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The relationships among high school STEM learning experiences, expectations, and mathematics and science efficacy and the likelihood of majoring in STEM in college

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ABSTRACT

This study examines college students' science, technology, engineering, and mathematics (STEM) choices as they relate to high school experiences, parent, teacher, and self-expectations, and mathematics and science efficacy. Participants were 2246 graduates of a STEM-focused public Harmony Public Schools in Texas, Harmony Public Schools (HPS). Descriptive analyses indicated that the overall percentage of HPS graduates who chose a STEM major in college was greater than Texas state and national averages. Logistic regression analyses revealed that males and Asian students are more likely to choose a STEM major in college than females and non-Asian students, respectively. Moreover, students whose parents had a college degree in the U.S. are more likely to major in STEM fields than those who did not. Furthermore, males with higher mathematics efficacy and females with higher science efficacy are more likely to choose a STEM major than their counterparts with lower mathematics and science efficacy.

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Integrative STEM; career choice; mathematics and science efficacy; Pygmalion

Introduction

A myriad of national reports emphasises the importance of science, technology, engineering, and mathematics (STEM) due to its critical role in securing a competitive edge in an increasingly global economy (Augustine, 2007; National Research Council [NRC], 2013; National Science Board [NSB], 2007; President's Council of Advisors on Science and Technology [PCAST], 2012). What is particularly unsettling, however, is that the U.S. colleges do not produce adequate number of graduates in STEM fields (Chen & Solder, 2013; Sass, 2015). Although the U.S. is a leader in the global economy and technology, university degrees conferred in STEM fields in the U.S. is far behind other developed countries. According to the National Science Foundation (NSB, 2016), almost one-third of university degrees awarded in 2012 were in science and engineering in the U.S., whereas in China, for example, almost half were in science and engineering. Among all university degrees in science and engineering globally, 23% were conferred in China; 23% were conferred in

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India; 12% were conferred in European Union; and only 9% were conferred in the U.S. (NSB, 2016).

Given this critical STEM gap in the U.S., educators, policy-makers, and scientists have been promoting students' interest and achievement in the STEM fields and have been trying to understand the factors that may play an important role for student persistence in STEM. The vast majority of existing evidence in the extant literature on student persistence on STEM pipeline is based on college-level experiences (Sass, 2015). However, this may conceal important impacts of pre-college experiences, preparation, and resources on STEM persistence. The focus on college coursework, instructors, and grades in understanding STEM major and career choices only provides limited information about what has happened to a student prior to attending college and, in turn, may not provide any connection between post-secondary STEM choices and pre-college indicators. Research indicates that high school and early grades are critical times for developing expectancies for interest and success in STEM fields (Tai, Liu, Maltese, & Fan, 2006; Wang, 2013). Therefore, the goal of this study is to investigate the factors at the high school level that may relate to students' entering the STEM pipeline. More specifically, high school STEM experiences, teacher and parental expectations, and students' motivational beliefs are the factors of interest in this study.

Theoretical framework

This study is grounded in social cognitive career theory (SCCT; Lent, Brown, & Hackett, 1994), which posits that one's career choice is influenced by the beliefs the individual develops and refines through complex interplay between the individual, environment, and behaviour. Like many other areas of human functioning such as organisational behaviour, SCCT is an extension and application of social cognitive theory (Bandura, 1986) to career choice (Lent & Brown, 2006).

SCCT focuses on the interconnection of self-efficacy, outcome expectancy, and personal goals and how they may interrelate with other personal, contextual, and experiential factors that generate aspirations for one's career choice (Lent et al., 1994). As part of social cognitive construct, self-efficacy is defined as 'a judgment of one's capability to accomplish a certain level of performance' (Bandura, 1986, p. 391). Perceived self-efficacy in a given academic domain has been found to predict sustained effort, choice, and performance in that domain (Crombie et al., 2005). Self-efficacy is influenced by personal mastery experiences, vicarious experiences (observation of models), social persuasion, and physiological indicators (Schunk, Pintrich, & Meece, 2008; Tschannen-Moran & Hoy, 2001).

Moreover, SCCT suggests that decisions about a particular intent to pursue a field can be explained by interests and goals (Lent & Brown, 2006; Wang, 2013). Selecting a STEM major in college is conceivably influenced by students' intent to pursue these fields upon high school graduation or college entry. Given the key role of early science and mathematics experience in STEM persistence (Ma & Johnson, 2008), interest in majoring in STEM can be argued as an outcome of motivational attributes and learning in science and mathematics at the high school level (Lee, Min, & Mamerow, 2015). Therefore, this intent may be closely related to high school students' motivational beliefs, course takings, and achievement in science and mathematics (Wang, 2013).

A limited number of studies related to academic major choices in STEM have utilised the SCCT theoretical framework to investigate issues relevant to STEM choice (Wang, 2013). Although SCCT emphasises the interchange among three main components (i.e. individual, environment, and behaviour), very few studies have taken into account all three aspects of career choice together. Lee et al. (2015) focused on self-efficacy and social expectations; Wang (2013) considered motivational beliefs and academic work, while Andersen and Ward (2014) examined motivational beliefs and academic performance in science and mathematics when studying the students STEM persistence. Maltese and Tai (2011) and Lichtenberger and George-Jackson (2013), two of the most comprehensive studies in terms of factors that may have impact on STEM persistence, did not investigate the social expectations and informal STEM activities students engage in. This may be due to the vagueness of defining environment which may refer to many different aspects of parental and school contextual factors. Moreover, some studies focused on aspirations and intentions to purse a STEM major or career rather than the long-term outcome of whether STEM choice has actually happened either in college or after graduation from college (Andersen & Ward, 2014).

The present study integrates SCCT and previous research on factors closely connected with academic choices of college students. While our goal is not to examine the structural model of SCCT directly, this study addresses the interconnectedness among personal and environmental factors and STEM choice. These factors are detailed below under two main headings: (a) school contextual factors and (b) parental and teacher expectations. Unlike previous research, the present study analyses the actual academic college records (i.e. academic major selection) of students who graduated from a public school system with a STEM focus. Most studies utilised national large databases such as High School Longitudinal Study-2009 (Andersen & Ward, 2014; Lee et al., 2015; Maltese & Tai, 2011; Wang, 2013) when studying STEM persistence. The present study avoids the issues with secondary analysis of national databases such as use of proper weights and restriction of variables of interest (Rutkowski, Gonzalez, Joncas, & von Davier, 2010).

Factors influencing students' choice of STEM majors

In their study of 25 education systems across the world, Barber and Mourshed (2007) analysed the student achievement outcomes of the best-performing school systems defined by Organisation for Economic Co-operation and Development. What 'schools' and 'school systems' have to offer for the best education possible for every child is among the three things that they found matter the most for student outcomes. School factors such as course-offerings, extracurricular activities including science fairs and STEM clubs, and early exposure to mathematics and science that schools can make available to its students may be influential in students' future choices and performance in STEM (Dabney et al., 2012; Dawes, Long, Whiteford, & Richardson, 2015; Gottfried & Williams, 2013; Simpkins, Davis-Kean, & Eccles, 2006). Research indicates that there are several school level factors related to both formal and informal STEM activities and experiences that are associated with STEM college major selection and STEM career choice (Bottia, Stearns, Mickelson, Moller, & Parker, 2015; Bouvier & Connors, 2011; Dabney et al., 2012; Dawes et al., 2015; Nugent et al., 2015). More specifically, researchers have found several factors that are related to students pursuing and persisting STEM fields, such as

(a) the number of courses taken (Chen & Solder, 2013; Simpkins et al., 2006); (b) early exposure to mathematics and science (Anderson & Kim, 2006; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013); (c) mathematics and science curriculum (Elliott, Strenta, Adair, Matier, & Scott, 1996); (d) advanced level courses in mathematics and science (Maltese & Tai, 2011; Wang, 2013); (e) STEM clubs and summer camps or internships (Gottfried & Williams, 2013; Kong, Dabney, & Tai, 2013); (f) STEM teachers' and parents' expectations (Lee et al., 2015); (g) opportunities and support students receive (Seymour & Hewitt, 1997); (h) participation to science fairs (Dawes et al., 2015); and (i) teacher quality and diversity (Andersen & Ward, 2014; Price, 2010).

Dawes et al. (2015) surveyed freshman college students studying STEM-related fields to understand the reasons why they choose STEM degrees. They found that STEM teachers, parents, and STEM engagement activities such as science fairs, STEM clubs, and STEM internships had a great influence on students' decisions about majoring in STEM. Gottfried and Williams (2013) studied the connection between mathematics and science club participation and the probability of STEM major selection in college and found that mathematics club participation was significantly associated with increased likelihood of choosing STEM major in college. Moreover, research has also found that participation in pre-college mathematics and science enrichment activities is positively associated with motivational beliefs such as self-efficacy, value, and interest mathematics and science in post-secondary years (Sass, 2015). Additional research has indicated that developing expectancies for success and interests in mathematics and science in pre-college years strongly increases the likelihood of students persisting in STEM fields (Tai et al., 2006).

Parental and teacher expectations on students' educational degree attainment

In addition to school and out-of-school level variables, researchers have also identified other factors that affect students' educational achievement and attainment including teachers and parents' expectations of students (Lee et al., 2015; Zhan, 2014). Both teachers and parents have significant influence on students' school performances and college matriculation (Fehrmann, Keith, & Reimers, 1987; Hossler & Stage, 1992). The effect of these variables cannot be underestimated due to their mediating roles in students' educational experiences (Hill & Tyson, 2009).

In their seminal work, Rosenthal and Jacobson (1968) investigated the effect of teachers' expectations on students' achievement. Their findings spawned research and led to the development of a new branch of research called expectancy research. They found that teachers' high expectations about their students increased the students' cognitive ability positively; a phenomenon often defined as 'the Pygmalion effect' (Rosenthal & Jacobson, 1968). Later, researchers found that teachers' expectations are influenced by students' gender, prior performance, race, ethnicity, and SES (Ferguson, 1998). Teachers were found to treat students differently based on their level of expectations for different students (Flores, 2007). For instance, depending on teachers' level of expectations, teachers have generally showed lower expectations for low-income students compared with their high-income peers (Alvidrez & Weinstein, 1999; Muller, Katz, & Dance, 1999). These lower expectations create a significant challenge for low-income students' academic outcomes (Zhan & Sherraden, 2011). Eventually, these expectations affect students' success and attitudes towards mathematics and science which are pivotal in students' aspirations in STEM-related majors (Crisp, Nora, & Taggart, 2009).

Researchers further found that teacher expectations affect not only students' academic performance, but also long-term educational goals like attending college (Benner & Mistry, 2007). In particular, studies have indicated that mathematics and science teachers' expectation and encouragement have a strong positive correlation with students' academic performance and majoring in STEM fields (Heaverlo, 2011). We also know that mathematics and science teachers play a pivotal role in augmenting low-income students' motivation and interest in mathematics and science which are precursors to develop STEM interest that may result with pursuit of a career in STEM area (Shumow & Schmidt, 2013).

Another adult group (especially mothers) that makes a difference in students' lives are parents. Previous research showed that parental expectations affect students' educational success (Stevenson & Stigler, 1992; Stevenson, Chen, & Uttal, 1990). Christenson, Rounds, and Gorney (1992) indicated that the connection between parental expectations and students' performance is complex because it involves many other mediating factors. For example, parental behaviours such as contacting the schools and regularly encouraging students to do school works have a direct effect on students' academic achievement (Seginer, 1983). In other words, academic success is positively correlated with parental expectations (Benner & Mistry, 2007; Boersma & Chapman, 1982; Catsambis, 2001).

Ma (2001) found that parents' expectations are more influential than teacher or peer expectations when it comes to college matriculation. Moreover, research found that parental expectations are critical in students' decision to attend a college (Brasier, 2008; Hossler & Stage, 1992). Children whose parents actively and positively intervene to their children's education perform higher than their peers whose parents do not (Epstein, 2001). According to Rutchick, Smyth, Lopoo, and Dusek (2009), parental expectations also change students' expectations of themselves. According to Rutchick, parental educational expectations continue to impact students' academic performance even five years later. Archer et al. (2013) found that aspirations in mathematics and science-related areas are also affected by familial attitudes mostly from parents. In other words, students' mathematics and science efficacy as well as academic and vocational choices are the results of parental expectations and attitudes (Lee et al., 2015). In summary, the expectations of parents, teachers, and others (Pygmalion effect), either positive or negative, have great potential to influence students' academic motivation, behaviour, and performance in content areas such as STEM (Brophy & Good, 1970; Lee et al., 2015; Ma, 2001). Given that early positive experience and performance are critical to a student's future success in STEM disciplines, Pygmalion effects may be pervasive in forming future STEM workforce (Crisp et al., 2009; Lee et al., 2015)

Purpose of the study

Due to strategic importance of STEM education in countries' global leadership in economy and innovation, there is a need to identify the characteristics of students who have successfully navigated the STEM pipeline (Lee et al., 2015; Steffens, Jelenec, & Noack, 2010). A very recent study investigated the effects of student' mathematics and science efficacy and students, parents, and teachers' expectations in students' STEM-M (edicine) career selection (Lee et al., 2015). The present study extends the Lee et al. study and adds additional school and out-of-school level variables to shed more light about what students do during high school in terms of academics and extracurricular activities that might lead them to choose a STEM major. To accomplish this, we worked with a Harmony Public Schools (HPS) that has a focus on STEM education. We aimed to collect three groups of variables: (a) student and parent demographics; (b) school and out-of-school academic variables; and (c) students, teachers, and parents' expectations, and students' self-efficacy in mathematics and science. The purpose of this study is to examine how students' high school experiences, their self, parent, and teacher expectations, and mathematics and science efficacy are related to them majoring in STEM choices after controlling student and parent demographics.

Our overarching research question was to investigate the characteristics of students who have successfully navigated the STEM pipeline. More specifically:

1. What are the numbers of HPS' alumni majoring in STEM degree compared to the state of Texas and the Nation?
2. What are the impacts of both students' school and out-of-school activities on the likelihood to pursue a STEM degree?
3. What are the impacts of both teacher and parental educational expectations on students' intentions to pursue a STEM degree?
4. What are the impacts of a students' self-efficacy in mathematics and science and college expectations on the likelihood to pursue a STEM degree?

Methods

Settings: HPS

HPS are a Texas-based charter management organisation (CMO) that operates 48 schools serving a diverse student population of more than 30,000 students. Of which 61% of students receive free or reduced price lunch and 68% are under-represented minorities. HPS are serving K-12 grade students located in Texas with a strong focus on STEM providing opportunities for underserved communities. The 48 schools are located in urban settings such as Houston and Dallas and more rural sites in Brownsville, Laredo, etc. Beginning with the launch of its first STEM-focused school in Houston in 2000 (HPS 2020, 2016), HPS are an open-enrollment college prep school system. Because HPS are public schools, they must follow all federal laws that apply to any other public school. Therefore, they have to accept students by lottery and cannot choose its students based on their interests or achievements. Within the international context, HPS can be thought of as regular public schools that have more autonomy in areas such as choosing their own curriculum and accepting students from any distance like private schools. Although implications of this study should be interpreted within HPS context, it could be informative for different schools, school districts, or education systems around the world.

We chose to study HPS because the system schools provided almost all the variables that SCCT described. For instance, HPS have their own integrative STEM teaching approach called STEM students on the stage (SOS). It is an integrated interdisciplinary, standards-focused, and engaging STEM teaching approach that is teacher-facilitated, student-centred and directed through sets of open-ended and inquiry-based projects (Sahin & Top, 2015). Students are required to use technology and social media extensively to complete their projects for each project including website, digital video presentation, brochure, and YouTube and Facebook pages. Culminating products are also presented and saved in their individual e-portfolio. Students present their projects in different occasions including school festivals, VIP visits, and different STEM Expos. STEM SOS is used in all STEM courses integrated with English Language and Arts and Social study courses. HPS also offers a variety of STEM clubs in addition to non-STEM clubs including Robotics, game design, rocketry, solar car, MATHCOUNTS, and American Mathematics Contest (AMC). Shortly, students find a variety of STEM-related opportunities as part of the school's STEM mission.

Sample

The study utilises data from HPS alumni ($n = 2246$) who graduated between years 2005 and 2015. These students were either currently attending colleges or already graduated from a college.

Data collection began in Fall 2015 by surveying all the HPS alumni ($n = 2246$) who enrolled in colleges (including community colleges) between years 2005 and 2015. We ended the data collection on 20 March 2016. A total of 697 students completed the survey for a 31% response rate. A total of 56 students already graduated from 4-year colleges (see Table 1 in supplementary online materials).[1]

The 697 participants included 298 males (43%), 141 white (20%), 59 black (8%), 347 Hispanic (50%), and 148 Asian students (21%). Only 15% of parents had obtained a master's degree or higher. Twenty-six per cent of the parents had a 4-year college degree. Parents with some college degree (e.g. 2 years) were 10%. The remaining 50%

Table 1. Student demographic information.

Group	Not graduated	Graduated	Total	Percentage
Gender				
Male	281	17	298	0.43
Female	360	39	399	0.57
Total	641	56	697	1
Ethnicity				
White	124	17	141	0.2
Black	50	9	59	0.08
Hispanic	326	21	347	0.5
Asian	139	9	148	0.21
Total	639	56	695	1
Parent education level				
High school or less	318	24	342	0.5
Some college	64	5	69	0.1
Bachelors	157	20	177	0.26
Master's degree or higher	94	7	101	0.15
Total	633	56	689	1
Grades				
Freshman	291		290	41.7
Sophomore	168		168	24.1
Junior	134		134	19.2
Senior	49		49	7
Graduated		56	56	8
Total	642	56	697	1

of parents had high school or lower degrees. Participating students' grades were scattered as 291 freshmen (43%), 168 sophomores (24.1%), 134 juniors (19.2%), 49 seniors (7%), and 56 college graduates (8%).

Instrument

We used an online survey consisting of 30 questions grouped under four categories of variables: (a) student demographics, (b) family context, (c) school- and out-of-school-related activities, and (d) Pygmalion-related variables including student expectation about themselves, parent and teacher expectations, and students' mathematics and science efficacy (see Appendix 1). We used items from previously developed reliable and valid instrument. We adapted Lee et al.'s (2015) instrument and study design, but we added more student and school-related variables to come up with a more comprehensive description of the characteristics of students who choose STEM majors in college. In addition to Lee's et al. study variables (student and parent demographics, student, parent, and teacher expectations, and students' mathematics and science self-efficacy), we also included the number of students' project and science fair completions, number of STEM club participation, number of STEM and total Advanced Placement (AP) course takings, status of summer STEM camp experiences, and internship completion. Mathematics and science self-efficacy items were adapted from previously developed valid and reliable scales used in Longitudinal Study of American Youth (Lee et al., 2015; Miller, 2014). These were the only constructs we measured in the study. Each question regarding efficacies required students to rate their responses on a Likert-type scale of 1–5, with 5 being strongly agree. High instrument reliabilities for the mathematics and science self-efficacy were obtained using Cronbach's alpha .939 and .947, respectively.

We shared the survey link with the alumni through Facebooks and e-mails. To increase participation, we gave 40 $50 credit card gift cards by lottery. The first author provided weekly updates to the director. After four reminders, the final participant number was 697.

Variables

We had one dependent variable named *STEM Major*. Students indicated either '1' as majoring in STEM-related area or '0' indicating not STEM majoring area. We used Lee et al.'s (2015) approach and defined STEM majors as the combination of National Science Foundation (2010)'s STEM profession classification and medicine-related majors. We used the term 'STEM' as our acronym to represent all STEM and Medicine majors. We had two groups of independent variables. The first group included school- and out-of-school-related activities like students' number of STEM club participation, STEM AP course taking, number of science fair participation, number of STEM-related project completion, summer STEM camp participation, and any STEM-related internship done at local universities or medical institutes. The second group of variables included students' expectation about their educational attainment, parents' and STEM teachers' expectations, and students' mathematics and science efficacy. We used students' gender, ethnicity, parents' education level, parents' college degree, and household income as our control variables to examine how other variables related to STEM major, after statistically controlling for student and parent demographics.

Analyses

First, we did descriptive analyses to show how the school system's graduates' STEM selection percentage compared with the state and national averages. Second, because our dependent variable is a dichotomous, we employed multiple binary logistic regression to test our models. We first ran a binary logistic regression to examine which group of variables predicted students' probability of STEM major selection. Later, we ran separate binary logistic regressions for each gender because gender was significant in the first analysis. Table 2 provides the descriptive for the variables used in the data analyses.

Results

Research question 1

For the first question, the descriptive findings highlight the fact that HPS graduates who responded to the survey were more than twice as likely to choose a STEM field major than the average of students (a) across the state of Texas and (b) across the U.S. (see Table 3). In addition, about four times as many females chose a STEM major than the state and national averages. Finally, we saw that Black, Hispanic, and Asian students were twice as likely to choose STEM majors than other students in the state and national averages.

Research question 2

First, the data analyses revealed that from among all school and out-of-school factors, none of them came out as significant (see Table 4). Covariates male and Asian variables were significant. That is, male students are 2.15 times more likely to choose a STEM major in college than female students do. Likewise, Asian students are 1.92 times more likely to choose a STEM major than non-Asian students do.

Table 2. Descriptive data for participants.

	N	Range	Mean	Std. deviation
Gender	697	0–1	0.43	0.50
White	698	0–1	0.20	0.40
Black	698	0–1	0.08	0.28
Hispanics	698	0–1	0.50	0.50
Parent college degree (Y/N)	689	0–1	0.35	0.48
Parents' education level	689	1–5	3.05	1.16
Household income	688	1–3	1.95	0.76
Count STEM club participation	698	0–2	0.76	0.80
Count STEM project participation	636	0–5	2.75	1.64
Count science fair participation	698	0–8	2.69	3.30
STEM AP course taking	603	0–8	1.89	1.80
Summer camp(Y/N)	634	0–1	0.13	0.336
STEM internship(Y/N)	634	0–1	0.14	0.349
Student expectation	608	1–7	4.61	1.08
Parents expectation	624	1–4	3.67	0.68
Teacher expectation	624	1–4	3.59	0.69
Math efficacy	624	1–5	3.83	1.10
Science efficacy	624	1–5	3.83	0.96

Table 3. STEM field majoring percentages by gender and ethnicity.

	Overall	Male	Female	White	Black	Hispanics	Asian
HPS STEM	58.1	61.7	55.2	52.5	56.7	58.1	63.5
State_STEM[a]	27	43.20	13.60	29	24.20	27	33.70
National_STEM[b]	25	40	15	27	22	25	33

[a]From My College Options (2012).
[b]From ASTRA (2015).

Table 4. Logistic regression coefficients for school- and out-of-school-related variables.

	B	Exp(*B*)
Parent bachelor degree in the U.S.	0.451	1.570
Parent education level	−0.001	0.999
Household income	−0.05	0.951
Male	0.770*	2.159
Asian	0.657*	1.929
Black	−0.089	1.037
Hispanics	−0.412	1.077
STEM club participation	0.136	2.051
STEM projects completed	0.043	0.757
Science fair participated	0.036	1.977
STEM AP taking	0.074	0.609
Summer camp	0.719	0.915
STEM internship (Y/N)	−0.279	0.663
Constant	−1.726	0.178

$^{*}p < 0.05$.

Research questions 3 and 4

For the second and third questions, we ran another logistic regression analysis where we controlled for gender and ethnicities (see Table 5). We found that male students are 2.05 times more likely to consider a STEM degree in their first year of college. It was also found that students with higher measures of mathematics efficacy are 1.33 times more likely to select a STEM major in college. Similarly, students with higher measures of science efficacy are 1.37 times more likely to consider a STEM field in their college study.

We ran separate analyses for male and female students, respectively. Table 6 presents findings from the third logistic regression analysis for males. We found that Asian students are 2.51 times more likely to choose a STEM major during first year of college ($p < .05$).

In the second part of logistic regression analysis for males' Pygmalion effect variables, we found that male Asian students are 3.05 times more likely to choose a STEM major in college. It was also found that male students with higher mathematics efficacy are 1.60 times more likely to pursue in STEM-related field in college (see Table 7).

In a separate analysis for girls, it was found that students whose parents had a college degree in the U.S. are 2.08 times more likely to major in STEM fields in college (see Table 8). In the second part of logistic regression analysis for females' Pygmalion effect variables, we found that students with higher science efficacy measures are 1.40 times more likely to major in STEM in college (see Table 9).

Table 5. Logistic regression coefficients for Pygmalion effect variables.

	B	Exp(*B*)
Male	0.718*	2.050
Black	0.352	1.422
Hispanics	0.260	1.297
Asian	0.617*	1.854
Parent bachelor degree in the U.S.	0.232	1.261
Household income	−0.054	0.948
Parent educational level	0.050	1.051
Student expectation	0.033	1.033
Parents expectation	−0.019	0.981
STEM teacher expectation	−0.042	0.959
Math efficacy	0.291*	1.337
Science efficacy	0.316*	1.371
Constant	−2.617	0.073

*$p < 0.05$.

Table 6. Logistic regression coefficients for male students' STEM major selection: in school and out-of-school variables.

	B	Exp(*B*)
Black	0.461	1.586
Hispanics	0.042	1.043
Asian	0.923*	2.517
Parent bachelor degree in the U.S.	−0.264	0.768
Household income	0.037	1.038
Parent educational level	0.133	1.142
STEM AP course taking	0.044	1.045
Summer camp	0.827	2.287
STEM internship	−0.397	0.672
Science fair participation	0.019	1.019
STEM projects completed	0.026	1.026
STEM club participation	0.170	1.186
Constant	−0.208	0.812

*$p < 0.05$.

Table 7. Logistic regression coefficients for male students' STEM major selection: Pygmalion variables.

	B	Exp(*B*)
Black	0.605	1.831
Hispanics	0.424	1.529
Asian	1.118*	3.059
Parent bachelor degree in the U.S.	−0.229	0.795
Parent education level	0.218	1.244
Household income	0.011	1.012
Student expectation	−0.130	0.878
Parents expectation	−0.291	0.747
STEM teacher expectation	−0.022	0.978
Math efficacy	0.476*	1.609
Science efficacy	0.312	1.366
Constant	−1.627	0.197

*$p < 0.05$.

Table 8. Logistic regression coefficients for female students' STEM major selection: in school and out-of-school variables.

	B	Exp(**B**)
Black	0.207	1.230
Hispanics	0.193	1.212
Asian	0.482	1.619
Parent bachelor degree in the U.S.	0.731*	2.077
Parent education level	−0.152	0.859
Household income	−0.082	0.921
STEM clubs participated	0.104	1.110
STEM projects completed	0.091	1.095
Science fair participated	0.089	1.093
STEM AP course taking	0.070	1.073
Summer camp	0.219	1.245
STEM internship	0.312	1.366
Constant	−0.613	0.542

*$p < 0.05$.

Table 9. Logistic regression coefficients for female students' STEM major selection: Pygmalion variables.

	B	Exp(*B*)
Black	0.150	1.161
Hispanics	0.236	1.266
Asian	0.302	1.352
Parent bachelor degree in the U.S.	0.631	1.879
Parent education level	−0.087	0.917
Household income	−0.086	0.918
Student expectation	0.117	1.124
Parents expectation	0.123	1.131
STEM teacher expectation	−0.043	0.958
Math efficacy	0.203	1.225
Science efficacy	0.334*	1.397
Constant	−2.851	0.058

*$p < 0.05$.

Discussion

In the present study, we examined whether HPS' students who graduated from high school choose STEM as their major in college and what factors they perceived influenced their decision for choosing STEM as their college major. The results of the present study are encouraging, although not surprising since HPS's STEM focus, in that they suggest that HPS students who responded to the survey were much more likely to choose a STEM major in college than typical high school students from the state of Texas and the U.S. This finding suggests that schools and school districts may be able to influence students' interest in becoming a STEM major. What is even more encouraging is that we found that female, black, and Hispanic students from HPS were also much more likely to choose a STEM major in college than the typical student from the state of Texas and the U.S. The gap for female and black students, in particular, seemed to be a lot smaller for HPS students when compared to statewide and national rates. These dramatic findings of STEM field majors suggest that the HPS have been successful in closing the STEM opportunity gaps that have persisted over time for female and minority students in Texas and the U.S. Although females from HPS were much more likely to choose STEM majors than other female students in Texas and the U.S., we still found that HPS male students were about twice more likely than HPS female students to consider a STEM degree in their first year of college. Explanations for these sex-related differences need to be explored in greater detail in future studies. Similar to other U.S. studies, we also found that HPS Asian students were more likely to choose a STEM field than students from other racial groups. This 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 class ranks.

Factors influencing STEM career choice

Our study used logistic regression to examine whether (a) school and out-of-school factors and (b) student, teacher, parent expectations and students' mathematics and science efficacy impact students' decision to major in a STEM field. Surprisingly, we found that students', parents', and STEM teachers' expectations were not predictive of choosing a STEM major.

Although prior research found that parent expectations influence students' persistence in STEM fields (Archer et al., 2013; Lee et al., 2015; Ma, 2001), our findings show that parents' college degree, education level and household income did not impact students' decision to enroll in a STEM major in college. One explanation for this finding is that there may be an inherent selection bias due to the fact that HPS are a charter school system where parents chose to send their children to school because of its reputation, especially in the STEM area. Consequently, most HPS parents probably have similar high expectations and STEM aspirations for their children.

Prior research has found that teacher expectations (Heaverlo, 2011; Shumow & Schmidt, 2013) strongly increase the likelihood of students persisting in STEM fields. The findings from the current study, however, did not arrive at the same conclusions. This may be due to the fact that the emphasis on STEM is prevalent in all 48 HPS. Furthermore, the district's inquiry-based project STEM teaching approach is consistently implemented across the district (Sahin & Top, 2015). Consequently, teacher expectations and encouragement for students' success in STEM are fairly high and consistent across the district, but that invariance did not allow us to determine its actual impact on students' career choice.

Prior research has found that student participation in STEM school-based activities influences students' STEM aspirations (Dabney et al., 2012; Dawes et al., 2015; Gottfried & Williams, 2013; Nugent et al., 2015; Sass, 2015). We found, however, that none of the school and out-of-school factors such as participating in a STEM club, STEM projects, science fair, summer camp, or a STEM internship were predictive of choosing a STEM major in college. This may be due to the limited frequency of most of the activities like summer camp, STEM internships, and STEM clubs. It may also be related to the way we measured school activities. We focused on the quantity of activities rather than the perceived quality of those activities. A more comprehensive measure focusing on the quantity and quality of school activities may be important to consider in future studies.

We also found that students with higher measures of mathematics and science efficacy were more likely to consider a STEM field for their college major than students with lower measures of mathematics and science efficacy. This lends support to the importance of social cognitive theory (SCCT) that focuses on how aspects of self-efficacy are associated with career choice.

Overall, it appears that student, parent, and STEM teacher expectations did not influence students' choosing a STEM major. This may be due to the limited variability of responses (i.e. small standard deviations) for parent and teacher expectations. Although there is more variation for students' expectations, it appears that students' mathematics and science efficacy may be more influential in students' STEM career choice than their expectations.

Limitations and future research

One of the limitations of this study is the relatively small response rate (31%) of HPS graduates. While this response rate is quite similar to other studies, we ideally would have preferred a much higher response rate. Future studies might want to include more incentives to potentially increase the response rate.

Another limitation of the study relates to the measurement of variables. Although student self-report measures have been used in many similar STEM studies (Gottfried & Williams, 2013; Lee et al., 2015), there are some concerns about the use of such measures due to the possible large measurement error with self-reporting items (Bertrand & Mullainathan, 2001). Future studies could address this issue by either including other data resources or triangulation of the data (Denzin, 2012).

A final limitation of the study is that it was conducted in one large school district that was implementing an integrated STEM curriculum for several years. For future studies, it would be interesting to include other large school districts so that we could possibly compare across districts on how the three factors of (a) demographics, (b) school and out-of-school factors, and (c) Pygmalion effect variables such as student, teacher, parent expectations and students' mathematics and science efficacy differentially affect students' choosing STEM majors in college.

Additional studies could also include other research methods such as interviewing students, teachers, and school administrators to address research questions that focus on other personal, school, and out-of-school factors that may have motivated students to choose STEM majors in college. Content analyses of teachers' lesson plans and the HPS school curriculum could also provide interesting data about the extent to which STEM is integrated in the curriculum. Finally, observational studies would be useful to determine the actual quality of the STEM integration in schools and classrooms.

Additional research is also needed to the relations among students' expectations and their mathematics and science efficacy. Future studies, for example, might want to see what school and out-of-school factors influence students' mathematics and science efficacy.

Conclusions

Although the descriptive and correlational nature of the results does not allow causal inferences, the findings of this study provide valuable information to educators and researchers involved in STEM education. First, the study makes an important contribution and provides support for the SCCT (Lent et al., 1994). 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 behaviour) together. A second important contribution of this study involves the adaptation of an existing instrument (Lee et al., 2015) that includes more student- and school-related variables (e.g. number of student projects, STEM courses, STEM club, and internship participation). This adapted instrument provides us with a comprehensive measure of the STEM-related opportunities that students had in high school. A third important contribution of this study is that it focuses on high school graduates and the decisions that they have already made regarding entering the STEM field. Most prior studies in this field generally obtained high school student perceptual data of whether they expect to enter a STEM field without actually knowing whether they will even graduate from high school. Fourth, the unique school system that participated in the present study suggests that urban and rural schools serving predominantly low-income and unrepresented minorities can be successful in closing the STEM opportunity gaps by encouraging *all* of their students to enter the STEM pipeline. This finding should be heartening to many school systems across the world that have been challenged with the encouraging more of their low-income high school students to choose STEM careers in college. This district invested heavily in STEM-related school activities and the findings appear to be promising.

Last but not least, even though implications of this study should be interpreted within HPS context, it could be informative for different schools, school districts, or education systems around the world. Many countries are emphasising the need to incorporate STEM activities in high school in order to encourage students to choose STEM careers. The findings from this study provide some promise in that this school system is doing better than the state and national averages in terms of having students choose STEM majors in college. The findings from this study also provide caution to educators across the world because most of the STEM school activities such as STEM clubs, STEM projects, science fairs, summer camps, and STEM internships were *not* found to be predictive of students choosing a STEM major in college. What we did find, however, was that high school students' with high measures of mathematics and science efficacy were more likely to choose a STEM field for their college major. This suggests that schools may need to focus on developing interventions to increase students' efficacy in science and mathematics rather than merely implement more school-related STEM activities. This emergent finding provides new insight into how school systems may want to proceed in order to promote STEM in their high schools.

Note

1. All the tables are provided in the supplementary materials for the interested reader.

Disclosure statement

No potential conflict of interest was reported by the authors.

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APPENDIX 1

Student Demographics

Please answer questions below:
* 2. Please enter your first name
3. Middle initial
* 4. Last name
* 5. Campus name
* 6. High school graduation year
* 7. College name
* 8. Year in college

Freshman
Sophomore
Junior
Senior
Graduated

* 9. What major did you get admitted to after high school?

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

Family Context

Please answer the following questions:

* 10. Did either of your parents have a college degree in the United States when you were in high school?

Yes
No

* 11. What was your parent's highest level of education when you were in high school?

Less than high school
High school diploma or GED
Associate's degree
Bachelor's degree (4-year)
Master's degree or higher

* 12. What was your estimated household income when you were in high school?

Less than $30,000
Between $30,000–$69,000
Higher than $69,000

* 13. Which clubs did you attend during high school? (Check all that apply)

American Mathematics Competition (AMC)
Math Contest
Science Olympiad
Astronomy
Harmony Scientific Research Society
Biology
Computer Science Club
Rocketry Club
Advanced Research Club
Environmentalists
FTC Robotics
Sea Perch
Project Construction Scale Modeling
Spanish
Health
French
Folk Dance
Cheerleading
Chess
Poetry
Odyssey of the Mind
Drama
Shell Eco
College Readiness and Leadership Program (CRLP)
Other (please specify)

* 14. How many Science, Technology, Engineering, and Mathematics (STEM)-related projects did you complete?

- 0
- 1
- 2
- 3
- 4

* 15. In which subject(s) did you complete a STEM-related project(s)?

	Check all that
Algebra I	☐
Geometry	☐
Algebra II	☐
Biology	☐
Chemistry	☐
Physics	☐

Other (please specify)

* 16. Where did you present your STEM project(s) at? (Check all that apply)

School, city, and/or state science fairs
Classroom
School festivals VIP visits
I-SWEEEP Competition
STEM EXPOs
Texas Celebration of STEM Education Week
Outside STEM Events
Other (please specify)

* 17. Please enter the information regarding science fair competitions you participated in during your high school years.

	# of Participation
Schoolwide	
Regional State	
National	
International	

* 18. How many STEM-related Advanced Placement (AP) courses did you take during high school?

* 19. Did you attend any Science, Technology, Engineering, and Mathematics (STEM)-related summer camps?

- Yes
- No

* 20. Did you participate in any Science, Technology, Engineering, and Mathematics (STEM)-related internships at a medical and/or higher ed(university) institutions?

- Yes
- No

* 21. Did you already graduate from a college?

Yes
No

* 22. Was your college degree in one of STEM-related areas?

Yes
No

* 23. Do you have intent to declare a science, technology, engineering, and mathematics (STEM)-related major in college?

Yes
No

* 24. What type of career did/will you pursue?

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)

* 25. Do you feel that your high school experience at CSS provided you the opportunities to obtain/develop skills and content necessary to perform your college STEM work?

Strongly Agree
Agree
Neither Agree nor disagree
Disagree
Strongly Disagree

* 26. Please choose three factors you think affect(ed) your career interest most.

Teachers
Parents
Science Fairs
Afterschool clubs
Summer camps
Internships
Early exposure to science and/or mathematics
Science curricula
Gender
Socioeconomic status
Self interest
Other (please specify)

Pygmalion Effect Variables

We would like to know how much influence your, your parents', and your STEM teachers' expectations had on your college enrollment and persistence (and completion if applies). Please answer the following 5 questions as much as you remember about your perceptions or beliefs about yourself, your parents, and your teachers.

* 27. What was your educational degree expectation about yourself <u>during high school</u>?

High school or less
Vocational training
Some college (ex: 2-year)
College graduation
Masters
Doctorate or Professional Degree
Don't know

* 28. How encouraging were your parents about going to college?

Not encouraging at all
Somewhat encouraging
Encouraging
Strongly encouraging

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

Not encouraging at all
Somewhat encouraging
Encouraging
Strongly encouraging

* 30. How confident were you about your performance in math while you were in high school?

Strongly Agree Agree Neutral Disagree Strongly Disagree
I was good at Math
I understood Math well

* 31. How confident were you about your performance in science while you were in high school?

Strongly Agree Agree Neutral Disagree Strongly Disagree
I was good at Science
I understood Science well