Factors Affecting High School Students' Stem Career Interest: Findings from A 4-Year Study

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Abstract

The present study focuses on the results of a four-year study that examined a Harmony Public School (HPS) high school students' STEM major selection patterns. We utilize 626 12th grade students who were common participants in each year of the 4-year study. We used quantitative method for the question 1 and 2 and a mainly qualitative focus for the question 3. Descriptive statistics for the first question revealed that HPS students had higher rates in STEM career interest in all categories including gender and race/ethnicity throughout each of the four years of the study. For the second research question, we found that male students with higher science self-efficacy scores and less STEM club participation have a statistically significant effect on students' STEM major choice. For the third question, students indicated that their parents and teachers, and courses taken in high school were their top three factors that influenced their STEM career selection.

Keywords: social cognitive career theory, STEM interest and motivation, gender and racial gaps in STEM

Introduction

Science, Technology, Engineering, and Mathematics (STEM) education has become strategically important in the global economy because countries' current and future economic and innovation success depends on the size of their STEM-literate workforce. However, both in the United States and Europe countries there has been a struggle in graduating quality STEM specialists to supply their needs (Archer et al., 2012; Business Europe, 2011, National Science Board, 2012). For example, the United States has focused on reforms to boost both the quality of STEM education and the percentage of students who graduate with STEM college degrees (National Science Board, 2012). It is projected that employment in STEM occupations in the US will grow by 10.5%, or 8 million jobs until 2015 (Fayer, Lacey, & Watson, 2017). These numbers will get closer to 13.5% or 9 million jobs until 2022 (Vilorio, 2014). However, there is a shortage of qualified graduates in STEM fields needed for STEM occupations, especially in data sciences, electrical engineering, material science, and cybersecurity (Xue & Larson, 2014). Unfortunately, the proportion of students who graduated with degrees in science and engineering has not grown and it has been about 16% for the last 10 years (National Center for Educational Statistics [NCES], 2012). These numbers are even worse for females (10.4%) and students of color (13.3%) (Fouad & Santana, 2017; Landivar, 2013; NCES, 2012). To address this problem, we need to increase participation of all students including female and minority students into STEM careers.

Although there are quite a few studies on how students choose their careers in general (e.g., Nauta & Epperson, 2003; Moakler & Kim, 2014), the specific research on STEM career aspirations is somehow limited (Mau & Li, 2017). Second, while there is a substantial amount of research conducted on students' STEM persistence and career selection in college-level experiences (Mau & Li, 2017; Sass, 2015), there is a research gap on the development of STEM interest in high school (e.g., Harris Interactive, 2011). To close this gap, we designed a longitudinal study to investigate how high school students aspire STEM interest. We used social-cognitive career theoretical framework (Lent, Brown, & Hackett, 1994) to focus on a critical and comprehensive examination of various factors in influencing the students' STEM career selection. We specifically tracked 9th through 12th grade high school students from an open-ended college prep charter school system in Texas.

Theoretical Framework

The social cognitive career theory (SCCT, Lent, Brown, & Hackett, 1994) is the theoretical framework for our study due to its comprehensive and well-established structure in explaining the development of students' interests and educational and career choices. Lent et al. (1994) divided SCCT into two corresponding levels of theoretical analysis. First, they defined cognitive-person variables including self-efficacy, outcome expectations, and personal goals as an agency in their own career development. Second, they included additional sets of variables such as sex, gender and other physical attributes, features of the environment, and particular learning experiences as influences on career-related interests and choice behavior (Lent et al., 2000). Based on Bandura's (1986) general social cognitive career theory, Lent and his colleagues asserted that one's career decision is affected through a complex interplay among person, environment, and behavior factors. For SCCT, this complex interplay has three groups of variables: (a) Individual factors (e.g., gender, race, SES), (b) Environmental factors (e.g., academic and expectational factors), and (c) Psychological factors including motivational beliefs (Yu, Corkin, & Martin, 2016).

Among those, self-efficacy, outcome expectations, and goals play crucial roles in SCCT's models of educational and vocational interest development and choice making (Lent et al. 2006). SCCT also employs several environmental/contextual variables into account (e.g., supports and barriers at home and at school) which shape individual's career aspirations and selections (Maltese & Tai, 2011; Lent & Brown, 2006). More specifically, parents, teachers, and peers have substantial effects on students' academic success and career-related decisions. The present study uses SCCT and related literature to explain how these three groups of variables influence students' STEM interest development. Figure 1 displays the visual representation of the model used in this study.

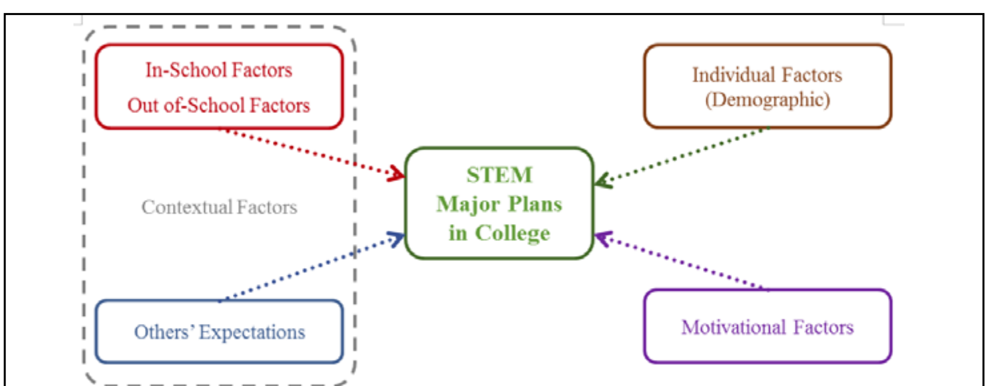

Figure 1. Social Cognitive Career Theoretical framework for this study

Underrepresentation of Female and Minority Students in STEM Selection

There are numerous policy and research reports that focus on increasing and diversifying the STEM workforce because there is a persistent representation gap among certain subgroups in their educational attainment and employment in the STEM-related areas. Although women make up almost 51% of the U.S. population and half of the college-educated workforce, they only hold 25% of STEM jobs overall (Noonan, 2017; U.S. Department of Commerce, 2011). Women disproportionately represent a low share of STEM undergraduate degrees, especially in engineering. This problem has not been changed since the early 2000s, even though women have increased their presence in the overall workforce (U.S. Department of Commerce, 2011). Furthermore, women were awarded 59% of degrees in the biological/biomedical sciences, however they only make up 19% of degrees in in engineering and 18% of computer and information sciences (U.S. Department of Education, NCES 2014). Similar problems exist for other minority groups including Hispanics and African American populations (Funk, & Paker, 2018; Hayden, Ouyang, & Scinski, 2011). Therefore, it is critically important to utilize this untapped opportunity in order to expand STEM employment and interest of both groups.

Multiple studies have investigated some of the reasons for these low representations of females and students of color in STEM areas (Eccles & Wang, 2016; Wang & Degol, 2017). Some of the factors influencing why these gender and racial gaps happen are, but not limited to, social class/status, race/ethnicity (Jackson, Suizzo, & Harvey, 2017; Mau, Perkins, & Mau, 2016), their relatively lower math and science expectancies, and values in comparison to men and other ethnicities (Wang & Degol, 2016). In a STEM motivation study, students in college level science courses showed that female students had lower science self-efficacy, coping self-efficacy, and STEM interests compared to their male counterparts (Hardin & Longhurst, 2016). Conversely, in two longitudinal studies, DeWitt et al., (2011) and Archer et al., (2012) studied the careers of young adolescents (age 10-14) and found that Asian students showed higher positive attitudes and interest towards science and STEM careers compared with students of other ethnic groups. Briefly, in addition to gender and racial factors, students' demographic and psychological/motivational factors play significant roles in their development of STEM interest and career outcomes (Eccles & Wang, 2016; Sahin & Waxman, 2019; Yu et al., 2017).

Psychological/Motivational Factors

Previous research has found that there is a significantly high correlation between psychological variables such as self-efficacy, self-esteem, outcome expectations, and interest and high school students' educational and/or vocational aspirations (Eccles & Wigfield, 2002). These factors are considered as the most influential factors in students' development of STEM interest and career selection (Mau & Bilos, 2000; Lent & Brown, 2006; 2013; Yu et al., 2016). Self-efficacy is defined as *"individual's personal beliefs about his or her capabilities to perform particular behaviors or courses of action'* (Lent et al., 2006, p. 750). These are dynamic and specific to particular domains. Outcome or self-expectations, on the other hand, are about the moments or outcomes of performing particular behaviors (e.g., What will happen if I say this?). According to the SCCT, the choices people make are linked with what they hope to receive as an outcome in the end. For example, people involved in an activity expect that their involvement will lead to some tangible rewards or approval (Lent et al., 2006). Empirical research showed that students with higher self-expectations and self-efficacy regarding STEM areas are more likely to major and be successful in these areas (Andersen & Ward, 2014; Lee, Min, Mamerow, 2015; Mujtaba & Resiss, 2014).

Likewise, K-12 students' STEM interest and psychological beliefs in mathematics and science play a significant role in their career selection (Dabney et al., 2012; Eccles & Wingfield, 2002). Their choice to engage in and develop interest in STEM activities are related to one's outcome expectations – to what extent they see themselves as a STEM person. Secondary years, especially high school years are crucial in students' development of educational and vocational aspiration including STEM education. Researchers such as Maltese and Tai (2011) have found that students who study STEM in college most likely made that choice in high school years due to their high self-efficacy beliefs in math and science rather than the grades they obtained. These were similar for female and low-income students (Schumow & Schimdth, 2013). In other words, the roles of psychological factors have to be addressed in order to develop students' K-12 STEM interest and career decisions.

Expectational Factors

Another dimension of SCCT framework is about others' expectations (students' parents, teachers, and peers). Depending on the situation, we might see these factors either as a support or a barrier for students in their choice-making process regarding STEM career selection (Lent & Brown, 2006; Muctaba & Reiss, 2014). For instance, students' parents, and teachers expectations play a substantial role in SCCT because students accomplish more or less depending on how much is expected of them (Rosental & Jacobson, 1968; Shells, 2015). In other words, students perform well and are more successful in school and careers when others such as their teachers and parents have high expectations of them in their education and career selection (Rosental & Jacobson, 1968; Sahin, Ekmekci, & Waxman, 2017; Shells, 2015).

To SCCT, from their childhood to adolescence, people are exposed directly to a variety of occupationally-relevant activities in school, at home, and in their communities. (Lent et al., 2006). These activities or influences are a function of the context and culture they live in. For example, girls are typically exposed to and expected to engage in different types of activities than boys. Interest development is mostly a fluid decision up until late adolescence where it becomes more stable (Lent et al., 2006). Student environments like their parents, teachers, and peers have significant roles in their interest development. Research found that parental attitudes towards science and their encouragement of students to engage in science-related activities strongly predicts students' interest in science (e.g., DeWitt et al., 2011). In addition, parental support is, at least, equally important in encouraging students to choose a STEM major in college (Archer et al., 2012, Garriott, Navarro, & Flores, 2017; Hui Lent, 2018; Thomas & Strunk, 2017). However, it would be interesting to examine how the roles of parent and teacher expectations change when we include all the SCCT variables—individual, psychological, expectational, and academic—together.

Formal and Informal STEM Experiences

Although self-efficacy beliefs are directly related with students' personal accomplishments in different areas, (Lent et al., 2006), it is important to review the literature on formal and informal STEM learning activities as part of contextual factors in developing self-efficacy beliefs. Studies have shown that engaging students in authentic learning activities along with their formal STEM course taking at school increases their interest in STEM (Dabney et al., 2012; Maltese & Tai, 2010; Sahin, Ayar, & Adiguzel, 2014). For instance, studies have underlined the importance of structured in-and out-of-school STEM programs such as after-school clubs and STEM summer camps in cultivating interest in STEM (Bell, Lewenstein, Shouse, & Feder, 2009; National Research Council, 2009: Sahin, Ayar, & Adiguzel, 2014) as well as expanding participants' consideration of STEM as a career (Sahin, Ekmekci, & Waxman, 2017).

In order to investigate students' development of STEM interest and selection, researchers have focused on some of the following formal and informal school-related factors: (a) the number of courses taken (Chen & Solder, 2013; Eccles & Wang, 2016: Simpkins et al., 2006), (b) early exposure to science and mathematics (Anderson & Kim, 2006; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013), (c) advanced-level courses in mathematics and science (Maltese & Tai, 2011; Sahin, Erdogan, Morgan, Capraro, & Capraro, 2012; Wang, 2013), (d) STEM clubs, summer camps, and internships (Gottfried & Williams, 2013; Kong, Dabney, & Tai, 2013; Sahin, 2013), (e) STEM teachers' and parents, expectations (Lee et al., 2015), and (f) participation in science fair competitions (Dawes et al., 2015; Sahin, 2013). In a high school intervention study, researchers found that students who had more STEM course-taking and higher ACT (American college testing) scores were more likely to purse in a STEM major in college (Rozek, Svoboda, Harackiewicz, Hulleman, & Hyde, 2017). In another study, researchers compared inclusive STEM high schools with a non-inclusive high school to examine how each school type affects students' STEM interest (Means, Wang, Young, Peters, & Lynch, 2016). They found that students who attended an inclusive STEM high school took more pre-AP and AP courses, had more extracurricular STEM activities, and developed better STEM career aspirations compared to their counterparts in non-inclusive schools.

In addition, research has found that participation in pre-college mathematics and science enrichments activities has positive effects on students' motivational beliefs such as self-efficacy, value, and interest in post-secondary mathematics and science courses (Sass, 2015). Furthermore, holding higher expectations of student success and interest in pre-college mathematics and science courses are highly correlated with students' choice of STEM majors in college (Tai et al., 2006). Therefore, it is not difficult to hypothesize that the activities that students participate in during their high school years plays a significant role in their STEM career interest development (Maltese & Tai, 2011).

Purpose of the Research

The purpose of this research is to investigate the roles of environmental, psychological, and expectational factors in high school students' STEM major choice. To accomplish this, we designed a four-year longitudinal study by incorporating social-cognitive career theory (Lent, Brown, & Hackett, 1994). This study is timely and different than other studies in several ways: 1. The following research questions were studied: 1. This is specifically focused on high school students. 2. We tracked the same group of students 4 years. Therefore, it is one of the few longitudinal studies in secondary levels if not the only one. 3. We tested all components of SCCT in one study which is very rare among the literature. 4. To accomplish this, we worked with a STEM-focused charter school system. The research questions we seek answers are given below:

1. How do the rates of 9th, 10th, 11th, and 12th grade *common survey takers*' intentions to major in STEM-related fields in college change by year, gender, and compare to actual rates of college STEM majoring at the state and national level?
2. What are the relationships between of students' demographics, in-school and out-of-school-related academic activities, teacher and parental educational expectations, and students' motivational (self- educational, mathematics and science self-efficacy) expectations and 4-year common survey takers/persisting students' intention to pursue a STEM degree in college?
3. What are the factors that students describe that affected their STEM interest and why?

Methods

Setting: Harmony Public Schools (HPS)

The HPS is a non-profit open enrollment K-12 college preparatory school district in Texas. It includes more than 57 schools serving a diverse student population of over 34,000, where 60% of students receive free or reduced-price lunch and 70% are under-represented minorities.

We purposefully selected HPS schools because of the district and school-wide emphasis on integrating STEM across the curriculum and the large student diversity within the school population. The school system uses a project-based learning as their teaching approach in core subjects in addition to variety of STEM clubs, science fairs, STEM school festivals, and such. Also, HPS provided us with access to the variables we needed in order to test and utilize SCCT as a framework in this study.

Participants

We shared our purpose of research with the school system's director of research person. After we got consent, we started talking about strategies to conduct this four-year study. They provided us a contact person from each high school campus. We agreed on the time interval to administer our survey each year. We shared the instrument with contact person each year for the duration of two months. In year 1, out of 2,157 9th grade students (class of 2019) from 23 HPS high schools, 1,520 (70%) participated in the study. For the second year of the study, out of 1945 10th grade students, 1595 (82%) of them participated in the study. Among 1,620 11th graders, 1,228 (76%) of them completed the survey. In the final year, a total of 1586 12th graders from 23 high schools were invited to participate in the study. Of those, 1348 (85%) 12th graders in 22 high schools completed the survey.

Persisting students: At the end of the fourth year, 626 students were common participants in all four years. In other words, there were same 626 students who participated in the study and completed the instrument each year. The participants included 308 females (49%), 318 males (51%), 90 Asians (14%), 89 African American (14%), 357 Hispanics (57%), and 72 Whites (12%).

Instrument

We used an online survey consisting of 46 questions to request information about five categories of variables: (a) student demographics, (b) family context, (c) school and out-of-school related activities, and (d) parent and teacher expectations, and (e) students' self-expectations about their future education, and mathematics and science efficacy (see Appendix A). We also included three open-ended questions to investigate students' thought processes related to their STEM major selection over the years. The last question asked participants if we could contact them in the future in order to track their career selection. The current instrument was adapted from previously developed and validated scales (Lee et al., 2015; Sahin, Ekmekci, & Waxman, 2017a, 2017b). The same instrument was administered to students each of the four years. One of the sections of the instrument was adapted from Friday Institute for Educational Innovation (2012) and focused on students' math and science-self efficacy levels. Cronbach's alpha reliability values for the math self-efficacy (8 items) and science self-efficacy scales (9 items) were calculated and found to be high (.92 and .94, respectively) for year 4. The authors of these instruments from Friday Institute calculated reliability levels for these constructs and found those around 0.83 (Friday Institute for Educational Innovation, 2012). We also got similar values of Cronbach's Alpha reliability in year 1, year 2, and year 3 studies around .90.

Variables

We used students' intention of choosing a STEM major (Yes/No) in college as our dependent variable. Students indicated 'Yes' as majoring in STEM-related area or 'No' indicating not STEM majoring area. There were two different questions measuring this (Question 19 and Question 26) (see Appendix A). Q19 was a yes/no question asking whether students were planning to major in a STEM-related area in college. To cross-check students' answers, we asked the second question of what career they want to work at after graduating from college (Q26). We used the National Science Foundation's (2010) list of career classification and medicine-related careers for question 26. Then, we coded students' choices of careers as STEM and non-STEM. Finally, after we compared students' answers to Q19 with their answers to Q26, we created a binary dependent variable as 1 (STEM) and 0 (non-STEM). The Kappa agreement between the two questions was .71. Our independent variables were all the environmental, parent and teacher expectations, individual, and contextual factors (see Table 1).

Analyses

Both quantitate and qualitative methods were used in this study. First, we calculated descriptive statistics for all four years' common survey takers' rates. For the second research question, we utilized 626 high school students as our sample (i.e., all students who participated in all four years of the study). To Bujang, Sa'at, Sidik, and Joo, (2018), for observational studies with large population size, we need a minimum sample size of 500 to utilize binary logistic regression. Specifically, we ran a logistic regression to investigate which set of independent variables predict

	N	Range	Mean	Std. Deviation
Gender	608	0-1		
Ethnicity	626	1-4		
Parent College Degree (y/n)	588	1-2		
SES[1]	608	1-2		
Count STEM Clubs	603	0-6	0.68	1.12
Count STEM Summer Camp	626	0-4	2.15	0.70
Count STEM Internship	626	0-4	2.12	0.67
Count STEM AP Course	604	0-8	0.68	1.12
Count Science Fair	626	0-11	0.89	1.29
GPA	605	1-4	2.93	0.72
Educational Degree Expectations	606	1-6	4.32	1.34
Parent Support	605	1-4	3.6	0.67
STEM Teacher Support	605	1-4	3.12	0.87
Math Self-efficacy	604	1-5	3.46	0.91
Science Self-efficacy	605	1-5	3.44	0.86

Note:[1] SES is calculated based on students' lunch status. Low SES students are defined as those who received either free or reduced-price lunch (1). High SES students are defined as those who paid their lunches (2).

Table 1. Descriptive Data for Variables

students' probability of choosing a STEM major. Before we ran the logistic regression, we verified the assumptions of absence of multicollinearity, independence of errors, and linear relationship between the independent variables and the log odds (Meyers, Gamst, & Guarino, 2006). We utilized SPSS 26.0 software for all the analyses carried out in this study. Aligned with our framework, we chose four groups of variables and entered them in blocks using a forward stepwise procedure. For Model 1 as our baseline model, we entered gender, dummy variables of African American, Asian, and Hispanic, SES status, and parents' college degree status. White students were our reference group. In Model 2, we entered in and out-of-school academic variables (i.e., Weighted year 4 GPA, science fair participation, STEM club participation, STEM AP course taking, STEM summer camp, and internship participation). Next, in Model 3, we added parent and teacher expectations of students' success. In the final step of our Model 4, we entered students' motivation (i.e., self-expectation of educational attainment, math and science self-efficacy). For the third question, we asked an additional qualitative open-ended question to help explain quantitative multiple-choice question simultaneously (the embedded sequential design). For the multiple-choice question (*21. Please choose three factors you think affect(ed) your career interest most), we provided nine researched-based factors and had students choose three of them as the most influential to least influential in their STEM career interest development. We conducted a frequency analysis to reveal what factors our senior students chose as top three. For the open-ended question, we asked a similar question, but we did not provide any options to choose from (#46. What factors affected your intentions? Please list the factors from most influential to the least and tell more about why they had an impact on your major selection). To analyze, we initially read each response multiple times. Once we had general information about the content, we coded and counted factors. Then, we grouped those associated with several quotations for each factor.

Results

Research Question 1

Out of the 626 common survey participants, 388 12th grade students were planning to major in STEM areas where 52 of them indicated interest in computer and mathematics related-areas, 106 of them showed interest in architecture and engineering, and 230 of them contemplated majoring in health /medicine, physics, astronomy, and chemistry related areas. Descriptive analyses revealed a steady decrease from 9th to 12th-grade in students' interest in choosing a STEM-related major in college (see Table 2). However, HPS students' rates are still substantially higher than the average number of STEM major students in the state of Texas and the Nation. Overall HPS students' STEM selection interest decreased from 77% to 62% between year 1 and year 4 (15% decrease).

Research Question 2

Our four logistic regression models had all good fits and Hosmer and Lemeshow p values ranged from .39 to .97. Results of the logistic regression analyses are provided in Table 3. Model 1 included gender, African American, Asian, and Hispanic students, SES status, and parents' college education in the U.S. to predict HPS junior students' STEM intentions. The baseline model revealed that there was a significant difference between male and female students in terms of STEM major selection rates ($B = .43$, $p < .05$) in favor of male students. Hispanic senior students were statistically significantly less likely than White senior students to choose a STEM major in college ($B = -.47$, $p < .05$). This means that Hispanic students had odds of majoring in STEM over .6 times less than White students.

Model 2 examined in-and out-of-school academic variables after controlling for gender, ethnicity, SES, and parents' college education status. Gender and being Hispanic were similar in model two. Gender was statistically significantly predicting senior students' STEM major selection in favor of males ($B = .37$, $p < .05$). Being a Hispanic was a statistically significantly negative factor for Hispanic students in their STEM major selection ($B = .23$, $p < .05$). Among academic variables, senior students with more STEM AP course taking ($B = -.34$, $p < .01$) were statistically significantly more likely to show STEM major interest in college than their peers with less STEM AP course taking. On the other hand, the HPS class of 2019 seniors that had more STEM club participation ($B = -.15$, $p < .01$) were statistically significantly less likely to major in STEM areas compared to their counterparts with less STEM club participation.

	Male	Female	AA	Asian	Hispanic	White	Overall
HPS 9th Graders	80%	73%	82%	87%	73%	78%	77%
HPS 10th Graders	74%	59%	73%	78%	61%	72%	67%
HPS 11th Graders	60%	64%	63%	52%	65%	56%	62%
HPS 12th Graders	67%	57%	69%	74%	58%	63%	62%
State Average[1]	46%	14%	25%	36%	31%	33%	28%
National Average[2]	45%	15%	25%	37%	30%	33%	27%

Note: [1] Texas' 2018 STEM & Innovation Report Card™, [2]Texas' 2017 STEM & Innovation Report Card™

Table 2. Percentages Four-Year Common Takers' Year 1, 2, 3, and 4 STEM Major Plans by their Demographics (n=626)

	Model 1		Model 2		Model 3		Model 4	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Gender	.43*	1.53	.37*	1.45	.43*	1.53	.65**	1.92
Hispanic	-.47**	.62	-.39*	.67	-.37	.71	-.21	.81
STEM AP Courses			0.23***	1.26	.21***	1.23	.12	1.13
STEM Clubs			-0.15***	0.86	-0.15*	0.86	-.11*	.90
STEM teachers' expectation					.31**	1.37	0.08	1.09
Science efficacy							1.54***	4.65

*Note: * p<.05, ** p<.01, *** p<.001*

Table 3. Logistic Regression Model Predicting Students' STEM Major Intention

Model 3 investigated parents and STEM teachers' expectations of students' success after controlling student demographics and academic variables. In Model 3, gender was still statistically significant factor in students' STEM major selection decision ($B = .43$, $p < .05$). Being Hispanic was not a significant advantage or disadvantage anymore in STEM major selection ($B = -.37$, $p > .05$). In addition, STEM teachers' expectations statistically significantly predicted students' STEM major interest in college ($B = .31$, $p < .01$). Senior students' STEM AP course taking, and STEM club participation continued to predict students' STEM major intention statistically significantly. Senior students with more STEM AP course taking ($B = .21$, $p < .01$) were significantly more likely to major in STEM-related areas in college their other HPS seniors with less STEM AP course taking. Seniors with more STEM club participation were statistically significantly but negatively affecting students' selection of STEM major areas in college ($B = -.15$, $p < .05$).

In Model 4, we tested expectational factors (students' self-educational expectations, math and science efficacy) after controlling for the variables included in the previous models. Gender continued to significantly affect senior students' STEM major selection interest ($B = .69$, $p < .01$). Male students had odds of majoring in STEM over almost 2 times more than female senior students. STEM club participation was still significantly but negatively affecting students' selection of STEM major areas in college ($B = -.11$, $p < .05$). STEM club participation was still significantly but negatively affecting senior students' STEM major interest ($B = -.11$, $p < .05$). Finally, HPS' 12th grade students with higher science self-efficacies were more likely to choose a STEM major in college than their counterparts with lower science self-efficacies ($B = 1.54$, $p < .01$).

Research Question 3

For the multiple-choice question, we found that HPS seniors indicated that *parents* (383) were the most influential factor in their STEM career interest development out of 1052 top four factors (see Table 4). The second most influential factor was their *teachers* (333). The seniors chose *courses taken in high school (197)* as third most influential factor affecting their STEM career interest development.

For the open-ended question, 41 students did not provide any responses. Out of remaining 585 seniors, we found the same three factors in different orders that we found in the previous question as mostly influencing their STEM career selection. HPS seniors mentioned *parents* (124) most as a factor in their STEM career selection (see Table 5). Then, they named the *courses* they took (81) as the second most influential factor. The seniors chose *teachers* (69) as the third most influential factor in students' STEM major choice.

Factors	Count	Total Count	Percentage
Parents	383	1052	36%
Teachers	333	1052	32%
Courses taken in high school	197	1052	19%
Early exposure to science and math	139	1052	13%

Table 4. Order of Factors Influencing Students STEM Major Selection

Factors	Parents	Courses/classes taken in high school	Teachers
Frequency	124	81	69

Table 5. Factors Affecting Students STEM Major Selection

Parents

Many students indicated that their parents had a major influence in their development of STEM career interest. For instance, several students indicated how much their parents' expectations had influenced their STEM selection. As one student stated it *"my parents and my grandparents always wanted a doctor in the family, and I like medicine and I have a passion for healing people but mostly I want to do it for my parents and my grandparents."* There were other students who were inspired by their parents' current profession such as in these examples *"My dad being in the field of geotechnical engineering has been my inspiration of perusing this job field." and "My family, my dad is an engineer and I like how he works with computers and fixes stuff."*

In addition, there were many other students who shared similar statements about their parents' roles in their STEM major selections: *"Main factors have been my parents and..", "My parents haven't been really influential about me wanting to pursue a career in..", "My family especially my parents have influenced me on my [STEM] career choice", and "My parent and . . . are the most influential. They have never stopped supporting me".*

Courses /classes taken in high school

Another common factor HPS seniors kept pointing out was about the courses they took during their high school years: *"The courses I have taken throughout my high school years guided me towards the career I would like to pursue." and "I always had the mindset of entering the medical field regardless, however the courses in high school helped give me a better insight on the medical field.".*

Students also indicated that the courses they took were interesting and a perfect fit for their career goals in mind such as *"courses have affected my intentions, because I was able to find my strong suits and potential passions in each." and "I have always been interested in building and creating and I feel that engineering would be a very fun career for me and I am excited to get started with my career.".* Other students named some specific courses and how taking those courses helped them develop interest to STEM areas:

> . . . . my *courses*, ... All of these factors impacted my decision in my major selection in Biology because I intend to pursue a career in the medical field. All of these factors provided me with advice, guidance, and knowledge about what this field is about and influenced me to select this major.
>
> Having a *biomedical course* for four years is the major factor that affected my intentions.

AP. . . and my *PLTW* classes influenced my major immensely.

Factors that strengthen my intentions [of choosing a STEM major] is the *PLTW* pathway.

I have contemplated about pursuing a career in STEM throughout high school due to the great *PLTW Biomedical classes* I have taken all 4 years.

I have decided to pursue a career in STEM, in this case *biology*, because since I began taking science courses in high school, the teachers and the lectures really impressed and intrigued me.

I came to an orientation in *engineering* class and that made me realize that i could be working in a place where i can be helping others and being guided to create a product by myself. that really made me want to become an engineer at my early stages in high school.

I never contemplated it [until] I found my love *for computers* freshmen year and decided to pursue a career in that.

Teachers

Students who were inspired by their teachers emphasized how great and helpful their STEM teachers were in helping them to understand and love the course they took

As they made the subject of the class more interesting and not boring.

Factors that affected my intentions when it came to a STEM field was my teachers and

the way they taught their class.

I think one of the main reasons why I would like to get in STEM, is because the teachers have really showed me how it is like. I had no interest in learning about, in this example science, but they make it so fun and enjoyable to learn. They are also very open and accept your ideas and opinions in a good way.

Factors that affected my intentions were the courses that I took, my teachers, and my parents. They taught me so many things and I've learned a lot from them.

Some students did not mind giving the name of the teacher and course that helped them develop STEM interest.

The courses I took and the teachers of those courses. Mr. X made me passionate about *physics*, so I continued on taking.

PLTW Teacher - helped me realized what I wanted to do (exactly)

A huge factor was the classes I took and the teachers that ran them.

My teacher Ms. Y affected me greatly. The biomedical sciences class really impacted my choices about it.

Parents and teachers were cited together most of the times. For example, two students said these *"Main factors have been [including] my parents and most of my teachers I had throughout my time in school.". and "My parents and my teachers are the most influential. They have never stopped supporting me."*, respectively.

Discussion

In the present study, we used social-cognitive career theoretical framework (Lent, Brown, & Hackett, 1994) to focus on a critical and comprehensive examination of various factors in influencing the students' STEM career selection. We specifically focused on 12th grade STEM students who persisted (i.e., participated in the study for all 4 years) and examined the factors they perceived were related to their interest for choosing STEM as their college major. Finally, we examined 12th grade students' perceptions on the factors that influenced them the most regarding STEM career selection.

For the first research question, descriptive statistics revealed some promising rates for students of this particular school system. We realized that 12th grade HPS students had higher rates of STEM major intentions each year compared to Texas and U.S. averages for actual STEM major selection in college. These higher rates were consistent for all subgroups by gender and race/ethnicity throughout each of the four years of the study. These findings may be partially due to the school system's STEM focus that provides all students a variety of year-long project-based learning courses and STEM clubs every year. In addition, the school system uses an integrated STEM curriculum and provides STEM professional development for most teachers. Overall, these findings are quite encouraging because they suggest that HPS may be successful in stimulating high school students' interest in STEM careers.

Another important finding from this study relates to reducing the STEM gap for female and minority students. In particular, female students, African American students, and Hispanic students were found to have dramatically higher intentions for majoring in STEM than the state and national average. On the other hand, similar to other studies (Archer, et al., 2012; DeWhitt, et al., 2011), males and Asian students were more likely to choose a STEM field than students from other racial groups. The overrepresentation of Asians in STEM majors has similarly persisted over time and is due to a number of factors including Asian students' higher test scores and grade point averages. While these racial/ethnic-related differences are similar to the state and national average, the gender and minority gap is dramatically lower for HPS students' intention than the state and national averages. This suggests that HPS is successful to a certain extent on reducing the gender and minority gap in STEM.

Surprisingly, we found a consistent decrease from 9th grade through 12th grade in the rates for intentions to pursue a STEM degree in college. Overall, students' interest in STEM decreased from 77% to 62% between 9th and 12th grade. This finding, however, is similar to the research by STEMconnector (2012) where high school seniors were found to be about 10% less likely than high school freshmen to declare an interest in a STEM-related field. There might be several reasons why this decrease occurred. First, this might suggest that students may be over-saturated with STEM by the time they reach 11th and 12th grade and consequently begin to lose interest in it. Second, these students are the same group of students all four years. Naturally, they have known what STEM careers were available to them and what they needed to do in order to be able to major in those fields in college. Therefore, students might have been more conscious in their decision to choose the field in college compared to those who have not been exposed much to STEM education and what it takes to get there. This might have let some students rationally decide that STEM is not the right major for them.

Our second and main research question examined the relationships between school and out of school-related activities, parents and teachers' expectations of students' success, students' self-expectation, math and science self-efficacies and 12th grade students' intention to pursue a STEM degree. To examine the applicability of the SCCT (Lent et al, 2002), we simultaneously examined the four groups of variables. Our results are mostly similar with prior research that found that gender and science self-efficacy have a statistically significant effect on major choice (Brown, Concannon, Marx, Donaldson, & Black, 2016; Ocumpaugh, San Pedro, Lai, Baker, & Borgen, 2016; Mau & Li, 2018). Male HPS students were more likely to choose STEM careers than female students as found in the previous literatures. Students with higher science self-efficacy scores were also found to more likely choose STEM careers. In other words, students' perceptions of their ability to do well in science is important. We also found STEM club participant negatively affected students' choice of a STEM career. This result may be related to the previous finding that students' interest in STEM declined in the 11th and 12th grade. Students may be over-saturated with STEM by the time they reach 11th and 12th grade and consequently begin to lose interest in it, especially if they participated in STEM clubs every year of high school.

Surprisingly, we found that there were no differences by (a) students' ethnicity, (b) STEM AP courses, (c) STEM club participation, and (d) STEM teachers' expectations except students' STEM club participation. While previous research found these factors significant predictors of STEM careers, our study did not find these variables to be significant. This may be due to the fact that our study used a more comprehensive model that simultaneously examined the four groups of variables from the SCCT theory. Our earlier logistic regression models (i.e., Models 1, 2, & 3) did find significance for all of the variables. It was only on the final model (Model 4), where we saw that STEM AP courses and STEM teachers' expectations were no significant predicators. There may be some collinearity between those variables and students' science self-expectations which may explain why those variables were not significant in the final model.

For the third research question, we examined 12th grade HPS students' perceptions of three most influential factors that affected their STEM career interest development. Parents, teachers, and courses taken in high school were cited most frequently as students' choice of influential factors. Most of the school-based programs like science fairs, afterschool clubs, summer camps, and internships were not listed as influential factors. Similarly, early exposure to math and/science, gender (4th most influential), and socioeconomic status were not cited as influential factors either. The open-ended responses from students illuminated on the influential factors. Many students described how their parents supported them and encouraged them to pursue STEM careers. They similarly described their teachers 'role in influencing them by stimulating their passion in STEM, supporting them, and motivating them to do well. Finally, students' open-ended responses regarding the importance of their courses highlighted how specific courses helped them develop interest, insight, and passion in STEM areas.

The present study is one of the few studies in the field that have used the SCCT framework to examine all three aspects of career choice (i.e., individual, environment, and behavior) together. Also, this study involves the adaptation of an existing instrument (Lee, Min, & Mamerow, 2015) that includes more student- and school-related variables (e.g., number of student projects, STEM courses, STEM club and internship participation) that allows us to obtain a more comprehensive description of the STEM-related opportunities that students had in high school. Another contribution of this study is that it focuses on 9th through 12th grades high school students. Most of the research evidence on student persistence on the STEM pipeline is either on a single grade or based on college-level experiences rather than high school (Nakakoji, Wilson, & Poladian, 2014; Sass, 2015). Third, the inclusion of some qualitative data presents some richness to why students are interested and motivated in STEM areas. Finally, the school system that participated in this study suggests that schools serving predominantly low-income and unrepresented minorities can be successful in encouraging their students to enter the STEM pipeline. For future studies, we might also include collecting data about high school college counselors (e.g., Ledbetter, 2012) and educational backgrounds of teachers (e.g., Falco, 2017) to investigate impacts of those factors in high school students' STEM major selection.

Conclusions

The results of this study lead to several implications for policymakers, administrators, and educators. First, it suggests that school districts and schools with similar STEM activities and project-based learning types inquiry-based teaching programs can have a positive impact of students' intentions to major in STEM areas. About 62% of the 12th grade-HPS students who responded to this survey are contemplating majoring in STEM areas. This is dramatically higher than the state and national average. This is also an important finding given that 60% of the HPS students receive free or reduced-price lunch and 70% are under-represented minorities (Hispanics and blacks). Overall, these findings from our study are especially encouraging because they suggest that schools serving students from disadvantaged circumstances can implement school-based programs and practices that may impact students' future careers in STEM.

A second implication is that there are still STEM aspirational gaps between (a) female and male students, and (b) Hispanic and non-Hispanic students. Prior research has found that science gaps often begin to occur in elementary schools and are generally stable across secondary school levels (Morgan, Farkas, Hillemeier, & Macuzuga, 2016). The findings from the present study are similar to prior research in that we found the gaps generally stable across the four years of high school. Although general interest in STEM careers declined from 9th to 12th grade, the male-female gap and minority–White gap remained stable. It appears that the learning experiences and expectations in high school may not make a difference and reduce the STEM opportunity gap. It is important that schools try to address the serious gaps that already exist in elementary and middle school so that they are reduced or eliminated by the time students enter high school. Targeted intervention programs may also need to be developed to specifically reduce these aspirational gaps.

Third, we have found that specific district and school-based programs and courses influence students' STEM career aspirations. Some programs such as STEM AP courses, were found to be positively related to students' STEM career interest, while other programs such as participation in STEM clubs were found to negatively affect students' STEM career interest. More research is needed to understand why participation in STEM clubs negatively related to students' STEM career interest. Science fairs, summer camps, and STEM internships were not found to significant predict STEM aspirations. Further research is necessary to see why those programs do not appear to influence students' STEM interests. On the other hand, 12th grade HPS students do discuss several ways that teachers and their parents encouraged them to pursue STEM careers. Further research may need to explore teacher and parent perceptions of how they successful motivate and support their students.

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APPENDIX A

*1. I agree to participate in this study and allow the use of information referred to in the attached letter.
Yes No

*2. Gender
Male
Female

*3. Ethnicity
African American
Asian
Hispanic
White

*4. Lunch Status
Free
Reduced
Paid

*5. Did either of your parents receive a college degree in the United States?
Yes No

*6. What is your parent's highest level of education?
Less than high school
High school diploma or GED
Associate Degree (two-year)
Bachelor's degree (4-year)
Master's degree or higher

*7. Which clubs have you attended in high school (including 9th grade)?
American Mathematics Competition
Advanced Research Club
Arduino Club
Astronomy
Biology
Computer Science Club
Drone FPV Racing Club
E-Cyber Mission
Environmentalists
FTC Robotics
Harmony Scientific Research Society
Health
Junior Solar Sprint
Math Contest
NABT Bio Club
PBL Club
Project Construction
Rocketry Club
Scale Modeling
Science Olympiad
Sea Perch
Solar Car Club
Shell Eco
3D Printing Club

Cheerleading
Chess
College Readiness and Leadership Program (CRLP)
College Readiness and Leadership Program (CRLP)
Drama
Folk Dance
French
Odyssey of the Mind
Poetry
Spanish
Other (please specify)

*12. Did you participate in Digital Storytelling Competition (DISTCO) with your STEM SOS project video in years below?
2015-2016
2016-2017
2017-2018
None

*13. Please enter the number of SCHOOLWIDE science fair events you participated in during high school (including 9th and 10th grade):
1-5
6-10
11-15
16-20
More

*14. Please enter the number of REGIONAL science fair events you participated in during high school (including 9th and 10th grade):
1-5
6-10
11-15
16-20
More

*15. Please enter the number of STATE LEVEL science fair events you participated in during high school (including 9th and 10th grade):
1-5
6-10
11-15
16-20
More

*16. Please enter the number of INTERNATIONAL science fair events (e.g., ISWEEEP and Intel) you participated in during high school (including 9th and 10th grade):
1-5
6-10
11-15
16-20
More

*17. How many science, technology, engineering, and mathematics (STEM)-related summer camps did you participate in during high school years (including 9th and 10th grade)?
Enter your response here

*18. How many science, technology, engineering, and mathematics (STEM)-related internships did you attend at a medical or higher education institution (university) in high school (including 9th and 10th grade)?
Enter your response here

*19. Do you have intention to declare a science, technology, engineering, and mathematics (STEM)-related major in college?
Yes†No

*20. Which STEM-related Advanced Placement (AP) courses have you taken so far (including 9th and 10th grade)?
AP Biology
AP Chemistry
AP Environmental Science
AP Physics 1
AP Physics 2
AP Physics C
AP Calculus A B
AP Calculus BC
AP Computer Science A
AP Computer Science Principles
AP Statistics
Other (Specify)

*21. Please choose three factors you think affect(ed) your career interest most.
Teachers
Parents
Science Fairs
Afterschool clubs
Summer Camps
Internships
Early exposure to math and/or science
Courses taken in high school
Gender
Socioeconomic status
Other: please specify

*22. How many advanced Placement (AP) courses have you taken so far?
Enter your response here

*23. What was your educational degree expectation about yourself during high school?
High school or less
Vocational training
Some college (ex: 2-year)
4-year college
Masters' degree
Doctorate or professional degree

*24. How encouraging were your parents about going to college?
Not encouraging at all
Somewhat encouraging
Encouraging
Strongly Encouraging

*25. How encouraging were your STEM teachers about going to college?

Not encouraging at all
Somewhat encouraging
Encouraging
Strongly Encouraging

*26. What type of career do you want to pursue in after college?

Agricultural sciences
Chemistry
Computer Science
Engineering
Environmental science
Geosciences
Life/biological sciences
Mathematics
Physics/Astronomy
Medicine/Medical
Business
Social Sciences
Communication/RTF
Liberal Arts
Other (please specify)

*27. Math has been my worst subject

Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*28. would consider choosing a career that uses math

Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*29. Math is hard for me

Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*30. I am the type of student to do well in math

Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*31. I can handle most subject well but I cannot do a good job with math
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*32. I am sure I could do advanced work in math
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*33. I am good at math
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*34. Your current GPA
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*35. I am sure of myself when I do science
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*36. I would consider a career in science
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*37. I expect to use science when I get out of school
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*38. Knowing science will help me earn a living
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree

*39. I will need science for my future work
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*40 I know I can do well in science
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*41. Science will be important to me in my life work
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*42. I can handle most subjects well but I cannot do good job with science
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*43. I am sure I could do advanced work in science
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

44. Thinking back to the beginning of the high school, please tell us about how you have contemplated about majoring in STEM or non-STEM field in college, and pursuing a career in STEM or non-STEM after college?

45.How has your intentions about persisting in STEM or non-STEM fields changed throughout your high school years?

46. What factors affected your intentions? Please list the factors from most influential to the least and tell more about why they had an impact on your major selection.

Note: * stands for compulsory questions.