Maintaining Career Aspirations in Science, Technology, Engineering, and Mathematics (STEM) among College Students

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Nationally between 1986 and 2006, relative increases in entering college students' interests in science, technology, engineering, and mathematics (STEM) fields have been observed (Higher Education Research Institute [HERI], 2010). Furthermore, the gap between the STEM interests of underrepresented minority (URM) students, specifically African Americans, American Indians, and Latino/a students, and their White and Asian American peers has narrowed (HERI, 2010). Although these vary by field of intended study, URMs' proportionate initial interests in STEM are nearly identical (approx. 34%) to the interests of their White and Asian American peers in 2004, whereas URM students lagged behind their counterparts by over 10 percentage points in initial STEM interest in 1971. Despite increasing interest in STEM disciplines, degree completion rates among URM students continue to lag behind those of White and Asian American students (HERI, 2010; National Academy of Sciences, 2011).

URM students' departure from their initial interests in STEM fields and low degree completion rates translate to underrepresentation of these groups within the STEM workforce. It is estimated that STEM-related employment is composed of 77.3% White, 17.2% Asian American, 3.9% Black, and 4.5% Latino (NSF, 2009). The National Science Foundation (2010) states that science and engineering positions will outpace job growth in other fields, with projected increases of 21 percent; therefore, increasing the number of STEM degrees awarded to domestic students is seen as vital to maintaining national economic competitiveness in a globalized economy (Hira, 2010). Given the need for national competitiveness and innovation, some scholars posit that scientific endeavors can be improved and enhanced by having a greater diversity of perspectives (Blickenstaff, 2005) through a more diverse workforce. In the context of the projected demand for additional science and engineering workers and the need diversifying the STEM workforce, increasing the preparation for science and engineering careers of students from historically underrepresented groups is especially important (NSF, 2006), particularly for higher education initiatives seeking to respond to this call.

Given the disproportionately low numbers of minorities represented in the STEM workforce (National Science Board, 2007), promoting URM interests in STEM careers and recruiting, retaining, and graduating these students within STEM degree programs are essential to diversifying the STEM workforce. In 2006, African American, Hispanic, and Native American students garnered 5%, 6.9% and .5% of engineering degrees while representing 12%, 11.5% and .79%, respectively, of the total U.S. population (National Science Foundation, 2008). This demonstrates the underrepresented share of engineering degrees earned by URM students relative to their representation in the overall population. Although STEM retention and completion goals are highly linked to STEM career interests, it is essential to examine the factors that promote or deter students' career interests specifically, as individuals leave the pipeline at different points to pursue another career field (Blickenstaff, 2005).

The purpose of this study is to examine students' retention of STEM career aspirations during the college years among a highly diverse student sample. We employ structural equation modeling to explore the associations between measures of students' perceptions and motivations, college experiences and institutional contexts, while controlling for student's background characteristics and pre-college preparation. A better understanding of the salient considerations and influences on students' retained interest in STEM careers, especially for URM students, through identification of campus-based programs and student experiences that promote STEM career interests may advance policies and initiatives seeking to increase minority participation in the scientific workforce.

Guiding Research and Theory

As with college in general, prior academic achievement, as demonstrated through high school GPA and SAT/ACT tests, serves as one of the strongest predictors of college academic achievement and persistence in STEM (Astin, 1993; Crisp, Nora, and Taggart 2009). Similarly, precollege experiences and academic preparation play a role in students' likelihood to persist in STEM fields (Elliott, Strenta, Adair, Matier, & Scott, 1996). URM students tend to have less access to precollege experiences that better prepare them for college STEM majors, including advanced math and science coursework and resources, such as Advanced Placement (AP) courses (Schneider, 2000; Solorzano & Ornelas, 2004).

Access to good high school preparation is often linked parental education, as they may influence students' career interests through communication of career expectations and career-related beliefs (Tang, Fouad, & Smith, 1999). It is critical to consider how student background characteristics influence URM students' success in college and STEM career aspirations, as pre-college characteristics are often cited as a primary explanation of observed outcomes for these students in STEM fields. The question, however, is whether other factors play an important role once student background characteristics are controlled.

Values that are particularly relevant for the field, like a commitment to science (Pascarella & Terenzini, 2005), have been noted as critical attributes for students to possess and to be fostered by undergraduate programs (Villarejo, Barlow, Kogan, Veazy, & Sweeney, 2008). For example, Carlone and Johnson (2007) emphasize recognizing oneself as a scientist in developing one's science identity is a critical precursor to STEM completion. In examining the factors that influence students' math and science goals, Byars-Winston and Fouad (2008) assert that barriers, perceived or real, can influence undergraduates' academic or career development if those barriers are assessed as impeding on one's ability to successfully complete a given outcome or goal. Therefore, the "contextual factors" of the undergraduate experience (Byars-Winston & Fouad), both within college and within students' personal life, are important considerations in attempting to determine what might deter students from their initial STEM interests. Perna and associates' (2009) study on African American women in STEM define these contextual barriers as encompassing four areas: academic, psychological, social, and financial. Therefore it is important to identify the educational interventions and supports that institutions can provide to assist students in overcoming these barriers.

The undergraduate experience itself is an important venue for fostering the academic, practical, and professional skills that are necessary to persist in a STEM degree program and eventually in a STEM-related career. Mentoring, from both faculty (Maton & Hrabowski, 2004; Packer, 2004) and advanced student peers, has been noted to acquaint students to scientific norms and provides them with networks to access information and opportunities (Hurtado, Eagan, Cabrera, Lin, Park, & Lopez, 2008; Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, & Gary, 2009). Social network theorists have identified critical "institutional agents" (Stanton-Salazar & Dornbusch, 1995) who can promote students' development. For example, faculty in STEM fields orient students toward science research careers (Carter, 2002) and foster their initial career interests (Seymour et al., 2004). Undergraduate research programs are well documented as providing these social and academic networks and research experiences, which helped students to clarify, confirm, and refine their career goals (MacLachlan, 2006; Seymour et al., 2004). Structured research programs help reinforce students' identification with science and help students to overcome the barriers that may detract from their initial STEM interests (Hurtado et al., 2008).

Prior literature indicates that students seem to benefit most from intervention programs that promote academic confidence, like undergraduate research programs, because their experiences within math and science courses can lead them to doubt their academic ability in these subjects (Perna et al., 2009) and their decisions to remain in a STEM major (Crisp et al, 2009). Some science and math introductory courses have a highly competitive environment that may discourage students to continue with more advanced coursework (Seymour & Hewitt, 1997). Therefore, initiatives that focus on providing URM students with out-of-class support programs, such as supplemental instruction (Bonsangue & Drew, 2006; Villarejo & Barlow, 2007), tutoring (Perna et al., 2009), and career support and development (MacLachlan, 2006) have been cited as increasing STEM persistence and solidifying interests in STEM careers.

Social Cognitive Career Theory

Past research on career development has investigated "what factors influence career choices, how people make career choices, how context influences career choices, and effective interventions" (Fouad, 2007, p. 543). A useful framework developed by Lent, Brown, & Hackett (1994) applied and extended Bandura's (1986) Social Cognitive Theory to the domain of career and academic development. Lent et al.'s (1994) Social Cognitive Career Theory (SCCT) seeks to explain the processes that occur within career development by examining three interlocking models of interest development, career choice, and performance (Lent, Brown, & Hackett, 1994). SCCT is a useful framework for deconstructing and understanding how people make career decisions, develop interests, and deal with the barriers that arise in their educational and career pathways. Although much of higher education research is devoted to assessing the impact of college by measuring students' experiences, often focused on their behavior and actions, SCCT centers on the psychological processes that influences individual action. Bringing these conceptual insights to our examination of college experiences adds a layer of depth to our inquiry and provides insights into how students' psychosocial factors impact URM students tendency to gravitate toward or away from STEM fields. Research using SCCT emphasizes the concepts of interests, goals, outcomes, expectations, and measures of self-efficacy as they relate to career goals (see Figure 1).

Utilizing SCCT as a lens for examining the career development process among students in STEM fields, this study explores student background characteristics, perceptions, experiences, and institutional environments among students who initially began college with STEM career aspirations. Just as past research has focused on specific aspects of the full SCCT model (Flores Navarro, Smith, & Ploszaj, 2006; Lent Brown, Sheu, Schmidt, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005), this study considers students' continued interests in pursuing a STEM career as a *choice goal* that clearly indicates near-future intent to acquire STEM employment (see Figure 1).

SCCT theory guides the conceptual mapping of the variables included in the hypothesized model as visualized in Figure 1. *Person inputs* are represented by the inclusion of race/ethnicity and gender. *Background affordances* are factors that affect the learning experiences through which career-relevant self-efficacy and outcome expectations develop. Early role models are influential, particularly with parents who have achieved higher educational levels, as past research has shown that parents can influence children's interests, goals and perceptions of value toward specific careers (Byars-Winston & Foud, 2008). Pre-college learning experiences are controlled for with high school GPA.

Outcome expectations are defined by Bandura (1977) as beliefs regarding the consequences or outcomes of performing particular behaviors. This study is focusing specifically on students' expectations to impact STEM with their commitment to making a theoretical contribution to science. *Self-efficacy* refers to a person's beliefs about his or her ability to perform the particular behaviors or courses of action (Bandura, 1986) that are required to attain the desired career performance indicators. In the context of college students pursuing career specific degrees, this study examines academic, math, and leadership self-efficacy in terms of student self-ratings of performance capability in these areas. Past literature focused specifically on students pursuing engineering and science majors has shown that academic self-efficacy is predictive of students' career interests (Lent, et al, 2003; Lent, Larkin, & Brown, 1989).

SCCT proposes that students hold a high commitment to their chosen career field (Lent & Brown, 2006, pg 17). This study's operationalizes *interests* freshmen's "best guess" as to whether or not they intend to change major as an indication of their solidified commitment to their initial STEM career of choice. Career g*oals* can be defined as a determination or intention to pursue a career-related action as is measure in through our primary outcome measure:

senior year continued interest in pursuing a STEM career. This focus may provide significant insights that can inform future research using the SCCT model. The *performance and choice actions* of the SCCT framework could be defined more explicitly as persisting and/or completing a STEM degree and obtaining employment within the STEM workforce and are not included in our abbreviated model.

Lastly, SCCT emphasizes the value of accounting for *contextual supports and barriers* (Lent et al., 1994). Supports are factors that encourage the attainment of successes related to pursuing a STEM related career (e.g., undergraduates' positive interactions with faculty , institutional focus on STEM disciplines). Barriers refer to the aspects of the undergraduate experience that can impede the pursuit of a STEM career. Beyond student's actual experiences, we consider student's assessment or personal perceptions of environmental conditions within STEM coursework in alignment with the framework, which focuses on salient psychological measures.

Based on Lent's (1994) conceptualization of SCCT, we hypothesize (see Figure 1) that students' inputs and background characteristics are direct predictors of the early learning experience from which academic self-concept is formed. Academic self-concept is conceived as directly influencing students' career outcome expectations. Student's career outcome expectations are also thought to influence interests, which shape their careers aspirations and are in turn impacted by contextual (college/institutional) supports and barriers (see Figure 1).

Methodology

Sample

This study analyzes a longitudinal sample that comes from the 2004 Freshman Survey (TFS) and 2008 College Senior Survey (CSS), both of which were administered by the Cooperative Institutional Research Program (CIRP) at the Higher Education Research Institute. CIRP's TFS and CSS are administered annually to college students nationally and collect a wide range of information on students at two key time points in their collegiate experiences (for more information on these surveys see Liu, Ruiz, DeAngelo, & Pryor, 2009). The 2008 CSS had a supplemental administration that targeted institutions that produced high numbers of STEM baccalaureates as well as a select set of minority serving institutions (MSIs). This supplemental administration had a longitudinal response rate of approximately 23%; therefore, the appropriate weights were calculated to account for this low response rate to make the 2008 CSS sample look more like the entering class of 2004, and to reduce the probability of response bias.

The targeted sampling strategy made it possible to obtain a large sample of URM students interested in STEM as well as a comparison group of White and Asian American STEM aspirants. The sample for this study includes 3,156 students who indicated on the 2004 TFS an interest in a STEM-related career upon entering college. Given the study's interest in the effect of racial classification as an underrepresented racial minority (URM), it is important to note that the sample includes approximately 46.8% URM students (n=1477), specifically defined as Latino (23.4%), African American (18.1%), and American Indian students (5.3%), with the remainder of the sample (53.2%) being composed of White and Asian American (Non-URM) students as a comparison group. In terms of gender, the sample is 63% female. Additionally, institutional data for the 217 institutions included in the study were merged into the database from the

Integrated Postsecondary Education Data System (IPEDS) 2004 database to supplement the institutional characteristics provided by the TFS and CSS surveys.

Measures

Primary dependent variable. This study focuses on one primary outcome variable indicating students' senior year interests in a STEM-related career. This a dichotomous measure indicating whether or not a student continues to have STEM career aspirations at the end of four years of college. Eleven STEM-related careers are included: computer programmer or analyst; conservationist or forester; dentist (including orthodontist); engineer; lab technician or hygienist; nurse; optometrist; pharmacist; physician; scientific researcher; and veterinarian. (See Appendix A for a description and coding of all variables in the model).

Hypothesized endogenous variables. Excluding the primary dependent measure, there were four additional hypothesized endogenous variables in the model. We operationalize *self efficacy* as it relates to the study sample of college students with a measure of freshman year academic self-concept. This construct is indicated by four self-rated items (e.g. academic ability, intellectual self-confidence), each of which asks students to rate themselves on a four-point Likert scale (1="Lowest 10%", 5="Highest 10%"). The academic self-concept construct and the faculty mentoring construct (described later) were identified from previous research that relied on item response theory (IRT), a modern psychometric method that uses response patterns for an entire set of construct questions (i.e., survey items) to obtain construct score estimates (for more technical details, see Sharkness, DeAngelo, & Pryor, 2010). In examining student's *outcome expectations*, a single measure indicated the degree of personal importance of "making a theoretical contribution to science" on a four-point Likert scale (4-point scale ranging from (1 = "not important" to 4 = "essential"). A single measure indicated students' intentions to change their major and account for *interests* in the model, as it demonstrates a student's solidified commitment to the field of their prospective careers.

Hypothesized exogenous variables. The remaining variables are related to SCCT's definitions of *person inputs, background* and *contextual influences* and are operationalized in this study based on students' precollege characteristics, college experiences, and college contexts. *Person inputs* account for a student's gender and race/ethnicity (measured URM vs Non-URM). *Background affordances* include a proxy for socioeconomic status measured as mother's education level. Pre-college *learning experiences* control for prior academic achievement, specifically high school GPA. *Contextual influences* are specified in three areas: student perceptions of environmental conditions, student college experiences, and institutional characteristics. Student's perceptions of math & science courses are accounted for by a single measure. Students' college experiences focused on the role of faculty in promoting student's STEM career interests. The frequency of faculty mentoring activities is a construct identified through CIRP using IRT and is defined as the "extent to which students and faculty interact in relationships that foster mentorship, and guidance" (Sharkness, et al., 2010, p. 4). In addition, a variable specifically examining students' engagement in research with faculty is included. The model also specifies institutional characteristics including institutional selectivity, which is the average SAT score of entering freshmen, and the percent of students majoring in STEM fields within each institution. The study's measures, along with their coding schemes, are summarizes in Appendix A.

Missing Data

Missing values analysis allowed us to examine the extent to which missing data occurred. First, listwise deletion was utilized to remove all cases for which no information was available on the outcome variable and key demographic characteristics. For the remaining variables in the model, we applied the expectation-maximization (EM) algorithm. The EM algorithm uses maximum likelihood (ML) estimates to replace missing values when a small proportion of data for a given variable is missing (McLachlan & Krishnan, 1997). Overall, there was very little missing data and examination of missing data patterns suggested that missing data occurred at random. No variable had more than 8% of cases missing, with the exception of SAT scores, which only slightly surpassed the threshold with 11.4% missing data; therefore, ML estimates were used to impute values, as it is a more accurate method of dealing with missing data than listwise deletion or mean replacement (McLachlan & Krishnan, 1997).

Analyses

We utilize multilevel structural equation modeling (SEM) to analyze the relationships among the exogenous and endogenous variables and constructs posited in the Social Cognitive Career Theory (SCCT) framework. Multilevel SEM allows researchers to simultaneously estimate the relationships among sets of variables while accounting for the clustered nature of the data (Bentler, 2006; Bentler & Wu, 2002). Thus, we used SEM to also explain how the variables relate to each other within the final model and how each of those relationships impact retained STEM career aspirations, as the final outcome. Prior research (e.g., Cabrera, Nora, & Castaneda, 1993; Nora, 1990) has utilized SEM techniques to account for the inter-relationships among predictor variables in modeling dichotomous outcomes, such as student retention. Mplus 6.11

was utilized to test the hypothesized model seen in Figure 1, and this software has the capacity to handle dichotomous endogenous variables (Muthén, & Muthén, 1998-2010).

Model Building Process

There are several steps involved in building a multilevel structural equation model. Consistent with the multi-stage process for constructing a multilevel SEM recommended in Heck (2001), we first evaluated the intra-class correlation coefficients (ICC), which represent the ratio of between-level variance to total variance. This coefficient was used as an indication of the extent to which students' average probabilities of retained career aspirations significantly varied across institutions; multilevel modeling is warranted when differences across institutions account for a significant proportion of variance in the outcome. Although the ICC is less informative given dichotomous nature of the primary outcome variable and the logistic distribution of the level 1 variance, which is heteroscedastic (Raudenbush and Bryk 2002, p. 298), the ICC indicated that approximately 8% of the total variation in students' probabilities of retaining their STEM career aspirations can be attributed to differences across institutions. Ignoring an ICC of this size by performing single-level analyses with multi-level data is likely to be problematic, which is particularly concerning with larger sample, (n >1,000), as it has been shown that an ICC of <u>*any size*</u> among large samples can increase the probability of making a Type-I statistical error (de Leeuw & Meijer, 2008; Barcikowski, 1981).

The next step was a to analyzes the adequacy of the within-level (student-level) model only. A robust weighted least squares (WLS) approach (estimator = WLSMV in Mplus) was employed as this approach is the most appropriate method for categorical outcome and works best with sample sizes of 200 or larger (Muthen, du Toit, & Spisic, 1997; Flora & Curran, 2004).

Statistical significance and direction of the coefficient estimates, as well as overall model goodness of fit, were used to evaluate whether the between-level (institutional-level) components could be added. Ensuring a within-level model for which the measures of overall fit are good and the parameter estimates are reasonable establishes the base-line model, which can then be explored with multilevel SEM. Additionally, modification indices in this within-level model were utilized in conjunction with theory to examine and remove or add any unnecessary or missing parameters. Finally, the last step is to construct the full two-level structural equation model. In this multilevel SEM, the student-level and Institutional-level components were estimated simultaneously.

Limitations

The study is limited by the use of secondary data, which relies on proxy measurements of the theory's key concepts rather than the cognitive scale measurements originally developed for the theoretical model. Prior research has tested the validity of the full SCCT model through survey instruments designed specifically for evaluating the SCCT criterion (Flores Navarro, Smith, & Ploszaj, 2006; Lent Brown, Sheu, Schmidt, Gloster, Wilkins, Schmidt, Lyons, & Treistman, 2005). This examination utilizes SCCT as a theoretical lens, yet is restricted to the questions and measures of the existing data set, which was not designed from a SCCT perspective. Therefore, this is not an explicit test of SCCT theory, which explains some of the variation in the study's findings compared to prior literature.

Results

Descriptive Statistics

Appendix B presents descriptive statistics for the student and institution-level variables included in the analyses. Among students overall, 57.1% of college seniors retained the STEM-related career interests that they indicated having in their freshman year. Through disaggregation across all races included in the sample, we find that Asian Americans had the highest proportion of retained STEM career interests (70.5%), followed by White (57.9%), African American (53.9%), and American Indian students (53.6%), with Latino/a students with the lowest proportion (51.2%). Correlations for all independent variables and outcome measures can be found in Appendix C.

Model Estimation and Assessment of Fit

Several fit indices are used to assess model fit, in addition to using the χ^2 difference test, including: comparative fit index (CFI), Tucker Lewis index (TLI), and root mean square error of approximation (RMSEA). Based on the minimum thresholds, TLI and CFI values above 0.90 indicate adequate model fit, while RMSEA scores below 0.06 indicate an appropriate level of fit (Raykov, Tomer, & Nesselroade, 1991). Models considered to be extremely well fitting have CFI above .95 and RMSEA scores equal to or below .06 (Hu & Bentler, 1999). The CFI, TLI, and RMSEA indices are recommended for comparative fit analyses in educational research (Schreiber, Nora, Stage, Barlow, & King, 2006). First we assessed the overall model fit for the hypothesized single-level baseline SEM that did not account for the clustered data (see Figure 1). As expected with a sample of this size, the chi-square statistic for the final model was significant 2641.62 ($df = 57$, $N = 3156$, $p < 0.001$); although, the chi-square statistic is highly dependent on sample size and degrees of freedom and might not be a true representation of model fit (Bentler, 2006; Hu, et al, 1992). Other indicators of fit for the structural model suggested poor fit: CFI = 0.89, TLI = 0.85, and RMSEA = 0.05.

To establish a better fitting model, we carefully examined the theoretical perspectives surrounding SCCT, including the recent additions to the framework considering *contextual influences,* along with finding from current empirical research to determine if modification to the model could be made. Modification indices revealed that *person inputs* and *precollege learning experiences* directly impact retained STEM career aspirations in addition to the hypothesized indirect effects. Additional paths indicated a direct influence of racial identification as a URM student and high school GPA on this primary dependent variable. The influence of *person inputs* are pervasive, as paths were added to reflect influence on the types of activities they participate in and the perceptions they develop while in college, which confirms prior research on STEM retention and completion.. Specifically, post-hoc modifications showed that several college experiences (*contextual influences*) are directly predicted by students' perceived importance of making a theoretical contribution to science *(outcome expectations)*. Lastly, several paths were added indicating that participation in specific college experiences may directly impact participation in other college experiences (i.e. faculty mentorship predicting research opportunities with professors). In an effort to make the model more parsimonious, we deleted non-significant paths from the final structural model. Specifically, the theorized path connecting learning experiences to outcome expectations did not hold true in our sample.

The baseline model (or the final single-level SEM, which ignored the cluster-level variance) indicating good fit was estimated as a multilevel SEM. In this model, student-level and institutional-level components were estimated simultaneously. The final within-level structural model (see Figure 2) resulted in the following goodness of fit statistics: X^2 (df=47; p<0.001) = 2241.80; CFI = .96; TLI = .93; RMSEA = .03. These three fit indices suggest that the final model more appropriately represents the relationships among students' *backgrounds, academic self-concept, their career outcome expectations, interests, contextual influences* and their retained STEM career aspirations. Figure 2 diagrams the paths in the final structural model, along with the standardized regression coefficients, and provides notation for post hoc modifications. Table 1 shows the results of the final structural model, including unstandardized regression coefficients, standardized regression coefficients, and significance for the model's direct effects.

Findings

Retained STEM career interests. In discussing the finding on the primary dependent variable of interest, we will first report the within-level effects. Student *interests* and *contextual influences* directly impacted retained STEM career aspirations confirming the initial paths in the hypothesized model. Freshmen whose best guess was that they would at some point change majors were significantly less likely to retain their initial STEM career interests (β = -0.13, $p < 0.001$). Students who were more satisfied with their math and science courses in college had significantly higher odds of retaining their initial STEM career interests, and math and science course satisfaction represented the strongest predictor of retaining initial STEM career interests (β = 0.22, $p < 0.001$). Students direct involvement in research with faculty was a positive predictor of student's retained career interests (β = 0.11, $p < 0.001$). Interacting more frequently with faculty negatively predicted students' odds of retaining their initial STEM career interests ($\beta = -0.04$, $p < 0.05$); however, Appendix B shows that faculty mentorship and retention of STEM career interests have a positive simple correlation, which suggests that a suppressor effect causes the sign reversal in the relationship between these two variables. This sign reversal occurs when controlling for student's satisfaction with math and science courses. Given the strong positive correlation between course satisfaction and faculty mentorship, the suppressor effect is likely due to multicollinearity. Additionally, faculty mentorship has a significant positive indirect affect on retained STEM career interests operating through its association with students working on a professor research project. Other effects that were not initially considered in the hypothesized model indicated direct effects of *person inputs, learning experiences, and self-efficacy.* URM students were less likely to continue to aspire to a STEM career after four years of college ($\beta = -0.08$, $p < 0.001$) compared to their White and Asian American counterparts. Prior academic achievement matters, as entering college with a higher GPA had a strong significant and positive impact on student's likelihood of retaining their initial STEM career aspirations ($\beta = 0.10$, $p < 0.001$). Similarly, students who exhibited higher academic self-concept were more likely to retain their STEM career interests ($\beta = 0.05$, $p < 0.05$).

In examining the between-level effects, both institutional variables were significant predictors of student's retained STEM career aspirations. The proportion of the student body majoring in STEM improves students' likelihood of following through with their initial STEM career interests ($\beta = 0.66$, $p < 0.001$). In other words, students in colleges and universities that had a greater concentration of undergraduate STEM majors had significantly better odds of retaining their STEM career aspirations compared to their peers who enrolled at institutions with smaller concentrations of undergraduate STEM majors. By contrast, students attending more selective colleges were less likely to retain their initial STEM career interests (β =- 0.29, , p < 0.05). Clearly, the institutional context matters and appropriately modeling between level variance allows us to more accurately understand institutional impact.

--Place Table 1 here--

Learning Experiences. *Learning experiences, self-efficacy, outcome expectations,* and *interests* were all hypothesized endogenous variables. As expected, high school GPA is predicted by all of the *person input and background influences* included in the model. Females in comparison to males (β = 0.09, $p < 0.001$) and students with mother's who attained higher education levels (β = 0.04, $p < 0.05$), have higher high school GPAs. URM students (β = -0.16, $p < 0.001$) have lower high school GPAs than their White and Asian peers.

Self-efficacy. As hypothesized Academic self-concept was significantly predicted by high school GPA (β = 0.40, $p < 0.001$). Students with more educated mothers had significantly higher levels of academic self-concept (β = 0.11, $p < 0.001$). Although female students had higher GPAs in comparison to males, they had significantly lower levels of academic self-concept (β = -0.18, $p < 0.001$), which supports prior literature highlighting gender difference in self-concept among STEM students (Cole, 2007; Leslie, McClure, & Oaxaca, 1998).

Outcome expectations. Students who where more confident in their academic abilities, exhibiting higher levels of academic self-concept, had higher convictions for making a theoretical contribution to science (β = 0.19, $p < 0.001$). The hypothesized path showing *outcome expectations* being predicted from *learning experiences* (specifically measured by high school GPA) was non-significant in our sample therefore was deleted from the model. This is likely due to how we are measuring precollege learning experience with this single item. There may be other precollege learning experiences that might better predict student's drive for contributing theoretically to science. A path was added indicating that URM students feel significant more strongly than their White and Asian American peers about wanting to make a theoretical contribution to science ($\beta = 0.07$, $p < 0.001$).

Intention to change major field. *Self efficacy* and *outcome expectations* predict intentions to change major field (*interests)* as the SCCT framework theorizes. Freshmen with more academic confidence (academic self-concept) are less likely to foresee changing their major ($\beta = -0.09$, $p < 0.001$). Similarly, students who highly value contributing theoretically to science are less likely to have intentions of changing their major ($\beta = -0.04$, $p < 0.05$). URM student's also had a lower likelihood of intending to switch majors ($\beta = -0.07$, $p < 0.001$). After controlling for student preparation we see that URM students are less likely to have early doubts about their chosen major, yet URM students are less likely to retain their STEM career aspirations after four years of college. URMs students have early interests in STEM and aspirations for their STEM educational goals; therefore, institutions need to a better job of cultivating those interests and supporting URM students so they are able to realize their STEM career plans.

Satisfaction with science and math course. In addition to the hypothesized endogenous variables, paths were added predicting *contextual influences*. Considering that *contextual influences* were more recently added to the SCCT framework with recent research (Lent, et al., 2005), this area of the theory is still developing. From higher education research perspective, we focus on the college experiences and contexts that predict student outcomes; therefore, it makes sense that there is a strong association between college experiences suggesting more paths should be considered within the SCCT framework. For example, student's academic self-concept is a significant positive predictor of their overall satisfaction with math and science courses ($\beta = 0.32$, $p < 0.001$). This finding is not surprising considering that student's perceptions of their academic abilities have been shown to influence students' success in STEM fields (Cole, 2007; Leslie, McClure, & Oaxaca, 1998).

Faculty mentorship. Students who are satisfied with their math and science courses report significantly higher frequencies of mentoring activities with faculty ($\beta = 0.42$, $p < 0.001$); suggesting that those who felt better about their STEM coursework were also engaged in mentoring relationships from faculty. Female students in comparison to males reported more frequent mentoring activities with faculty ($\beta = 0.13$, $p < 0.001$). Freshmen with higher convictions for making a theoretical contribution to science had a higher likelihood of becoming engaged with faculty ($\beta = 0.53$, $p < 0.001$), suggesting students with these strong values seek out faculty in their efforts to contribute to STEM fields.

Worked on a professor's research project. Not surprisingly, faculty mentoring had the strongest association with working on research ($\beta = 0.26$, $p < 0.001$). Just as students who value making a theoretical contribution have significantly more frequent mentoring experiences with faculty, students who view this goal as important also tend to work with faculty on research significantly more often ($\beta = 0.13$, $p < 0.001$). Students with higher academic self-concept were more likely to engage in research with faculty ($\beta = 0.09$, $p < 0.001$). URM students in comparison to White and Asian counter parts were less likely to participate in a professor's research project ($\beta = -0.08$, $p < 0.001$). This is also in line with recent proposed additions to the

SCCT framework that suggests that *contextual influences* are predicted by person inputs (Lent, et al., 2005).

Indirect effects. Table 2 presents the indirect effects for the primary dependent measure. In terms of students' *person inputs*, there are significant negative indirect effects for females (β =- 0.01, $p < 0.05$) and URM students (β = -0.22, $p < 0.001$) in predicting retained STEM career interests. Having a mother who achieved higher education levels has a significant positive indirect effect on retained STEM career interests (β = 0.02, $p < 0.05$). Similarly, students high school GPA (β = 0.07, $p < 0.001$) and academic self-concept (β = 0.10, $p < 0.001$) had a significant positive effect on retained STEM career interests. Finally, a higher frequency of faculty mentoring appeared to exert a significant positive effect on retained STEM career interests through research opportunities with professors (β = 0.13, $p < 0.001$).

--Place Table 2 here--

Variance explained. The R^2 coefficients, which measure the percentage of variance in the criterion variable that can be explained by the predictor variables after correcting for measurement error, were as follows: high school GPA = .03, academic self concept = .21, , importance of making a theoretical contribution to science = .04, intention to change major field = .02, satisfaction with math and science courses =0.01, worked on a professor's research project = .08, and faculty mentoring = .01. In terms of the primary dependent variable, the R^2 for the between-level was 0.41. In other words, the R^2 coefficients revealed that the cumulative effect of the covariates, explained 41% of the institutional-level variance in students' retained STEM career aspirations. Given the heteroscedasticity of the variance at level-1 for retention of

STEM career aspirations, the R2 coefficient for the within-group model for retention of STEM career aspirations is not meaningful.

Discussion & Implications

This study contributes to our descriptive knowledge of the impact of students' backgrounds, perceptions and motivations, college experiences and institutional contexts on college student's retained STEM career interests and relationships among these influential factors. Departure from the STEM pipeline occurs at different points (Blickenstaff, 2005); therefore, this study focused particularly on career interests in STEM, rather than persistence in a STEM major. Considering the national drive to increase participation among URM students in the STEM workforce, examining what influences career plans and how develop their career aspirations is important for furthering these workforce initiatives.

We know that student's background characteristics affect students' successful progress through the STEM pipeline, but as higher education researchers, we are particularly focused on identifying the educational intervention and experiences that can promote these students in the college trajectories. Considering that freshmen's entering academic self-concept is so important (as it significantly predicts nearly all subsequent student-level measures in the model), institutions should focus efforts on further cultivating students' self-confidence in their academic ability and skills for scientific research. Carlone and Johnson emphasize the importance of performance and competence as part of their science identity model that also goes hand and hand with recognition from faculty. Other findings link to the underlying notions of SCCT suggesting psychological processes that influences individual action and are very important considerations in seeking to understand the career development. For example, students' commitment to science or the value they place on making a theoretical contribution to science influences students STEM career aspirations. Additionally this conviction also influenced their participation in other important college experiences, namely research opportunities and faculty mentorship. Considering the many higher education initiatives to recruit students to the STEM fields, it may be advantageous to better understand these motivations as these can be indicators of students' personal values in choosing STEM careers and persisting in their field of study despite substantial barriers.

The study findings also indicate that freshmen who are uncertain about whether or not they will follow through with their initial major choice are less likely to retain their STEM career aspirations. Considering that students have these doubts, institutions may help to solidify students' STEM career interests early on by providing more engaging experiences in the sciences. Students' satisfaction with math and science coursework was the strongest predictor of retained STEM career aspirations. Innovations in introductory coursework, and connections with specific careers in a variety of fields, sustain student motivation and interest. Introductory STEM classrooms can serve as initial entry points for strengthening student's career goals. Early college experiences that focus on professional skills and deliberately linking STEM-related academic work to applicable career objectives may also reinforce students' confidence in their ability to succeed in STEM careers.

We specifically examined the role of faculty in interacting with students by providing mentorship and guidance and in providing opportunities for students to gain direct research experience. Building faculty support networks associated with specific science careers also appear to be effective. More frequent interactions with faculty positively predict working on a professor's research project, which strongly predicts students' retention of their initial STEM career aspirations. These findings reaffirm the significant investments of NSF, NIH, and HHMI programs to help students prepare for careers, develop appropriate skills and build social networks for work and graduate and professional school in STEM fields. Furthermore, NSF and NIH should consider funding additional undergraduate research opportunities targeted toward students from diverse backgrounds as they are less likely to engage in research and the findings show that participation in research with faculty promotes STEM career aspirations. Each institution must redouble efforts to prepare a diversified scientific workforce for the future.

Several institutional contexts predicted students' likelihood of retaining STEM career interests. The percent of students at an institution who are majoring in a STEM field also had a positive effect on students likelihood of retaining their initial STEM career aspirations. It is difficult to identify exactly how the proportion of science majors contributes to STEM career development, but institution with a larger proportion of STEM majors might also have a stronger normative STEM orientation that provides a more specialized culture focused on science, which may further solidify students' career interest. The findings demonstrate that selectivity can negatively affect students' retention of their initial STEM career goals. As the most talented students seek to attend the most selective institutions, it is incumbent on these institutions to engage in further nurturing of student talent among underrepresented groups

The theoretical perspective of SCCT provides a framework for understanding how students' precollege experiences continue to influence educational outcomes. Utilizing this theoretical framework broadly to identify and analyze key influences on students' commitment to science allows for an interpretation that is more descriptive of students' experiences, which informs support programs and future research in this area. There is an opportunity for the SCCT to be more widely utilized in examining college student's career goal development with the expansion the theory to more fully explore how *contextual influences* interact in student career choices. Further research should disaggregate across STEM careers (i.e. engineering, biomedical) to see how these factors influence students within specific fields. Additional focus on disaggregation across racial groups may provide more specific information about what is most important for promoting STEM career aspiration among underrepresented populations. More scholarship is needed in this area to better promote the national goals of more prepared diverse STEM workforce

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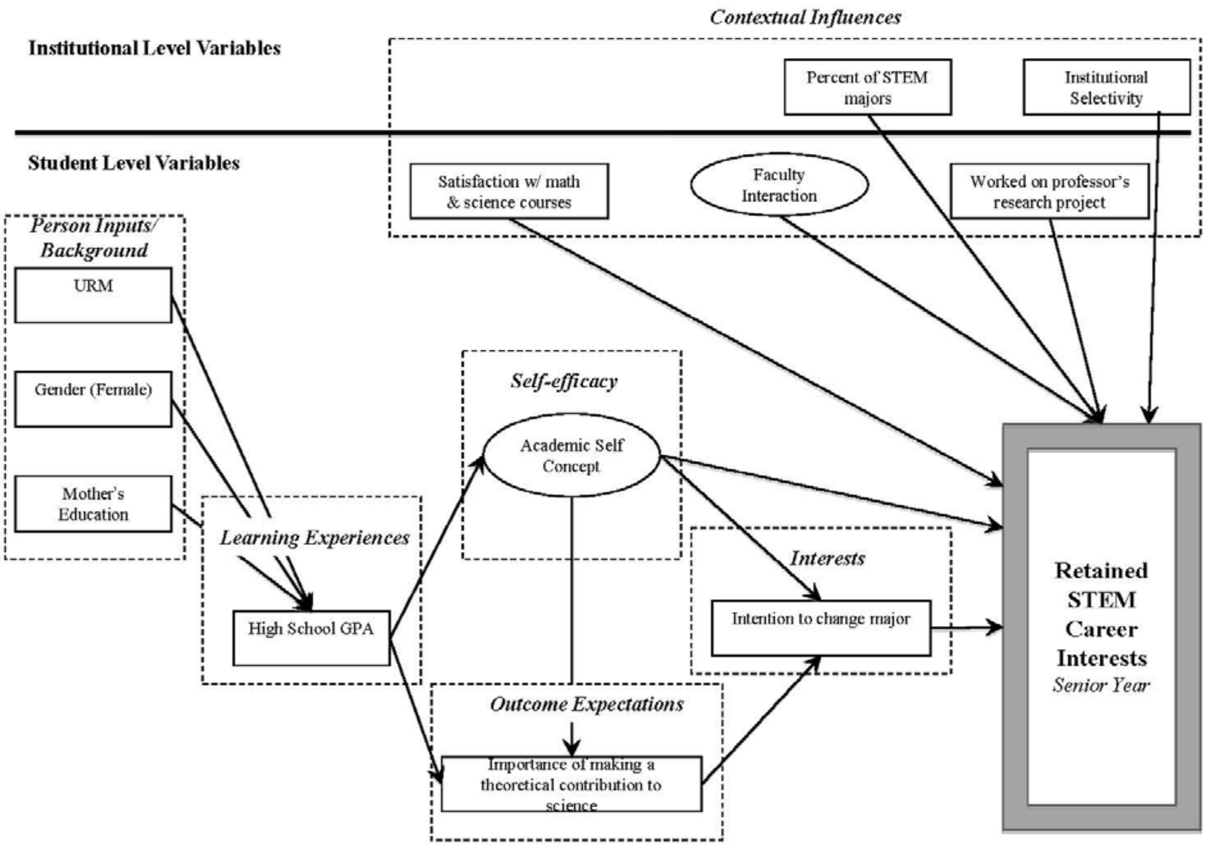

Figure 1. Hypothesized Model Utilizing SCCT Framework

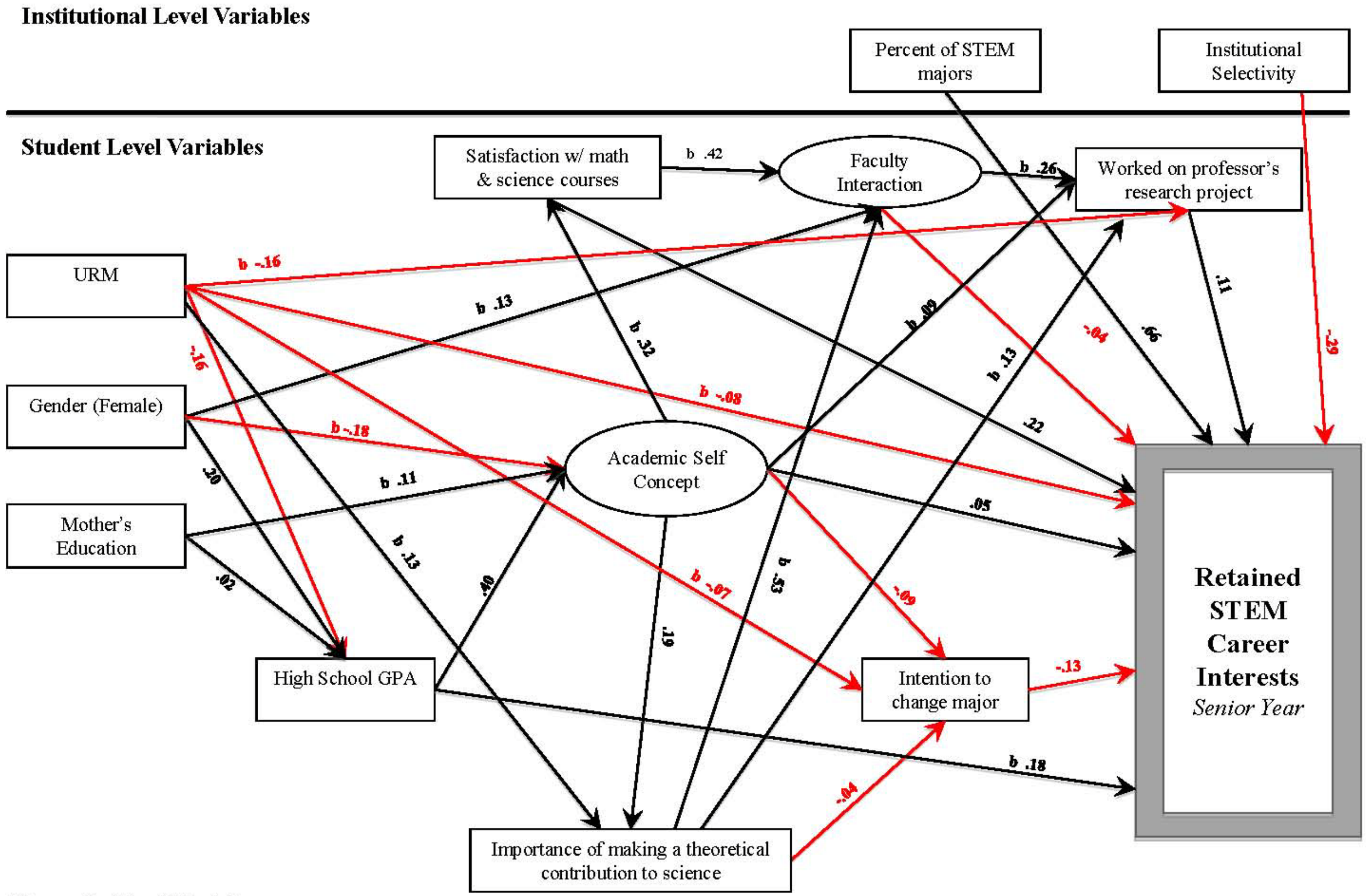

Figure 2. Final Model

a N=3156; X^2(df=47; p<0.001) = 2241.80; CFI = .96; TLI = .93; RMSEA = .03

b parameter added based on modification indices and theoretical/empirical review.

Note: All paths are significant at $p<.05$. Negative effects are noted in red.

Table 3 Parameter estimates for direct effects in the structural model

	b	β	S.E.	Sig.	R^2
High School GPA					0.03
Student's gender	0.20	0.09	0.04	***	
Underrepresented minority student	-0.34	-0.16	0.04	***	
Mother's education	0.02	0.04	0.01	*	
2004 Academic self-concept					0.21
Student's gender	-2.83	-0.18	0.26	***	
Mother's education	0.41	0.11	0.06	***	
High School GPA	2.83	0.40	0.13	***	
2004 Importance of making a theoretical contribution to science					0.04
2004 Academic self-concept	0.02	0.19	0.00	***	
Underrepresented minority student	0.13	0.07	0.03	***	
Intention to change major field					0.02
2004 Academic self-concept	-0.01	-0.09	0.00	***	
Underrepresented minority student	-0.12	-0.07	0.03	***	
2004 Importance of making a theoretical contribution to science	-0.04	-0.04	0.02	*	
Satisfaction w/ science and mathematics courses					0.01
2004 Academic self-concept	0.04	0.32	0.01	***	
Faculty mentorship					0.01
Student's gender	1.25	0.13	0.16	***	
2004 Importance of making a theoretical contribution to science	2.65	0.53	0.49	***	
Satisfaction w/ science and mathematics courses	2.02	0.42	0.09	***	
Worked on a professor's research project					0.08
Faculty mentorship	0.04	0.26	0.01	***	
2004 Importance of making a theoretical contribution to science	0.10	0.13	0.02	***	
2004 Academic self-concept	0.01	0.09	0.00	***	
Underrepresented minority student	-0.11	-0.08	0.03	***	
Retained STEM career interest (senior year)					0.11
Underrepresented minority student	-0.30	-0.08	0.08	***	
High School GPA	0.18	0.10	0.04	***	
Intention to change major field	-0.31	-0.13	0.04	***	
2004 Academic self-concept	0.01	0.05	0.01	*	
Worked on a professor's research project	0.30	0.11	0.06	***	
Satisfaction w/ science and mathematics courses	0.43	0.22	0.04	***	
Faculty mentorship	-0.02	-0.04	0.01	*	
Retained STEM career interest (senior year)					0.41
Institutional selectivity	0.00	-0.29	0.00	*	
Percent of students majoring in STEM in 2006	1.81	0.66	0.31	***	

N=3156; X2(df=47; p<0.001) = 2241.80; CFI = .96; TLI = .93; RMSEA = .03

Note: *** p<0.001, ** p<0.01, * p<0.05

Table 3 Parameter estimates for indirect effects in the structural model

	b	β	S.E.	Sig.
Retained STEM career interest (senior year)				
Student's gender	-0.03	-0.01	0.02	*
Underrepresented minority student	-0.05	-0.22	0.01	***
Mother's education	0.01	0.02	0.00	***
High School GPA	0.06	0.07	0.01	***
2004 Academic self-concept	0.01	0.10	0.00	***
2004 Importance of making a theoretical contribution to science	0.01	0.01	0.02	
Satisfaction w/ science and mathematics courses	-0.01	-0.01	0.01	
Faculty mentorship	0.01	0.03	0.00	***

N=3156; X2(df=47; p<0.001) = 2241.80; CFI = .96; TLI = .93; RMSEA = .03

Note: *** p<0.001, ** p<0.01, * p<0.05

Appendix A: Description of variables and measures

Variables	Scale Range
Retained STEM career interest (senior year)	0=no 1=yes 11 STEM Related Careers: Computer programmer or analyst; Conservationist or forester; Dentist (including orthodontist); Engineer; Lab technician or hygienist; Nurse; Optometrist; Pharmacist; Physician; Scientific researcher; Veterinarian
Student's gender	1=male 2=female
Underrepresented minority student	1=no 2=yes
Mother's education	1 = grammar sch., 8 = graduate deg.
High school GPA	1 = D, 8 = A or A+
*2004 Academic Self-Concept	Continuous, min = 17.09, max = 66.92
Intention to change major field	1=no chance, 4=very good chance
Importance of making a theoretical contribution to science	1=not important, 4=essential
Satisfaction w/ science and mathematics courses	1=can’t rate/don’t know, 6=very satisfied
*Faculty mentorship	Continuous, min = 27.33, max = 66.99
Worked on a professor's research project	1= not at all, 3 = frequently
Institutional selectivity	Continuous, min = 780.00, max = 1510.00
Percent of students majoring in STEM in 2006 (in 10-point increments)	Continuous, min = 0.00, max = 0.89

* See Sharkness, DeAngelo & Pryor (2010) for more details

Appendix B: Descriptive statistics

	Mean	S.D.	Min	Max
Retained STEM career interest (senior year)	0.57	0.49	0.00	1.00
Student's gender	1.63	0.48	1.00	2.00
Underrepresented minority student	1.47	0.50	1.00	2.00
Mother's education	5.37	1.97	1.00	8.00
High school GPA	6.99	1.17	1.00	8.07
2004 Academic Self-Concept	52.64	7.90	17.09	66.92
Importance of making a theoretical contribution to science	2.36	0.93	0.20	4.00
Intention to change major field	2.32	0.82	1.00	4.00
Satisfaction w/ science and mathematics courses	4.94	0.98	1.00	6.00
Faculty mentorship	50.17	4.71	27.33	66.99
Worked on a professor's research project	1.55	0.72	1.00	3.00
Institutional selectivity	1165.38	133.76	780.00	1510.00
Percent of students majoring in STEM in 2006	0.21	0.16	0.00	0.89

Appendix C: Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Retained STEM career interest (senior year)	1.000												
2	Student's gender	-0.075	1.000											
3	Underrepresented minority student	-0.085	0.068	1.000										
4	Mother's education	0.062	-0.027	-0.152	1.000									
5	High School GPA	0.146	0.040	-0.161	0.099	1.000								
6	2004 Academic self-concept	0.142	-0.155	-0.103	0.150	0.434	1.000							
7	2004 Intention to change major field	-0.112	-0.028	-0.066	0.029	0.031	-0.071	1.000						
8	2004 Importance of making a theoretical contribution to science	0.019	-0.034	0.029	0.017	0.062	0.188	-0.054	1.000					
9	Faculty mentorship	0.074	0.102	0.058	0.028	0.116	0.125	-0.059	0.091	1.000				
10	Satisfaction w/ science and mathematics courses	0.212	-0.057	-0.039	0.038	0.134	0.164	-0.033	0.060	0.430	1.000			
11	Worked on a professor's research project	0.131	0.002	-0.068	0.094	0.140	0.165	0.026	0.179	0.215	0.145	1.000		
12	Institutional selectivity	0.044	-0.121	-0.085	0.205	0.349	0.212	0.179	0.070	0.001	0.066	0.175	1.000	
13	Percent of students majoring in STEM in 2006	0.125	-0.169	0.022	0.046	0.104	0.117	0.053	0.026	-0.059	0.031	0.044	0.321	1.000