliefs and skills that are developed in collaboration by intersecting various subjects in STEM (Corlu, Capraro & Capraro, 2014). Therefore, concepts in STEM focus on finding solutions to the global issues and put emphasis on project-based systems of education. The main reason for developing STEM education is to enhance technological development as well as research and innovation (Uttal & Cohen, 2012).

The current global economy, which is increasingly shifting toward technological development, has posed a great challenge to the education system to produce skillful experts to fit into the job market (Brown et al., 2011). A further impetus in demand for STEM skills is the emerging practice of the idea of knowledge economy, which requires the most specialized skills to take to fill the vacancies. The significance of technology is its ability to enhance the competitiveness of a nation, and support the quality of jobs and exports. In addition, the demand for STEM experts extends to other fields because of diffusion of technology to non-STEM fields (Nicholls et al., 2007). Other significances of technological development include enhancing the living conditions of the community and its working conditions. However, workers and the society can only benefit from the advantages produced by technological innovation by acquiring appropriate skills and knowledge, which are necessities for effective working in the STEM-related jobs (Bybee, 2010a). This reveals that the competitiveness of a nation is determined by its ability to innovate and develop new means of working.

In America, 20 percent of all vacancies require STEM-related experts and it is projected to increase. For instance, there are a potential 2.8 million job openings by 2018 (Hawley et al., 2013). The gap in employment relates to a four percent increase in the number of vacancies, which is opposed to two percent increase in STEM graduates. Turkey also experiences a similar scenario (Maltese, 2008). In this case, Turkey has 18 percent of all national vacancies for STEM-related experts. The number of graduates in the same field is growing by three percent while the output of graduates is growing by 1.5 percent (Saxton et al., 2014). The disparity in growth in the graduate and STEM-related vacancies indicates a widening gap, which suggests an increasing level of demand for STEM experts. The chances of employments are high for STEM graduates. For instance, Uttal and Cohen (2012) revealed that graduates with STEM-related areas have 84 percent more chances of succeeding in life compared to other graduates from other fields. Additionally, STEM jobs are priced highly to motivate people to seek them. For instance, petroleum engineers earn five times the amount earned by counseling psychologists. Furthermore, whereas the demand for specializing in STEM-related fields increases, the enrollment at the graduate level is continuously recording a decline, which creates employment gaps.

Actions for STEM Motivation

The adaption of the acronym STEM was done in the 1990s by National Science Foundation. Its popularity emerged after its 2001 mention with the National Science Foundation's call and the relevance of STEM has continuously increased with the development in technology and globalization. In practice, the origin of STEM can be traced back to the19th century (Hawley et al., 2013). Major inventions and progress in science and technology during 19th and 20th century, including the launch of Sputnik, the Russian satellite, in 1957, ignited rigorous competitions among developed nations (Milgram, 2011), which led more focus on STEM fields. By the mid-1980s, American Engineering Commission was recording 80 thousand graduates in STEM-related majors annually.

Because STEM is one of the competitive areas that determine the future status of nations, most governments have taken powerful initiatives to promote STEM awareness and motivation. These initiatives aim at promoting the number of graduates to fill the growing vacancies in STEM-related fields (Bybee, 2010b). Compared to other areas, occupations in STEM are growing rapidly, highly paying, and the driver of innovation and economic growth. Through numerous initiatives, many countries have been willing to motivate youth to improve STEM career interest. For example, with the purpose of enhancing enrollment of the marginalized into STEM courses, USA has created more than two hundred programs in its education system, which are legalized through various legislations such as No Child Left Behind Act and Project GRAD (Crisp et al., 2009), as well as Educate to Innovate (Sahin, Ayar & Adiguzel, 2014). Despite increasing investments in STEM careers, deficit of qualified employees still emerges, so that America has increased its investments in STEM-related fields to fill the available vacancies. For instance, the annual growth rate in the budget allocation for STEM careers in America since 2008 has been 3 percent (Huelskamp, 2010).

On the other hand, Turkey has initiated various programs to promote interest in STEM careers. For

instance, through the exchange program between the Turkish and American governments, most students have been motivated to consider STEM careers (Bybee, 2010b). Further, the Turkish government has introduced industry-colleges partnership, especially in STEM-related fields, to enhance awareness among students about the available vacancies in various industries. Just like America, Turkey has also introduced scholarship programs to the best performers in STEM-related subjects, as well as the potential candidates from poor background (Kuenzi, 2008). In addition, the 2010-2014 Strategic Plans and Vision 2023 Project placed strong emphasis on STEM related fields (Corlu et al., 2014). To strengthen the quality of STEM education in Turkey, Turkish Industry and Business Association (TUSIAD) has also started various initiatives, such as enhancing employment, quality of education, and the welfare of the society, to promote its global position in STEM education and also to reduce mismatch between labor market and skills (Avci, 2015).

Factors Influencing Interest in STEM Career

The theoretical framework of this study is the Social Cognitive Career Theory (SCCT) that was theorized by Lent, Brown and Hackett (1994). According to the SSCT, career interests, choices, and educational and occupational success have been influenced by thoughts, beliefs, and personal and environmental factors (Petersen, 2014). More specifically, career interests were shaped by self-efficacy, outcome expectations, and goal orientation (Brown, 2002). Factors included in this study were selected based on the idea that students' STEM career interests have been shaped by major constructs including self-efficacy, outcome expectations, and goal orientation as the SSCT suggested. However, instead of these major constructs, factors that could be considered as sub-constructs including people (family, teachers, peers, relatives, etc.), school-related factors (courses, clubs, competitions/fairs, etc.), self-motivation, and occupational expectations were used.

Prior studies have identified several important factors that influenced students' interest in STEM careers. For example, Christensen et al. (2015) found that factors influencing student interest in STEM and STEM careers included a student's own self-motivation, a parent or family member, science and mathematics courses offered in school and a high quality, motivating teacher. In a similar study, Sheppard et al. (2010) found parental motivation for students studying engineering was significantly correlated with having a parent or sibling in engineering. In addition to influencing STEM interest, parents, teachers, school-related factors were frequently named to be playing important roles in students' motivation for learning science (Breakwell & Robertson, 2001, Olitsky, Loman, Gardner & Billup, 2010; Sjaastad, 2012). In another study, findings in regard to parental occupation suggested that students with at least one parent in a STEM field chose to major in STEM at a higher rate than students without parents in STEM-related jobs (Harwell & Houston, 2012). However, the authors also suggested that a students' choice of college major was greatly influenced by their parents, regardless of parent's occupation (Harwell & Houston, 2012).

Other factors that can be considered under cognitive category are the perception of students about science, influence of teachers on this perception and students' expectations, classroom culture and personal beliefs, and identity of student (Huelskamp, 2010). Heilbronner (2009) suggested that attitudes and preferences, as well as parental perception and mentoring, also determine career choice. In a quantitative study to examine educational factors, Crisp et al. (2009) examined determinants of career choice among STEM subjects. Out of a sample of 50 respondents, 22 ranked appropriate instructional environment first. Overall, school-related factors including classes, curriculum, course materials, instructional techniques, and after school activities were found to be enhancing students' interest in STEM subjects.

A primary purpose of this study was to analyze factors that influenced American and Turkish students to pursue a degree or career in STEM related fields. The following research questions were addressed to satisfy this purpose: To what extent are high-ability American and Turkish students different in regard to the (1) Factors influencing their present STEM interest and (2) Resons for their aspirations in STEM-related careers?

Method

This study was part of a larger project that was designed to investigate STEM perception of high ability students who have interest in STEM careers. Quantitative method was used for the exploration of potential comparisons and relationships among variables and numerical data were collected through a cross-sectional survey.

Participants

Participants of the study were students who were selected from two high schools in the United States and Turkey respectively. Of the 86 participants ($n_{US} = 39$ and $n_{TR} = 47$), 28 were female and 58 were male. The students that participated in this study were high ability students who declared that they were motivated to pursue a career in STEM.

The school from Turkey was one of the top private schools, which has a focus on science and technology mainly. Students in this school were placed through a nation-wide high school entrance exam and only top %1 of the test takers were accepted to this school. All students from the school were invited to take a survey and 47 of 76 students accepted to take part in the study.

The school from the United States was a public school focusing on math and science, which was located in one of the Southwestern states. The school has been consistently recognized as the top performing school by the state authorities. Students who had high performance at one of the STEM-related Advanced Placement (AP) tests (with a passing score 4 or 5) were invited to participate in the study and 39 of 57 students accepted to take part in the study. Information in regard to background of participants and variables that may potentially related to their STEM career is displayed across by the countries in Table 1.

Instrument

A five-part survey, designed by the authors for a larger project to examine STEM perception of high ability students in STEM focused high schools in the U.S., was used to compare the factors that influenced American and Turkish students' STEM interests. For the purpose of this

		American Students		Turkish Students	
	Variables	*n*	%	*n*	%
Gender	Female	14	35.9	14	29.8
	Male	25	64.1	33	70.2
Mother's education level	Lower than high school	0	0.0	3	6.4
	High school graduate	7	17.9	19	40.4
	2-year college degree	7	17.9	1	2.1
	College graduate (4-year)	16	41.0	20	42.3
	Graduate degree (Master`s degree)	7	17.9	2	4.3
	Doctorate (Ph.D or equivalent)	2	5.1	2	4.3
Father's education level	Lower than high school	0	0.0	1	2.1
	High school graduate	2	5.1	12	25.2
	2-year college degree	5	12.8	3	6.4
	College graduate (4-year)	24	61.5	22	46.8
	Graduate degree (Master`s degree)	4	10.3	5	10.6
	Doctorate (Ph.D or equivalent)	4	10.3	4	8.5

Table 1. Participants' demographics

		American Students			Turkish Students		
	Variables	Mean	*SD*	*SE*	Mean	*SD*	*SE*
Factors influenced present STEM interest	Mother	5.59	1.90	0.31	5.36	1.80	0.22
	Father	4.41	1.96	0.31	4.33	2.27	0.33
	Brother	4.08	2.03	0.33	4.36	2.04	0.30
	Sister	3.95	2.10	0.34	4.13	2.18	0.32
	Subject Teacher	5.21	1.79	0.29	4.70	2.12	0.31
	Club Teacher	4.92	2.37	0.38	4.34	1.93	0.28
	College Counselor	3.97	1.99	0.32	3.11	1.76	0.26
	Friends	3.56	2.01	0.32	3.64	1.96	0.29
	Knowledge about occupation	4.36	2.15	0.34	4.00	2.25	0.33
	Naturally inclined	5.85	1.48	0.24	5.32	1.70	0.25
	STEM related classes	5.05	1.84	0.29	4.00	2.06	0.30
	STEM related clubs	4.95	2.35	0.38	3.30	2.24	0.33
	STEM related fairs/competitions	5.44	1.43	0.23	5.00	2.05	0.30
Reasons for aspirations in STEM-related careers	Social status of occupation	5.18	1.64	0.26	5.38	1.74	0.25
	Income of occupation	5.61	1.41	0.23	5.81	1.48	0.22
	Social expectations	4.00	2.32	0.37	5.06	1.75	0.25
	Self-motivated/naturally inclined	5.77	1.31	0.21	5.26	1.82	0.27
	Attainable lifestyle	4.08	2.04	0.38	3.87	1.90	0.28
	Ease of occupation	3.44	1.89	0.30	3.75	2.06	0.30

Note. Responses given on a Likert-type scale ranging from 1 (disagree) to 7 (strongly agree).

Table 2. Descriptive statistics: Comparison between American and Turkish students

study, while the original version of the survey was administered to American participants, its translated version was conducted to Turkish students. Two professors in the field of Education —one certified Turkish elementary teacher and one doctoral student in the field of educational psychology— reviewed the Turkish translation of the survey for the content validity and wording. After the reviewing process, the authors made some minor changes on the wording of the translation to make the survey items relevant for Turkish students. However, they did not change the format and content of the items.

Responses for only Part 1, Part 4, and Part 5 were used and analyzed in this study. Part 1 of the survey focused on personal and demographic background of the student. The questions in this part either included yes-no or open-ended type items. Part 4 included items to explore the importance of factors that influenced students' interests in STEM. In this part students were asked to rate specific influences on their career considerations using a seven-point Likert scale from 1 (no influence) to 7 (very strong influence). The areas of influence included factors such as people (family members, teachers, friends, and other), classes, clubs, competitions, and personal attitudes. Part 5 of the survey allowed students to rate how pre-determined factors were important in developing their current career interests in STEM from 1 (not important) to 7 (very important). This section included factors such as social status of occupation, income of occupation, self-motivation, attainable lifestyle, and ease of occupation.

Data Collection and Analysis

The study of the American group was conducted during regular class time in late spring semester. Participants in Turkey took part in the study while they were taking summer classes. The surveys were delivered to the schools and each teacher was provided with a survey packet that contained copies of the survey with an introductory letter having detailed instructions for administering the surveys. Surveys were distributed to the students and instructions covering each part of the survey were given by school teachers. Students were told not to put their names on the paper for the sake of confidentiality. The students were asked to print answers for the first part of the survey. For the fourth and fifth part of the survey, students were told to rate the given factors, which were designed in a 7-point Likert-type scale format. Each participant completed the survey in 15 to 30 minutes.

The participants' responses to the survey items were transferred into a spreadsheet and analyzed with SPSS software. Descriptive analysis was employed and a series of independent samples *t*-tests were conducted to answer research questions and examine if there were any differences in response to surveyed variables.

Results

Comparison of Influential Factors for Students' Present STEM Interest

The first research question was designed to explore the most important influential factors in participants` STEM interest. Specifically, mean differences of responses between two distinct groups, American and Turkish students, were investigated (Table 2 and 3). Among the factors rated, *self-motivation (naturally inclined)* was found to be the most influential for American students ($M = 5.85$, $SD = 1.48$) while mother was found to be the most influential factor for Turkish students ($M = 5.36$, $SD = 1.80$).

For both American and Turkish students, *mother and subject teacher* were found to be the most influential people for students' STEM interests (Table 2). While *club teacher* was rated as the third most influential person for American students, *father* was ranked in third place for Turkish students. Furthermore, *friends, college counselor*, and *sisters* were found to be the least influential people for both American and Turkish students` STEM interests. Although the rankings of the people differ, no significant differences were found between Turkish and American students` ratings for people who influenced them for STEM interest except *college counselor*. American students ($M = 3.97$, $SD = 1.99$) ranked influence of college counselors as significantly higher than did Turkish students ($M = 3.11$, $SD = 1.76$), $t(76.6) = 2.283$, $p = .037$, $d=0.457$. The effect size for this analysis ($d=0.457$) was found to exceed Cohen's (1988) convention for a small effect ($d = .500$).

Among school related factors, *STEM related fairs/competitions* were rated as the most influential factors for both groups. In addition, significant differences were found between Turkish and American students` ratings for school related factors that influenced them for STEM interest. American students rated *STEM related classes* ($t(83.6) = 2.499$, $p = .014$, $d=0.538$) and *STEM related clubs* ($t(79.5) = 3.315$, $p = .001$, $d=0.719$) significantly higher than Turkish students as influential factors. The effect sizes for this analysis ($d = 0.538$ and $d=0.719$) were found to exceed Cohen's (1988) convention for a medium effect ($d = .500$).

Comparison of Reasons for Aspirations in STEM-related Career

The second research question was designed to identify specific differences between the two groups in regard to primary reasons for interest in STEM career. Descriptive statistics (Table 2) indicated that *self-motivation (naturally inclined)* was found to be the most important for American students ($M = 5.77$, $SD = 1.31$) while *income of occupation* was found to be the most important reason for interest in STEM career for Turkish students ($M = 5.61$, $SD = 1.41$). Furthermore, ease of occupation was found to be the least important reason for interest in STEM career for both American ($M = 3.44$, $SD = 1.89$) and Turkish ($M = 3.75$, $SD = 2.06$) students.

The independent sample *t*-test results (Table 4) in-

	Variables	*t*	*df*
People	Mother	0.567	79.3
	Father	0.060	83.9
	Brother	-0.646	81.2
	Sister	-0.386	82.1
	Subject Teacher	1.193	84.0
	Club Teacher	1.235	73.0
	College Counselor	2.119*	76.6
	Friends	-0.172	80.3
Personal attributes	Knowledge about occupation	0.756	82.3
	Naturally inclined	1.539	83.8
School related factors	STEM related classes	2.499*	83.6
	STEM related clubs	3.315**	79.5
	STEM related fairs/competitions	1.156	81.7

Note: *$p < .05$. ** $p < .001$.

Table 3. Comparison of factors that influenced students' present STEM Interest between American and Turkish students

dicated that although the rankings differ, no significant differences were found between Turkish and American students' ratings for primary reasons for interest in STEM career except *social expectations*. Turkish students (M = 5.06, SD = 1.75) ranked *social expectations* significantly higher than did American students (M = 4.00, SD = 2.32), $t(69.6) = -2.362$, $p = .021$, d=0.516. The effect size for this analysis (d = 0.516) was found to exceed Cohen's (1988) convention for a medium effect (d = .500).

Discussion and Conclusion

Although STEM-related career choice has not met the workforce demand in numbers and quality, efforts to increase interest to that point are being made academically and practically. This study investigated factors influencing STEM interest of high ability students who were from Turkey and the United States. Primary reasons for STEM career interest were also examined. Studying such factors and primary reasons by comparing two countries also provided information on potential similarities and differences.

One finding of the study regarding the most important influential factors for STEM career interest was that *self-motivation* and *mother* were the top ones for American and Turkish students respectively. Similarly, *self-motivation*, which was also rated as the second factor by Turkish students, was one of the top-impacting factors in almost all related studies with the same or derived names such as *belief in one's ability* (Heilbronner, 2009), *confidence* and *personal motivators* (Edzie, 2014), *self-efficacy* (Misher, 2014) and *intellectual self-confidence* (Nicholls, 2007). This might be interpreted as those students in both countries are eager for their career goals and believe in realizing such interests. Having 'mother' ranked as the most influential person for Turkish and second top for American students was one of the most interesting findings of this study. Our finding is consistent with prior studies, (Otto, 2000; Paa & McWhirter, 2000) documenting that mothers are more influential than fathers on construction of adolescents' career aspirations. However, some other studies found fathers to have a higher influence on children in regard to encouraging them to pursue a career for technical fields such as engineering (Simpson, 2003). Combining the controversial findings of prior studies, explaining why mothers have such strong influence on high-ability students' STEM interests would be a complicated task. We also think one might need to know of how high-ability students respond differently to maternal and paternal expectations in order to make further conclusions. At this point we present this finding as a remarkable fact to future researchers to be investigated in details.

One other finding was that *subject teacher* was rated the third and second highest factor by both American and Turkish students respectively, which is parallel to results of Edzie (2014)'s study examining primary factors influencing STEM enrollment. American students' consideration of *college counselor's* influence that was significantly more than Turkish students might be indicator of how effective and knowledgeable college counselors are in the United States (Heilbronner, 2009). Such profiles are sometimes critical people on students' lives for their decisions. Therefore, they should have enough knowledge about the local and nationwide policies and such young generations' characteristics. Parallel to the results of the studies (Petersen, 2014; Scinski, 2014), the other finding in regard to school-related factors was that *STEM-related fairs/competitions* was rated as the top by the students from both countries. It might be said that out-of-school context is always attractive and satisfying for students when compared to in-school factors such as *STEM-related classes and clubs*. Another reason might be related to the specific qualities of the participants of this study. As indicated, participants of the study were high ability high school students who were motivated to pursue a career in STEM fields. Usually fairs and competitions have been opportunities for gifted and high ability students to challenge their skills so that one might expect that *STEM-related fairs/competitions* could be a top factor that influence their interest in STEM.

On the other hand, STEM-related classes and clubs were significantly more influential in American students (Sahin et al., 2014). One explanation for this finding might be the lack of rigorous courses in Turkish high school curriculum including Advanced Placement (AP) and dual-enrollment courses. Unfortunately, current Turkish education system does not allow students taking advanced classes. Advanced classes have been identified as an important factor to challenge students including high ability ones and also motivate them for related fields.

Results also indicated that *income of occupation* was found to be the most important reason for interest in STEM career for Turkish students while *self-motivation (naturally inclined)* was found to be the most important for American students. Although no significant differences were found between Turkish and American students' ratings for *income of occupation*, we believe it is important to discuss why Turkish students ranked it as their top important reason for their STEM interest. We think Turkey's less strong economic status than the U.S, including higher unemployment rates, may have motivated Turkish students to pursue a degree in STEM careers with the expectation that it could provide them with a higher chance to guarantee an employment after college graduation and also higher salaries.

Results of comparative independent sample t tests on primary reasons revealed that only one was significantly different between American and Turkish. Turkish students indicated that *social expectations* influenced their interest in STEM career significantly higher than did American students. In this study we defined 'social expectation'

Variables	*t*	*df*
Social status of occupation	-0.558	82.6
Income of occupation	-0.618	82.5
Social expectations	-2.362*	69.6
Self-motivated/naturally inclined	1.518	82.4
Attainable lifestyle	0.478	78.5
Ease of occupation	-0.724	83.1

Note. *$p < .05$

Table 4. Comparison of reasons for aspirations in STEM-related career

as other people's (family, peers, teachers, relatives etc.) motivation and pressure that influence student's interest in career choice. One reason might be linked with differences between American and Turkish family structures or socio-cultural constructs. However, we believe we will need more evidence to disclose the factors that contribute differences between Turkish and American students' decisions. Future research comparing Turkish and American students in regard to social factors that influence their career choices might be needed to reveal deeper understanding.

Race/ethnicity was not considered in this study due to (1) differences how both subjects are defined officially in the United States and Turkey and (2) the low number of participants in potential sub-groups, which can limit appropriate use of statistics for subsequent analysis. Further research might be conducted by increasing sample size. Although gender gap problem is heavily studied in STEM-related research, it was not a focus of this study.

Although formal and informal pipelines have been offered to promote STEM interest by government and private sector, ensuring that students pursue STEM career is not an easy task. As the results of this study revealed that some factors influencing STEM interest and career choice are common in both countries while some vary significantly. Through the formal path, efforts, to make students self-confident/self-motivated-/self-competent in STEM subjects, should be made by following rigorous curriculum. By taking the parent role on their children's preferences into action, an instruction based on that curriculum should be introduced to students at elementary level. Furthermore, the literature and this study showed that subject-teacher has an important role to shape students' STEM interest. Therefore, teacher training on the purpose of developing and teaching STEM-focused course should be the first item in school agenda. Such course should have hands-on activities engaging students more and opportunities to observe STEM professionals with the purpose of increasing awareness in STEM. These actions can also be supported with extra-curricular activities such as after-school clubs and fairs/exhibitions. Due to fact that majority of the high school students in Turkey attend college prep classes during after school time, students have almost no time available for school clubs (including STEM related clubs). Overall, more students may have STEM interest and pursue STEM careers by highlighting the factors such as self-motivation, the roles of subject-teachers and mentors and STEM-related extra-curricular activities at K-12 level.

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