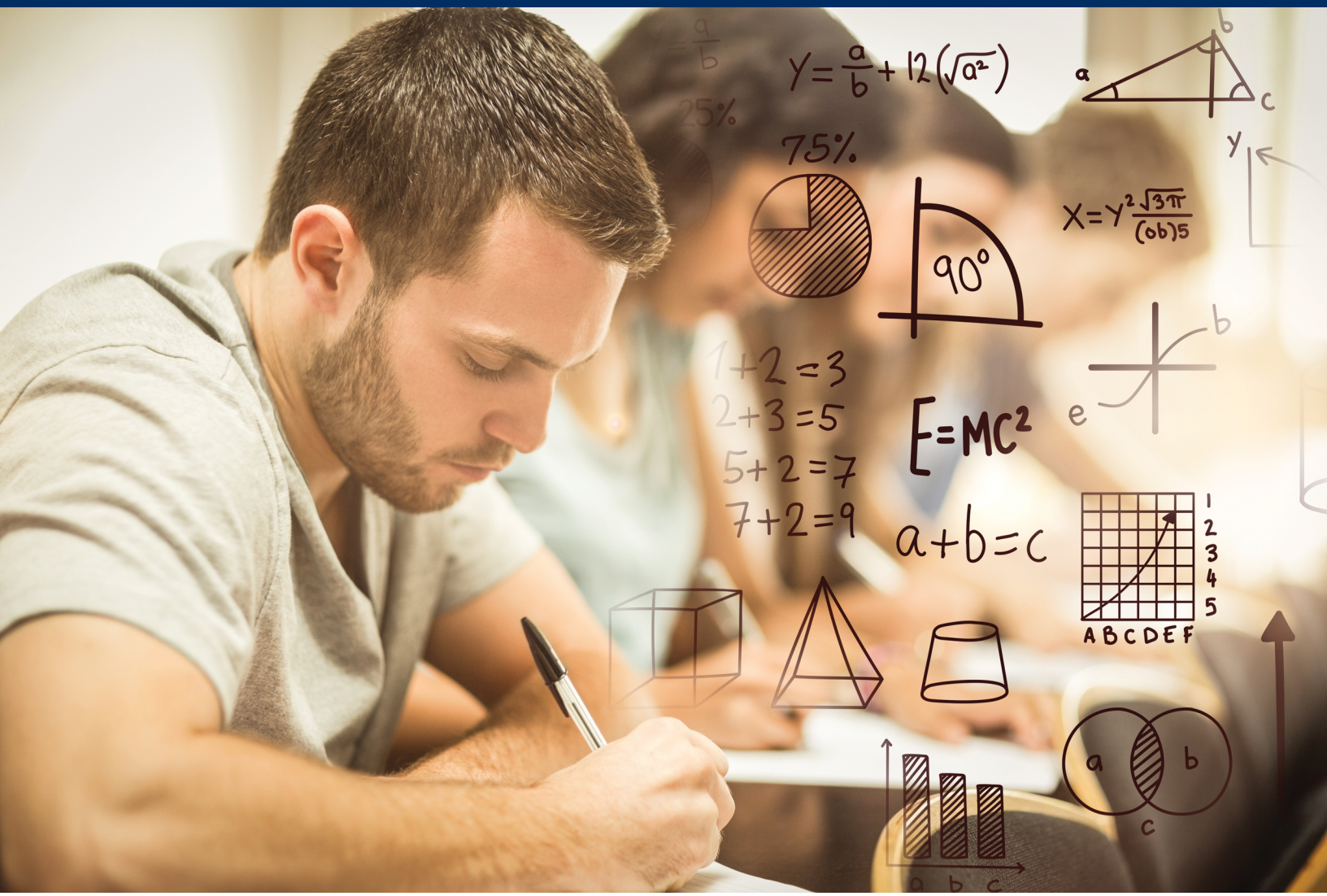
ACT Research Report Series 2017–4

Who will Declare a STEM Major? The Role of Achievement and Interests

Justine Radunzel, PhD
Krista Mattern, PhD
Paul Westrick, PhD



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Justine Radunzel is a principal research scientist in Statistical and Applied Research at ACT specializing in postsecondary outcomes research and validity evidence for the ACT test.

Krista Mattern is a director in Statistical and Applied Research at ACT specializing in the validity and fairness of assessment scores as well as more general issues in higher education such as enrollment, persistence, and graduation.

Paul Westrick is a research scientist in Statistical and Applied Research at ACT specializing in postsecondary outcomes research and validity evidence for the ACT test.

Acknowledgments

The authors thank Jeff Allen, Kurt Burkum, Ty Cruce, and Kyle Swaney for their helpful comments and suggestions on earlier drafts of this report.

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Abstract

As new initiatives and programs are being increasingly implemented to promote STEM (Science, Technology, Engineering, and Mathematics) interest and participation among U.S. students, the percentage of students who declare a STEM-related major in college continues to lag behind what would be expected based on students' intentions. Such findings underscore the value of understanding why students who are interested in STEM do not pursue a STEM degree. In order to answer that question, the current study developed a multidimensional model of STEM major choice based on academic and non-academic student characteristics. The identification of factors to include in the model was based on previous literature findings supporting psychological theories related to major selection. Namely, we focused on the theory of planned behavior and person-environment fit models. The findings support these theories with students' achievement levels, their high school coursework and grades, their major intentions, the certainty of their major intentions, and having measured interest in STEM being related significantly to STEM major choice. The results can help inform initiatives to identify students most likely to enter the STEM pipeline and provide resources and support for this career pathway.

Who will Declare a STEM Major? The Role of Achievement and Interests

Current shifts in the U.S. economic and labor markets have rejuvenated focus on Science, Technology, Engineering, and Mathematics (STEM) education and occupations. Employment opportunities in STEM occupations are projected to grow faster than the average of all occupations between 2012 and 2022 (13-percent rate of growth vs. 11-percent rate of growth), resulting in a projected increase of about 1 million STEM-related jobs during this period (Vilorio, 2014). There is concern that the current educational system will not be able to produce enough STEM graduates to fill these additional job openings (Gonzalez & Kuenzi, 2012). In response, new initiatives and programs are being increasingly implemented to promote STEM interest and participation among U.S. students. For example, the committee of Science, Technology, Engineering, and Math Education was established in 2011 with the goal of coordinating federal programs and activities in support of STEM education (National Science and Technology Council, 2011).

That being said, based on data collected by ACT, it appears that there is considerable interest in STEM among students in the secondary pipeline. Roughly half of 2016 ACT-tested high school graduates expressed interest in majoring in STEM or had responses to the ACT® Interest Inventory items that resulted in high science and technology interest scores (the latter labeled as having measured interest in STEM; ACT, 2016). However, the percentage of beginning postsecondary students who go on to declare a STEM major is significantly lower. Fewer than 30% of all undergraduate students actually declare a STEM major in college (Chen, 2009; Chen & Ho, 2012). Such findings raise the question: why are students who are interested in STEM not pursuing a STEM degree? Specifically, what other individual characteristics, in addition to interest in STEM, can help explain STEM major choice?

In order to answer that question, the current study developed a multidimensional model of STEM major choice based on students' achievement levels, their high school coursework and grades, their major intentions, the certainty of their major intentions, having measured interest in STEM, their educational goals, and demographic characteristics. The study also explored the effects of achievement and interests on STEM major cluster choice. The identification of factors to include in the model was based on previous literature supporting psychological theories related to major selection. Namely, we focused on the theory of planned behavior (Azjen, 1991) and person-environment fit models (Dawis & Lofquist, 1984; Holland, 1997). Relevant empirical findings based on these theories as it relates to the current study are summarized below.

Theory of Planned Behavior

In the theory of planned behavior, intentions – or an indication of an individual's readiness to perform a given behavior – are believed to be the most immediate antecedent of behavior (Ajzen, 1991). Thousands of studies have used the theory of planned behavior to explain human behavior and the model has received strong support. That being said, even though there is a strong link between intentions and behavior, the relationship is not perfect. A meta-analysis of 10 meta-analyses examining the intention-behavior relationship found that intentions accounted for 28% of the variance in behavior (Sheeran, 2002).

The extent to which major intentions is indicative of future behavior can be evaluated using ACT data. Specifically, students' self-reported intended majors are collected on the ACT

registration form. Using ACT student records matched to National Student Clearinghouse data on students' postsecondary enrollment status, declared major, and degree information, 57% of students attending a four-year institution declared a major during their first year of college that fell within the same intended major area (ACT, 2014). However, this rate varied substantially by major of study from a low of 3% for Health Administration and Assisting to a high of 69% for Business. Typical STEM-related major areas such as engineering, health sciences and technologies, biological and physical sciences, and computer sciences and mathematics tended to have some of the higher rates of intended-declared major consistency (ranging from 52% to 67% across the four areas). But, even among students intending to major in STEM, many students did not follow through on their plans (33% to 48%).

Given this variability in intended-declared major consistency, research has examined moderators of the intention-behavior link. For example, characteristics of the intentions have been shown to moderate the relationship (Cooke & Sheeran, 2004; 2013). Of note, certainty – the level of confidence/decidedness about a decision – has been shown to explain variance in the intention-behavior relationship where individuals who are more certain of their intentions are more likely to follow through on their plans.

In an earlier ACT report, the relationship between attaining a college degree in one's career field of interest by certainty of occupational choice and ACT Composite score was examined (ACT, 2009). The results clearly indicate that individuals who were more certain about their occupational plans were more likely to earn a degree in their career field of interest, even for students with similar ACT scores. Specifically among high-scoring students (ACT score of 28 or higher), 46% of students who were very certain about their occupational choice earned a college degree in their career field of interest as compared to 28% of students who were not sure. The current study will extend beyond these descriptive findings of earlier ACT studies to develop a model of STEM major choice that includes intentions, certainty of intentions, and other student characteristics to evaluate the extent to which certainty of intentions adds to the prediction.

Person-Environment Fit

The premise of person-environment fit (P-E fit) is that people seek out environments that match their interest, abilities, skills, values and attitudes (Dawis & Lofquist, 1984; Holland, 1997). When there is P-E fit, individuals are more satisfied, which reinforces their decision. P-E fit models that are particularly relevant to the college major choice process include Holland's theory of vocational choice (1997), which explains how different personality types fit with different occupational environments, and theory of work adjustment, which also includes a focus on the fit between abilities and occupation demands/requirements.

Holland's theory of vocational choice (1997) indicates that both individuals and work environments can be classified into six types: *Realistic* (e.g., working with things), *Investigative* (e.g., science), *Artistic* (e.g., creative expression), *Social* (e.g., helping people), *Enterprising* (e.g., leadership), and *Conventional* (e.g., structured business roles). People seek out environments where they can use their skills and abilities and express their values and attitudes. Research at ACT has also classified college majors by these types based on students who have successfully persisted in that major and earned a cumulative GPA of 3.0 or higher by the third year of college (Allen & Robbins, 2010). Based on a students' interest profile and the college major interest profile, the congruence or fit between the two can be computed.

Research has consistently shown that students who fit well with their environment in terms of interest are more likely to persist in college, persist in their college major, and complete a degree in a timely manner (Allen & Robbins, 2008; 2010; Nye, Su, Rounds, & Drasgow, 2012).

Being interested in the academic material or content is not the only important factor for persisting in a major; being academically ready is also important. The latter gets at the notion of abilities-demands fit (Dawis & Lofquist, 1984). Research has consistently found that students who are more academically prepared are more likely to persist in college, and more specifically to persist in their major (Allen & Robbins, 2010; Le, Robbins, & Westrick, 2014; Radunzel & Noble, 2012; Tracey, Allen, & Robbins, 2012). Note that this research indicates an overall main effect for academic preparation, but we are also interested in exploring whether academic fit within a specific major is important. For example, the level and type of academic preparation that is needed to be successful for science majors may be different than that required of students majoring in literature. Academic fit examines the student's academic preparation in comparison to that of those who have been successful in the specific major area.

The ACT College Readiness Benchmarks are the ACT test scores associated with a 50% chance of earning a B or higher grade in certain first-year college courses (English Composition, College Algebra, social science courses, and Biology; Allen, 2013). But recent ACT research suggests that academic readiness for STEM coursework may require higher mathematics and science scores than those suggested by the Benchmarks. Calculus – not College Algebra – is usually the first mathematics course for students majoring in STEM (Mattern, Radunzel, & Westrick, 2015; Radunzel, Mattern, Crouse, & Westrick, 2015). The median ACT mathematics test score associated with a 50% probability of earning a B or higher grade in Calculus is 27. Additionally, the typical first science course of STEM majors was Chemistry, Biology, Physics or Engineering. The median ACT science score associated with a 50% probability of earning a B or higher grade in these courses is 25. In comparison, the ACT College Readiness Benchmarks in mathematics and science are 22 and 23, respectively. Additional analyses showed that a higher level of mathematics and science preparation was needed to be ready for success in STEM across multiple indicators such as first-year grade point average (FYGPA), retention, and degree completion. Such findings led to the development of a STEM Benchmark of 26 based on the ACT STEM score (Radunzel et al., 2015).

Current Study

Building upon previous research, the current multi-institutional study had three objectives. The first objective was to identify student characteristics that are useful for identifying those who are likely to declare a STEM major during their first year. Student characteristics evaluated included achievement levels, other measures of mathematics and science academic preparation (high school courses taken and grades earned), intended major, level of certainty of major intention, vocational interests, educational goals, and demographic characteristics. The second objective was to determine whether the relationship between STEM achievement levels and STEM major choice depended upon a student's intended major and measured vocational interests. This objective might support findings from a previous study that suggested that academic ability (as measured by ACT Composite scores) moderates the effect of interest-major fit on STEM choice (Le et al., 2014). The third objective was to identify student

characteristics related to declaring a major within a specific STEM cluster in comparison to declaring a non-STEM major, and to determine whether there are any differences in the relevant predictors across the STEM clusters included in this study. The four STEM clusters included Science, Computer Science & Mathematics, Engineering & Technology, and Medical & Health.

Sample

Data for the study consisted of roughly 91,000 students attending one of 43 four-year postsecondary institutions who enrolled as first-time entering students in fall 2005 through 2009 and declared a major during their first fall term.[1] The institutions were diverse with regard to institutional control, selectivity, and size. Specifically, 70% of the institutions were classified as public, 23% as highly selective (as compared to traditional/less selective), and 56% had a student body of less than 5,000 students.

Measures

Institutions provided students' six digit Classification of Instruction Program (CIP) codes (National Center for Education Statistics, 2002) for the first fall term of enrollment, which was used to identify STEM majors. Data for students' demographic characteristics, high school coursework taken, grades earned in those courses, educational plans, major plans and interests, and ACT Interest Inventory results were obtained from the ACT registration data; official ACT test scores were also obtained. If students took the ACT more than once, only data from the most recent ACT administration was used.

Study Outcomes

The primary study outcome was STEM major choice during the first fall term of enrollment and was coded as a binary outcome (STEM major vs. non-STEM major). Many definitions of STEM exist; the current study employed ACT's definition of STEM (2016), which categorized STEM majors into four clusters based on their declared majors: Science, Computer Science & Mathematics, Engineering & Technology, and Medical & Health.[2] The secondary study outcome was STEM major cluster choice and was coded as a five-category variable that included the four STEM major clusters compared to non-STEM majors.

Academic Achievement and Preparation Measures, Student Demographics, and Educational Plans

Academic coursework measures included:

- whether Calculus was taken in high school (Yes; No)[3]
- whether advanced, accelerated, or honors courses in mathematics were taken in high school (Yes; No)

[1] Of the 163,342 students in the initial sample, 119,477 (or 73%) declared a major during their first fall term. Of those who declared a major during their first fall term, 91,208 (or 76%) students provided their intended major and level of major certainty, and completed the ACT Interest Inventory at the time they registered for the ACT.

[2] Given the lack of consistency among the various STEM definitions being currently employed, ACT (2016) conducted a comprehensive review of the literature and provided a refined definition of STEM. One distinction of ACT's definition is that it excludes social/behavioral sciences such as psychology and sociology (Green, 2007). To learn more about which majors and occupations are included in ACT's definition of STEM, see the full report (ACT, 2016). The CIP codes included for each STEM major category are shown in Radunzel, Mattern, and Westrick (2016; see Table A1, Appendix A).

[3] Students were asked to indicate courses that they have taken, are currently taking, or are planning to take. Only courses that students had or were currently taking at the time that they registered for the ACT were considered as taken in high school.

- whether Physics was taken in high school (Yes; No)
- whether advanced, accelerated, or honors courses in science were taken in high school (Yes; No)

The achievement measures included the ACT STEM score (the rounded average of the ACT mathematics and science scores), the rounded average of the ACT English and reading scores (labeled as the average ACT English and reading score), and high school GPA (HSGPA). ACT scores and HSGPA were examined as continuous predictors.

High school coursework and HSGPAs were based on students' self-reports of their coursework taken in up to 23 specific courses in English, mathematics, social studies, and science and the grades earned in these courses.[4] Prior studies have shown that students report high school coursework and grades accurately relative to information provided in their official high school transcripts (Sanchez & Buddin, 2016; Shaw & Mattern, 2009). Students also indicated whether they needed assistance in improving their mathematics skills.

Student demographic characteristics and educational plans included:

- gender
- race/ethnicity (categorized as Underrepresented Minority students, White/Asian students, and Other/Multiracial students)[5]
- family income range (categorized as less than $36,000, $36,000 to $80,000, and more than $80,000)
- highest level of education expected to complete (categorized as bachelor's degree or below; beyond a bachelor's degree)[6]

Intended Major and Measured Interests

Students' intended majors were categorized into one of the following groups: STEM, non-STEM, or undecided.[7] Students who plan to major in a STEM-related field are classified as having an *expressed* interest in STEM according to the annual ACT Condition of STEM Report (ACT, 2016). In addition to providing their intended major, students also indicated the level of certainty of their major intentions (very sure, fairly sure, and not sure). Major sureness was relevant for students with an intended major only; it was not evaluated for undecided students. Consequently, when the major sureness variable was included as a predictor in the models, it was included in relation to intended major.[8]

Students' *measured* interests in STEM were based on their ACT Interest Inventory scores. On the ACT Interest Inventory, students indicate whether they like, dislike, or are indifferent to 72 common activities related to four basic work tasks: data, ideas, people, and things.

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[4] In describing the sample, HSGPA was categorized into the following categories based on the tertiles of the distribution: 3.29 or lower, 3.30 to 3.74, and 3.75 or higher.

[5] Underrepresented minority students included African American, Hispanic, and American Indian/Alaskan Native students combined.

[6] Bachelor's degree or below included the following: a business/technical or certificate program, an associate's degree, a bachelor's degree, or other. Beyond a bachelor's degree included the following: a master's degree, a doctoral degree, or a professional level degree (e.g., M.D., J.D.).

[7] Out of the nearly 300 majors/occupations listed in the ACT Student Profile Section, 94 ACT majors/occupations are classified as STEM (see ACT Condition of STEM Report (2016) for major/occupations included by cluster).

[8] In the models, the major certainty variable was multiplied by a dichotomous variable denoting whether the student had an intended major (coded as 1) compared to undecided students (coded as 0) to ensure the inclusion of the undecided students in the STEM major choice models.

Examples of activities include: explore a science museum, make charts or graphs, conduct a meeting, and teach people a new hobby. Based on student responses to these items, six interest inventory standard scores are calculated. These six scores correspond to the six interest types in Holland's theory of careers (ACT, 2009; Holland, 1997). Internal consistency estimates of reliabilities of the Interest Inventory standard scores range from 0.84 to 0.91 across the scales.

A student was classified as having *measured* interest in STEM if one of the following conditions was met: 1) Science and Technology (Investigative) was the highest ACT Interest Inventory score or 2) Technical (Realistic) was the highest score, followed by Science and Technology (Investigative). This definition is consistent with the one used in the annual ACT Condition of STEM Report (ACT, 2016) and supported by other research (Porter & Umbach, 2006; Le et al., 2014).

Methodology

Multiple-predictor logistic regression models for STEM major choice were developed to estimate the likelihood of declaring a STEM major as a function of student characteristics (these characteristics are listed in Table 1). Design-based methods that account for clustering were employed (i.e., cluster-robust standard errors, a.k.a. sandwich or empirical estimators; Huber, 1967; White, 1980; White, 1984).[9] For the secondary five-category outcome, multiple-predictor multinomial regression models for STEM major cluster choice (vs. non-STEM) were estimated. Predictors were evaluated using a significance level of .01.

An interaction term between intended major and measured interests was included in the initial multiple-predictor model to accurately estimate the joint effects of these two predictors on STEM major choice. This allowed us to examine results for four categories that have been discussed in prior ACT research (ACT, 2016; Radunzel et al., 2016): having both expressed (i.e., intending to major in STEM) and measured interest; expressed interest only (no measured interest); measured interest only (no expressed interest); and no STEM interest.[10] Examination of the second objective of this study involved evaluating the significance of the interaction terms between ACT STEM score and intended major and between ACT STEM score and measured interest on STEM major choice.

For each variable, the odds ratio (OR) was reported. For the dichotomized outcome, the OR represents the odds of declaring a STEM major for a certain subgroup of students (e.g., students taking Calculus in high school or students having measured interest in STEM), compared to the odds of declaring a STEM major for another subgroup of students (e.g., students not taking Calculus in high school or students not having measured interest in STEM; the latter group is often referred to as the referent group). For the multinomial STEM persistence outcome, four ORs of STEM cluster choice compared to the base category (declaring a non-STEM major) were reported.[11]

[9] The regression models were run in SAS 9.2 using the GLIMMIX procedure.

[10] One difference between this study and these prior studies is that undecided students were considered as a separate group from students intending to major in a non-STEM related field in this study, whereas these two groups were combined together as those who did not express interest in STEM in the prior studies (ACT, 2016; Radunzel et al., 2016).

[11] For a multinomial outcome, the odds of declaring a specific STEM cluster is the ratio of the probability of declaring a specific STEM cluster to the probability of declaring a non-STEM major. For the dichotomized outcome, the odds is the ratio of the probability of declaring a STEM major to the probability of declaring a non-STEM major.

In comparison to members in the referent group, an OR greater than 1.0 indicates that students in the subgroup of interest are generally more likely to declare a STEM major, whereas an OR less than 1.0 indicates that they are less likely to do so. An OR estimated from a multiple-predictor model is labeled as an *adjusted OR*, because other student characteristics were adjusted for in the model.[12] The adjusted OR was calculated as the exponential of the corresponding logistic regression coefficient or the corresponding multinomial regression coefficient, except for the variables that were included in the interaction terms. For the variables included in the interaction terms, the adjusted ORs were calculated as the exponential of the sum of the relevant predictors in relation to the referent group holding all other predictors in the model constant. More details about how the adjusted ORs were calculated are provided in Appendix B. In addition to ORs, students' chances of declaring a STEM major were reported to help provide context for the practical significance of the findings, especially in light of the relatively large sample size. Students' chances of declaring a STEM major by a specific student characteristic were estimated by holding all other predictors in the model constant at their sample mean values.

Some students did not respond to high school coursework and grade items, as well as to the family income range and educational plans items, when they completed the ACT registration materials. Multiple imputation was used to estimate missing data for these student characteristics; missing rates ranged from 11% (for educational plans) to 28% (for advanced high school science coursework). Five data sets were imputed. Results are based on the initial imputed data set as no differences of practical significance were found across the data sets. Missing values were not imputed for gender, intended major, major sureness, and ACT Interest Inventory scores.

Results

Overall STEM Results

Descriptive Statistics. Overall, 39% of the sample declared a STEM major; however, this rate varied by student characteristics. As shown in Table 1, females were less likely than males to declare a STEM major; there were minimal differences in STEM major choice by race/ethnicity and family income. Students who were better prepared in mathematics and science in terms of the coursework taken in high school and ACT test scores were more likely than those who were less prepared to declare a STEM major. Students who intended to major in STEM (i.e., those with expressed interest in STEM) were nearly five times more likely to declare a STEM major (67%) as compared to students with non-STEM major intentions (14%). The percentage of students declaring a STEM major within an intended major area varied according to how certain students were of their major intentions (e.g., 72% for those very sure vs. 55% for those not sure among students intending to major in STEM). Likewise, students with measured interest in STEM were two times more likely than those without measured interest in STEM to declare a STEM major (61% vs. 30%), while students indicating that they needed help with improving their math skills were less likely to declare a STEM major.

[12] Adjusted ORs were estimated using the ESTIMATE statement within the GLIMMIX procedure. This note is especially relevant for any comparisons of interest that involved predictors included in the interaction terms.

Table 1. Percentage Declaring a STEM Major by Student Characteristics

Characteristic	Category	N	Percent
ACT STEM score	22 or lower	47,581	32
	23 to 25	21,218	40
	26 or higher	22,409	54
Avg ACT English & reading score	19 or lower	24,404	35
	20 to 26	41,647	39
	27 or higher	25,157	44
HSGPA	3.29 or lower	29,672	32
	3.30 to 3.74	27,853	38
	3.75 or higher	33,683	47
Took Calculus	Yes	18,063	54
	No	73,145	35
Took advanced, accelerated, honors math course	Yes	57,522	44
	No	33,686	32
Took Physics	Yes	35,583	45
	No	55,625	35
Took advanced, accelerated, honors science course	Yes	54,518	44
	No	36,690	33
Intended major	STEM	40,138	67
	Non-STEM	42,357	14
	Undecided	8,713	32
Intended major / Major sureness	STEM / Very sure	17,081	72
	STEM / Fairly sure	18,617	65
	STEM / Not sure	4,440	55
	Non-STEM / Very sure	17,508	12
	Non-STEM / Fairly sure	19,059	15
	Non-STEM / Not sure	5,790	19
Measured interest in STEM	Yes	26,145	61
	No	65,063	30
Indicated needing help with improving math skills	Yes	41,602	33
	No	49,606	44
Educational plans	Beyond a bachelor's degree	53,883	44
	Bachelor's degree or below	37,325	32
Gender	Female	52,169	35
	Male	39,039	45
Race/ethnicity	Minority	23,351	38
	White/Asian	5,145	40
	Other	62,712	39
Annual family income	< $36,000	27,061	37
	$36,000 to $80,000	36,581	40
	> $80,000	27,566	40

Model Based Results. Based on the results of the multiple-predictor logistic regression model that included academic, demographic, and non-academic student characteristics, seven of the 15 variables were significantly related to overall STEM major choice at the .01 level (see Table A1 in the Appendix for parameter estimates). In addition, the interaction between intended major and measured interests was statistically significant. The model correctly classified whether a student would initially declare a STEM major for 76% of the cases, which is a 95% increase over chance. Moreover, of those who actually declared a STEM major, 73% were predicted to declare a STEM major, and of those who declared a non-STEM major, 79% were predicted to declare a non-STEM major.

The academic factors that were positively related to STEM major choice included ACT STEM score (adj-OR = 1.10; Table A2) and taking Calculus in high school (adj-OR = 1.30).[13] Another academic factor that was related to STEM major choice was the average ACT English and reading score (adj-OR = 0.96), where higher values were associated with a lower likelihood of declaring a STEM major. Figure 1 provides an illustration of the strong positive relationship between achievement in mathematics and science (as measured by the ACT STEM score) and STEM major choice for three different values on the average ACT English and reading score, holding all other predictors constant at their sample means. For the examples shown in the figure, less than one-fourth of students with low STEM scores (<15) were likely to declare a STEM major as compared to over one-half of students with high STEM scores (>30). Figure 1 also illustrates that, at a given ACT STEM score, students' chances of declaring a STEM major slightly decreased as their average ACT English and reading score increased.

The only demographic characteristic significantly related to overall STEM major choice in the multiple-predictor model was annual family income. Higher-income students were less likely than lower-income students to declare a STEM major (adj-OR = 0.89 for higher vs. lower; adj-OR = 0.98 for middle vs. lower; Table A2). Gender and race/ethnicity were not significantly related to overall STEM major choice. The income-related finding, although somewhat counterintuitive, is consistent with results from another study (Lichtenberger & George-Jackson, 2013) that found lower-income high school students were more likely than higher-income high school students to plan to major in a STEM field in college, even after controlling for other relevant student and school characteristics.[14]

[13] The interpretation of the adjusted OR for a continuous predictor such as the ACT STEM score is as follows: for a one unit increase in the ACT STEM score, the odds of declaring a STEM major is 1.10 times greater.

[14] Lichtenberger and George-Jackson (2013) suggested that this finding may be due to "that for some students the decision to major in a STEM field may be more associated with economics than social forces" and that "high school students from low-income families may be more likely to perceive STEM majors as leading directly to the workforce" (p. 28).

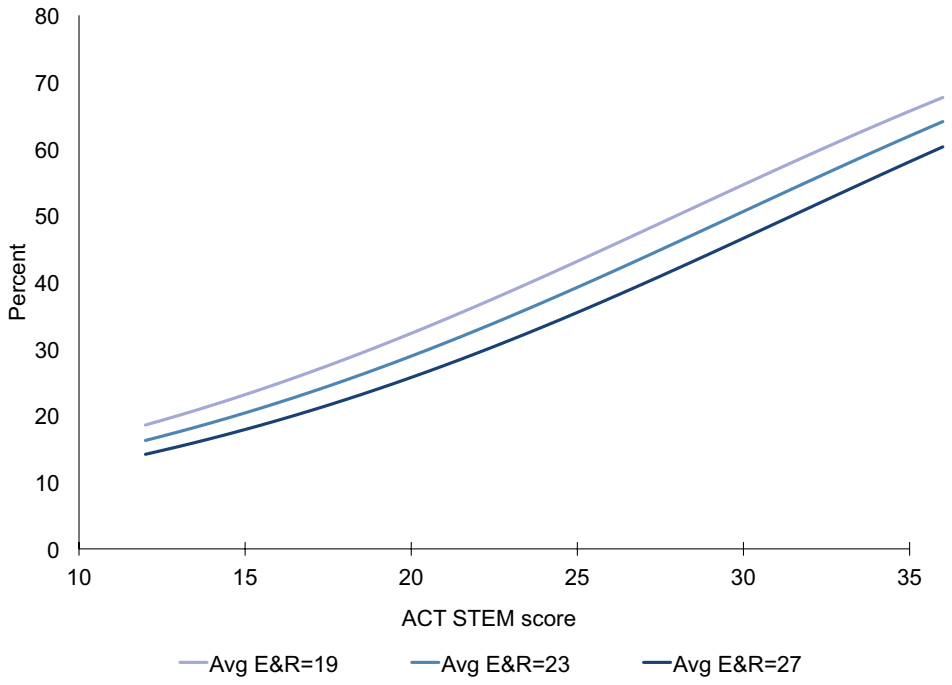

Figure 1. STEM major choice by ACT STEM score and average ACT English & reading score

Major intentions and level of sureness of those intentions also played a role in identifying which students are more likely to declare a STEM major. According to the multiple-predictor model, among students who intended to major in STEM, the odds of declaring a STEM major for those who were very sure and fairly sure about their major intentions were 2.25 and 1.51 times that of those who were not sure, respectively (Table A3). Conversely, among students who had non-STEM major intentions, the odds of declaring a STEM major for those who were very sure and fairly sure about their major intentions were 0.61 and 0.77 times that of those who were not sure, respectively. Figure 2 provides an illustration of the joint contribution of major intentions and the certainty of those intentions on STEM major choice, holding all other variables constant at their sample means. For the example shown, students' chances of declaring a STEM major increased from 51% to 70% as the level of sureness of one's STEM major intentions increased from not sure to very sure. The corresponding rates among students with non-STEM intentions decreased from 21% for those not sure to 14% for those very sure about their major intentions.

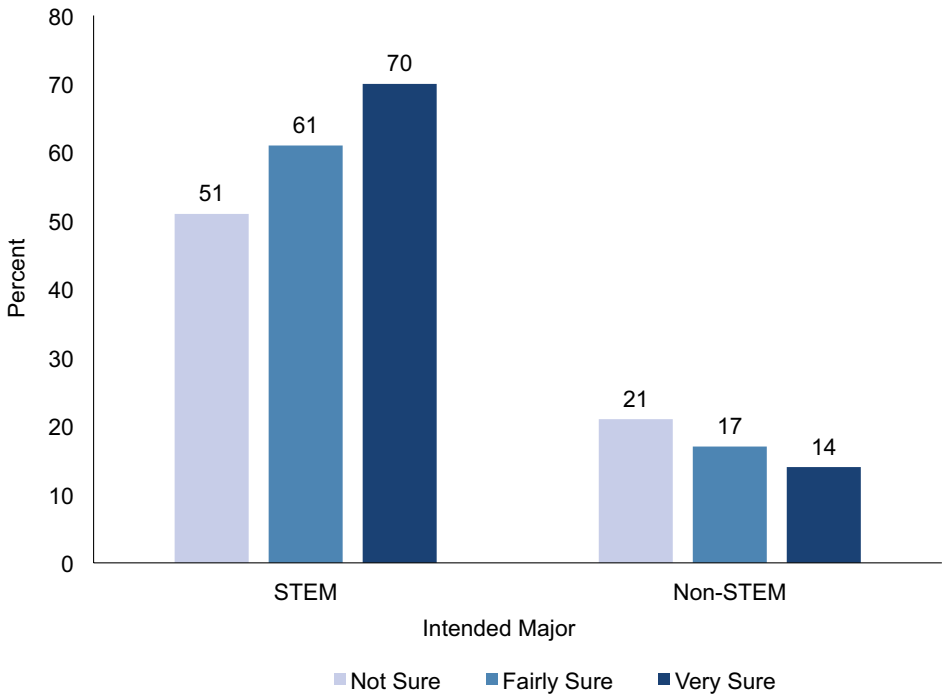

Figure 2. STEM major choice by intended major and major sureness

Having measured interest in STEM was also positively related to STEM major choice. However, according to the significant interaction term, the effect of having measured interest on STEM major choice depended on a student's intended major. Specifically, holding all other variables in the model constant, the effects of having measured STEM interest on STEM major choice were larger for those with non-STEM major intentions (adj-OR = 2.76; Table A3) and undecided students (adj-OR = 2.57) than for those with STEM major intentions (adj-OR = 1.53).[15] Figure 3 provides students' chances of declaring a STEM major in relation to intended major and measured interests for students who were very sure about their major intentions, controlling for all other variables in the model at their sample means. For this example, students who had neither measured nor expressed interest in STEM were not likely to declare a STEM major (11%). In comparison to this latter group, students with both expressed and measured interest in STEM were more likely to declare a STEM major (adj-OR=26.98; 76%) as were students who had only measured interest (adj-OR=2.76; 25%) or only expressed interest in STEM (adj-OR=17.62; 68%).[16] Interestingly, of students who were undecided about their college major, nearly one-half with measured interest in STEM went on to declare a STEM major.

[15] Based on the negative interaction term between these two predictors, results from the model suggested that the effects of intended major and measured interests in combination on STEM major choice were less than the sum of the two individual effects.

[16] For students who were fairly sure about their major intentions, the adjusted odds of declaring a STEM major for students with expressed and measured interest in STEM was 14.25 times that of students with neither expressed nor measured interest in STEM. The corresponding adjusted ORs were 9.31 and 2.76 for students with expressed interest only and for students with measured interest only, respectively. The corresponding adjusted ORs were 7.29, 4.76, and 2.76, respectively, for students who were not sure about their major intentions. See Table A3 for adjusted ORs for students who were undecided about their major intentions compared to those who intended to major in a non-STEM related field and had no measured interest in STEM.

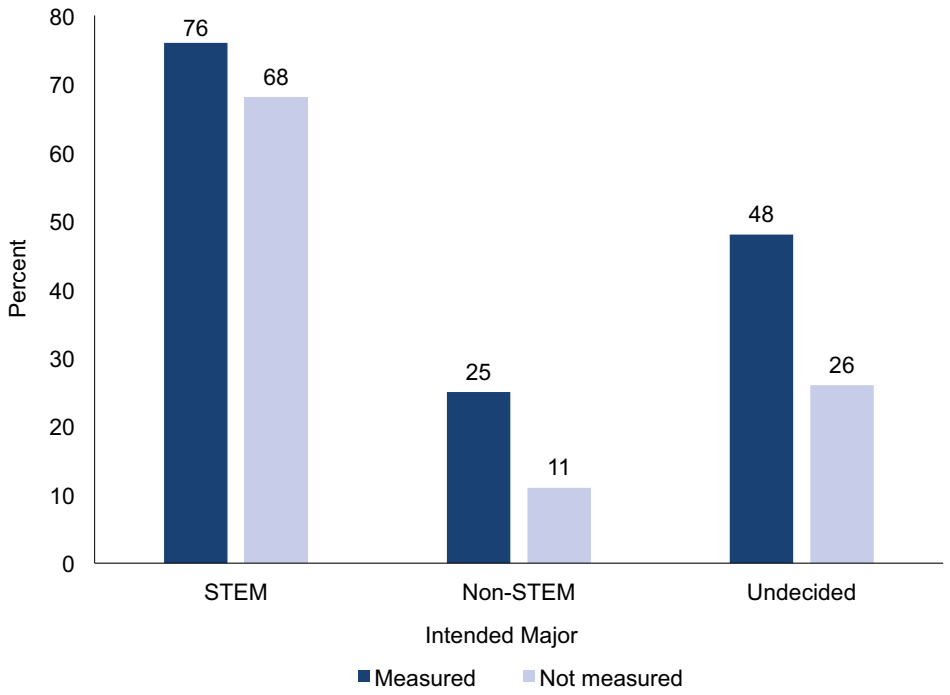

Figure 3. STEM major choice by intended major and STEM interest for students who are very sure about their major intentions

To answer the second study objective, we found that the relationship between STEM major choice and achievement levels in mathematics and science did indeed depend on students' major intentions, but this was not the case for measured interests (p=.03), after controlling for other student characteristics (parameter estimates from these models not shown).[17] Specifically, the relationship between ACT STEM score and declaring a STEM major was strongest (steeper slope) among students with STEM major intentions, and weakest for students with non-STEM major intentions (adjusted estimated slopes were 0.12, 0.09, and 0.05 for those with STEM major intentions, undecided, and non-STEM major intentions, respectively). Figure 4 illustrates these relationships after statistically controlling for the other predictors at their sample means. As illustrated in this example, students with STEM major intentions and higher STEM scores were very likely to declare a STEM major during their first term in college. In comparison, regardless of their mathematics and science ability, students with non-STEM intentions were unlikely to declare a STEM major. Figure 4 also illustrates that the differences in STEM major rates by major intentions were generally larger among higher-scoring students.

[17] The two terms from the three-way interaction that included ACT STEM score, intended major, and measured interests were not statistically significant at the .01 significance level (p values were 0.92 and 0.82, respectively).

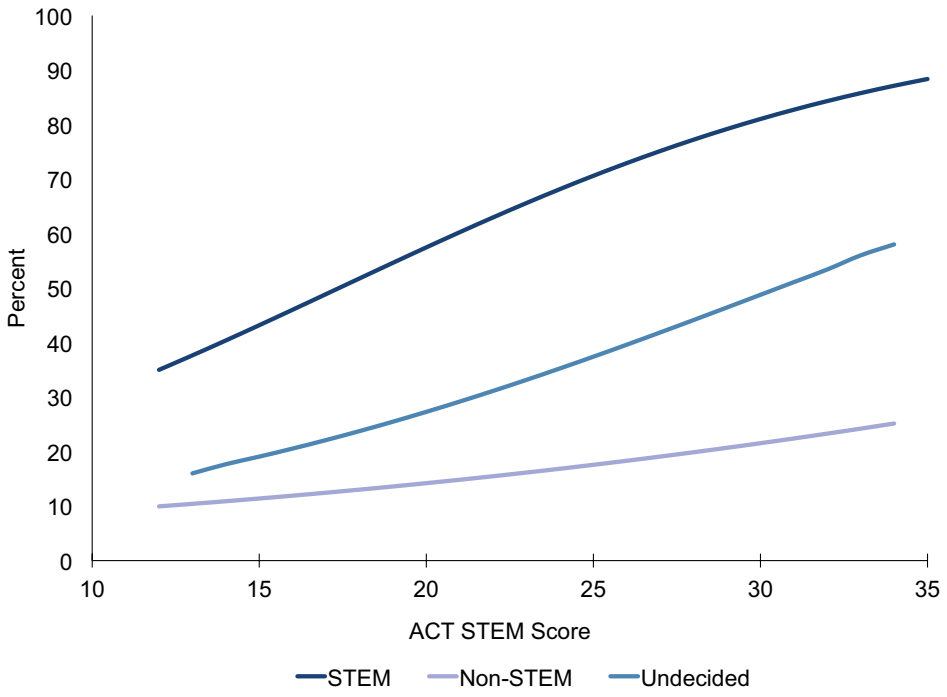

Figure 4. STEM major choice by ACT STEM score and intended major

STEM Cluster Results

Descriptive Statistics. Of the 39% of students included in the sample that were classified as a STEM major, the breakdown by STEM cluster was: 16% Science, 4% Computer Science & Mathematics, 11% Engineering & Technology, and 8% Medical & Health. As illustrated in Table 2, the percentage of students declaring a major in a specific STEM cluster varied across student characteristics. For example, students who were better prepared academically in mathematics and science as measured by higher ACT STEM scores and taking higher-level subject-related coursework in high school were more likely than those who were less prepared to declare one of the following STEM clusters: Engineering & Technology, Science, and to a lesser extent Computer Science & Mathematics.[18] This finding was not seen for the Medical & Health cluster. Another example is that females were less likely than males to declare a major in Engineering & Technologies and Computer Science & Mathematics, but they were more likely to declare a major in the Medical & Health cluster. Refer to Table 2 for more information on the observed STEM major cluster rates by student characteristics.

[18] In general, there was a relatively low percentage of students declaring majors in Computer Science & Mathematics.

Table 2. Percentage Declaring STEM Major Clusters and Non-STEM Major by Student Characteristics

Characteristic	Category	Sci	CS & Math	Eng & Tech	Med & Hlth	Non-STEM
ACT STEM score	22 or lower	13	4	4	11	68
	23 to 25	17	4	11	7	60
	26 or higher	20	6	24	4	46
Avg ACT English & reading score	19 or lower	13	5	7	11	65
	20 to 26	16	4	10	9	61
	27 or higher	19	5	16	5	56
HSGPA	3.29 or lower	11	5	6	10	68
	3.30 to 3.74	15	4	10	8	62
	3.75 or higher	20	4	15	7	53
Took Calculus	Yes	21	6	21	5	46
	No	15	4	8	9	65
Took advanced, accelerated, honors math course	Yes	18	5	14	7	56
	No	12	4	5	10	68
Took Physics	Yes	18	5	17	6	55
	No	15	4	7	10	65
Took advanced, accelerated, honors science course	Yes	19	4	13	7	56
	No	12	5	7	9	67
Intended major	STEM	28	7	20	13	33
	Non-STEM	6	2	2	4	86
	Undecided	12	4	9	6	68
Intended major / Major sureness	STEM / Very sure	32	7	17	17	28
	STEM / Fairly sure	25	7	22	11	35
	STEM / Not sure	21	6	20	8	45
	Non-STEM / Very sure	5	2	1	3	88
	Non-STEM / Fairly sure	6	2	3	4	85
	Non-STEM / Not sure	7	3	4	5	81
Measured interest in STEM	Yes	31	4	15	11	39
	No	10	4	9	7	70
Indicated needing help with math skills	Yes	14	3	6	10	67
	No	17	5	15	7	54
Educational plans	Beyond a bachelor's degree	21	4	12	7	56
	Bachelor's degree or below	8	5	9	9	68
Gender	Female	17	2	4	12	65
	Male	15	7	20	3	55
Race/ethnicity	Minority	16	5	9	8	62
	White/Asian	17	4	12	6	60
	Other	16	4	11	8	61
Annual family income	< $36,000	15	5	8	10	63
	$36,000 to $80,000	17	4	10	8	60
	> $80,000	16	4	14	6	60

Note. The percentages across the STEM major clusters and non-STEM majors may not sum to 100 percent due to rounding.

Model Based Results. Results from the multiple-predictor multinomial regression model for STEM major cluster choice (vs. non-STEM) suggested that having higher ACT STEM scores, intending to major in a STEM-related field, being more certain about one's major intentions, and having measured interest in STEM were generally positively related to declaring a major within each of the specific STEM clusters (see Table A4 in the Appendix for parameter estimates and Tables A2 and A3 for adjusted ORs). Moreover, similar to the overall STEM major choice results, the relationship between having measured interest in STEM and STEM cluster choice depended on a student's intended major (as evidenced by the significant interaction terms between intended major and measured interests for each cluster; Table A4). It is important to note that (1) there were a few exceptions to these findings and (2) the strength of the associations with these predictors generally varied across the STEM clusters. As illustrated in Figure 5, the first exception was that the ACT STEM score was not significantly related to declaring a major within the Medical & Health cluster, as evidenced by the flat line for that cluster. Among the other three STEM clusters, the steepest slope for ACT STEM score was associated with declaring a majoring within the Engineering & Technology cluster (Table A4).

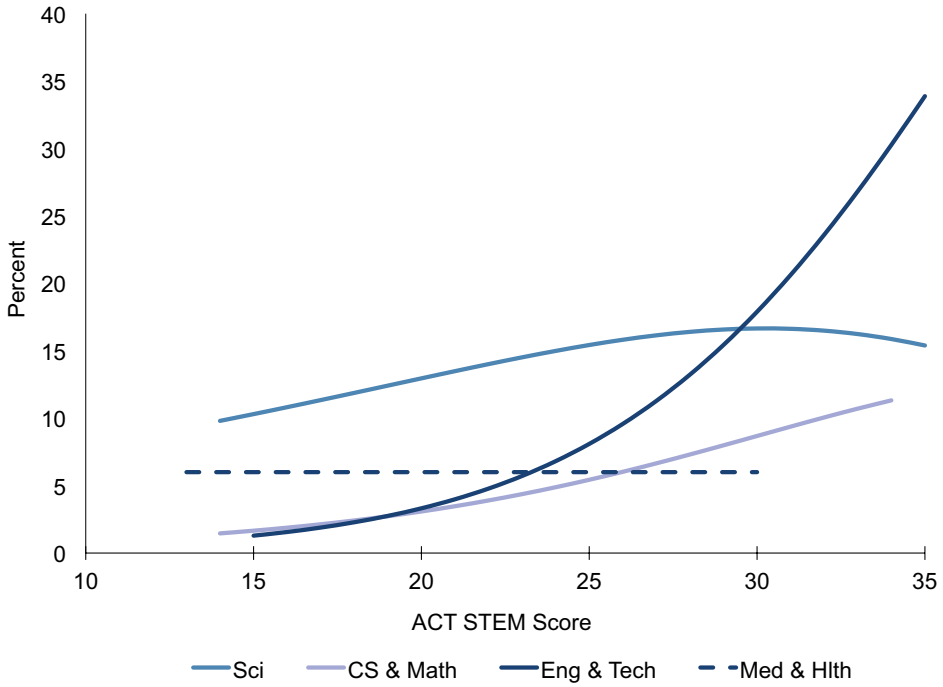

Figure 5. STEM major cluster choice by ACT STEM score

The second exception was related to the associations between having measured interest in STEM and declaring a major within specific STEM clusters. Having measured interest in STEM contributed positively to declaring a major in the Computer Science & Mathematics cluster only among undecided students (adj-OR=1.74; Table A3), but from a practical perspective this difference was relatively small (4% with measured interest vs. 3% without measured interest, holding all other variables constant at their sample means).[19] Moreover, there was not a difference in students' chances of declaring a major within the

[19] In general, a relatively small percentage of students declared a major in the Computer Science & Mathematics cluster.

Engineering & Technology cluster between those with and without measured interest in STEM among those who indicated that they intended to major in a STEM-related field (adj-OR=1.02; Table A3). However, in comparison, among those intending to major in a non-STEM related field as well as undecided students, there was a difference between those with and without measured interest (adj-OR=1.86 for those with non-STEM intentions and adj-OR=1.99 among undecided students).

As summarized in Table 3, the significance and directionality of the other predictors included in the model differed across the four STEM major clusters (see also Table A4 for actual parameter estimates). For some of these predictors, the relationship with STEM cluster choice was statistically significant for only one of the clusters or in the same direction for a subset of the clusters. This finding was seen for the following student characteristics: race/ethnicity, annual family income, took Calculus in high school, took advanced math courses in high school, HSGPA, average ACT English and reading score, and indicated needing help with improving math skills. As an example, students who took Calculus in high school were more likely than those who did not to declare a major within three out of the four STEM clusters (as compared to declaring a non-STEM major; adj-OR = 1.48, 1.43, and 1.22 for Engineering & Technology, Computer Science & Mathematics, and Science, respectively; Table A2); the exception was the Medical & Health cluster (adj-OR=0.96).

For the remaining predictors, the associations with STEM cluster choice were in the opposite direction for some of the clusters. This finding was seen for the following student characteristics: gender, took Physics in high school, and educational plans. As an example, females were less likely than males to declare a major in the Computer Science & Mathematics (adj-OR = 0.37) and Engineering & Technology (adj-OR=0.25) clusters as compared to declaring a non-STEM major, but they were more likely than males to declare a major in the Medical & Health cluster (adj-OR=3.71). Interestingly, students' educational plans was positively related to declaring a major in the Science cluster (adj-OR=1.86), but negatively related to declaring a major in the Computer Science & Mathematics (adj-OR=0.61) and Engineering & Technology clusters (adj-OR=0.81).

Table 3. Summary of Directionality for Some Predictors of STEM Cluster Choice versus Declaring a Non-STEM Major

Characteristic	Sci	CS & Math	Eng & Tech	Med & Hlth
Demographic characteristics				
Female (vs. male)		–	–	+
Minority (vs. White/Asian)		+	+	
High family income (vs. low)		–		
HS academic preparation/achievement in mathematics and science				
Took Calculus	+	+	+	
Took Physics			+	–
Took advanced math courses			+	
Other academic preparation measures				
HSGPA	+			
Avg ACT English & reading score		–	–	–
Needed help with math skills		–	–	
Educational plans				
Beyond bachelor's degree	+	–	–	

+ indicates that the student characteristic is positively related to declaring a major in the specific STEM cluster, or that students with the characteristic are more likely to declare a major in the specific STEM cluster at the .01 significance level.

– indicates that the student characteristic is negatively related to declaring a major in the specific STEM cluster, or that students with the characteristic are less likely to declare a major in the specific STEM cluster at the .01 significance level.

Blank indicates that the student characteristic is not significantly related to declaring a major in the specific STEM cluster at the .01 significance level.

Discussion

The results of the current study underscore the fact that students who are better prepared academically in mathematics and science, who intend to major in a STEM-related field, particularly those who are more certain about those intentions, and who have measured interest in STEM are generally more likely to declare a STEM major in their first year. The relationship between having measured interest in STEM and STEM major choice did however depend on the student's intended major. Specifically, the adjusted ORs for declaring a STEM major associated with having measured interests were greater among undecided students and those intending to major in a non-STEM related field than among those intending to major in STEM.

The current study also found that math and science achievement levels as measured by ACT STEM scores interacted with major intentions (expressed interest in STEM) but not measured interests to predict STEM major choice. The significant interaction between ACT STEM scores and major intentions suggested that differences by major intentions were larger among higher scoring students than among lower scoring students (Figure 4). In comparison, a study by Le et al. (2014) found that academic ability as measured by ACT Composite score moderated the relationship between interest-major fit and STEM major choice for both STEM Science vs. non-STEM and STEM Quantitative vs. non-STEM. Similar to the current study, larger effects of interest-major fit on STEM major choice were found in the 2014 study for students with higher ACT Composite scores than for those with lower scores.

Many students who are academically capable of succeeding in STEM are also academically capable of succeeding in non-STEM majors. Given such a wide selection of majors, they may choose an alternate career plan, presumably due to lack of interest in STEM or interest in other areas. However, it may be the case that these students are unaware of their readiness to succeed in STEM or of the abundance and variety of STEM pathways available that may align with their interest. Increasing STEM awareness among these students may be one potential solution for increasing the number of students who declare a STEM major in college.

Results for predicting STEM major cluster choice suggest that among the variables examined, mathematics and science achievement, major intentions, and measured interests are generally positively related for each cluster. However, differences exist in some of the other relevant predictors and in the direction of the relationships across the four STEM clusters. Some examples include gender, students' educational plans, and high school mathematics and science coursework. For example, having higher degree aspirations beyond a bachelor's degree was negatively related to declaring a major in the Computer Science & Mathematics and Engineering & Technology clusters as compared to declaring a non-STEM major. This may be attributable to the fact that many of these STEM-related majors lead to relatively high-paying jobs requiring only a bachelor's degree (Pascarella & Terenzini, 2005; U.S. Bureau of Labor Statistics, 2014).

In the models for STEM cluster choice, having STEM major intentions was evaluated in aggregate as a predictor instead of differentiating among the four STEM clusters. In supplemental analyses, the relationships between cluster-specific intentions and STEM cluster choice were examined to determine if students intending to major in a specific cluster were more likely to declare a major within that cluster during their first fall term of enrollment, after statistically controlling for all other student characteristics included in the model. The findings from these analyses suggest that specific major cluster intentions are generally informative for predicting specific STEM cluster choice, especially among those who are very sure about their major intentions. The results, however, did depend on students' level of sureness about their major intentions and whether the student had measured interest in STEM. This finding warrants further research on this topic.

The findings from the current study align with previous research on STEM success (Mattern et al., 2015; Radunzel et al., 2016). Specifically, data from these earlier studies indicate that STEM majors better prepared in math and science are more likely than those less prepared to persist in a STEM major through year four, earn a cumulative GPA of 3.0 or higher over time, and complete a degree in a STEM field. Moreover, students' interests in STEM (i.e., having measured and expressed interest) contribute incrementally to STEM success beyond academic readiness.

The findings from the current study may be useful to postsecondary institutions in their recruitment efforts, particularly if they are actively targeting potential STEM majors or have enrollment goals to increase the number of STEM majors on their campus. The variables identified in this study that are most related to STEM enrollment could be used by institutions in their search criteria in such services as ACT EOS (Educational Opportunity Service) and College Board Student Search, which can be used to target specific subpopulations of prospective students. Institutions can also use this information for enrollment planning to project resource needs such as lab space and course offerings based on the number of students anticipated to declare a STEM major in the first year.

The study results can also be used to help inform educational and career guidance strategies aimed at fostering STEM exploration, interests, and readiness. Counselors, teachers, and parents should encourage students to explore personally-relevant career options including those in STEM-related areas that are based on students' own skills and interests. Educators and counselors can help students to prepare academically for STEM-related coursework by (1) monitoring student progress to STEM readiness early and often, and intervening with students who do not seem to be on track, especially among those interested in pursuing STEM-related majors and careers and (2) ensuring students have access to rigorous higher-level mathematics and science coursework in high school, including exposure to Calculus-related concepts. Monitoring STEM readiness can be used to help align students' expectations with future course demands in STEM-related areas. To strengthen the STEM pipeline from K–12 to postsecondary, high schools may want to collaborate with local postsecondary institutions by offering STEM-related programs and activities to increase awareness and participation in STEM.

As for future research, the negative relationship between the average ACT English and reading score and STEM major choice should be explored as a potential reason why females tend to be underrepresented in the more math-intensive STEM majors, such as Engineering & Technology. In particular, research has suggested that many females who are academically ready to enter a STEM field also have high – or higher – English Language Arts (ELA) scores and therefore, have other career path options (Davison, Jew, & Davenport, 2014). On the other hand, males who have high academic STEM skills typically have lower ELA scores and thus fewer non-STEM options. Future research should explore this hypothesis and the impact it may have on gender differences in STEM major choice.

Another line of research would be to examine the major choices of students who intended to major in STEM but ended up declaring a non-STEM major. Specifically, future research should explore whether there are particular majors or major areas that intended-STEM majors are attracted to if it is not in a STEM-related field. Additionally, exploring whether these alternative career pathways differ for students who are academically underprepared for STEM as compared to students who lack interest-major fit would add to our understanding on major choice.

In sum, the current study highlights the fact that the decision to declare a STEM major is related to multiple factors including academic preparation, major intentions and the certainty of those intentions, vocational interests, educational goals, and demographic characteristics. Understanding the multidimensional and complex nature of STEM major choice can help inform interventions aimed at increasing participation in STEM.

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Appendix A—Tables A1 to A4

Table A1. Predictors of STEM Major Choice

Variable	Parameter estimate	Standard error	*p*-value
Intercept	-1.639	0.097	<.001
ACT STEM score[1]	0.092	0.008	<.001
Avg ACT English & reading score[1]	-0.040	0.006	<.001
HSGPA[1]	0.129	0.058	0.028
Took Calculus in HS	0.263	0.025	<.001
Took Physics in HS	-0.010	0.053	0.842
Took advanced HS math courses	0.025	0.026	0.329
Took advanced HS science courses	0.030	0.025	0.232
Beyond bachelor's degree goal	0.068	0.042	0.102
Intended major			
STEM (expressed interest)	1.560	0.077	<.001
Undecided	0.605	0.063	<.001
Measured interest in STEM	1.014	0.055	<.001
Intended major by Measured STEM interest interaction			
STEM / Measured interest	-0.588	0.055	<.001
Undecided / Measured interest	-0.070	0.059	0.239
Major sureness[2]			
Very sure	-0.498	0.057	<.001
Fairly sure	-0.259	0.037	<.001
Intended major by Major sureness interaction[2]			
STEM / Very sure	1.309	0.096	<.001
STEM / Fairly sure	0.671	0.051	<.001
Female	-0.131	0.091	0.149
Race/ethnicity			
Minority	0.079	0.058	0.168
Other	-0.040	0.043	0.352
Need help with improving math skills	-0.044	0.032	0.171
Annual family income			
$36,000 to $80,000	-0.020	0.033	0.549
> $80,000	-0.118	0.042	0.005

Note. HS stands for high school.

[1] Continuous variables were grand-mean centered. The means (standard deviations) were 22.4 (4.5) for ACT STEM score, 23.1 (5.4) for average ACT English & reading score, and 3.46 (0.50) for HSGPA.

[2] Major sureness was examined for students with an intended major only; it was not evaluated for undecided students. An additional indicator for whether the student had an intended major (coded as 1) compared to undecided students (coded as 0) was multiplied by the major sureness main effect and the intended major by major sureness interaction terms to ensure the inclusion of the undecided students in the STEM major choice models.

Table A2. Adjusted Odds Ratios of STEM Major Choice Overall and for Each Cluster (vs. Non-STEM) based on Academic Achievement, High School Courses Taken, Educational Goals, and Demographic Characteristics

Student Characteristic	Overall STEM	STEM Major Clusters			
		Sci	CS & Math	Eng & Tech	Med & Hlth
ACT STEM score[1]	1.096*	1.061*	1.147*	1.224*	0.983
Avg ACT English & reading score[1]	0.961*	0.980	0.961*	0.934*	0.958*
HSGPA[1]	1.138	1.361*	0.860	1.319	0.983
Took Calculus in HS					
Yes	1.301*	1.219*	1.426*	1.483*	0.961
No					
Took Physics in HS					
Yes	0.990	0.933	0.990	1.465*	0.717*
No					
Took advanced HS math courses					
Yes	1.025	0.991	1.111	1.313*	0.957
No					
Took advanced HS science courses					
Yes	1.030	1.120	0.880	0.998	1.015
No					
Educational goal					
Beyond bachelor's degree	1.070	1.857*	0.614*	0.811*	0.833
Bachelor's degree or below					
Gender					
Female	0.877	1.116	0.368*	0.252*	3.706*
Male					
Race/ethnicity					
Minority	1.082	1.129	1.556*	1.406*	0.668
Other	0.961	0.998	1.090	1.106	0.672*
White/Asian					
Need help with improving math skills					
Yes	0.957	1.012	0.796*	0.753*	1.107
No					
Annual family income					
< $36,000					
$36,000 to $80,000	0.980	1.031	0.812*	1.044	0.993
> $80,000	0.889*	0.917	0.652*	1.057	0.866

Note. Italics indicate the referent group. The adjusted OR is the exponential of the corresponding regression coefficient presented in Table A1 for overall STEM and in Table A4 for each STEM major cluster. HS stands for high school.

[1] Continuous variables were grand-mean centered. The means (standard deviations) were 22.4 (4.5) for ACT STEM score, 23.1 (5.4) for average ACT English & reading score, and 3.46 (0.50) for HSGPA.

* $p < .01$ indicates that the adjusted OR is significantly different from 1.0 at the .01 significance level.

Table A3. Adjusted Odds Ratios of STEM Major Choice Overall and for Each Cluster (vs. Non-STEM) based on Intended Major, Measured Interests, and Major Sureness in Combination

Student Characteristic	Overall STEM	STEM Major Clusters			
		Sci	CS & Math	Eng & Tech	Med & Hlth
Measured interest by intended major holding major sureness constant					
STEM					
Measured	1.531*	2.307*	0.766*	1.020	1.455*
No measured					
Non-STEM					
Measured	2.757*	4.059*	1.153	1.861*	2.898*
No measured					
Undecided					
Measured	2.570*	3.540*	1.735*	1.986*	2.425*
No measured					
Major sureness by intended major holding measured interest constant					
Intended STEM major					
Very sure	2.250*	2.382*	1.921*	1.833*	2.700*
Fairly sure	1.510*	1.502*	1.449*	1.493*	1.592*
Not sure					
Intended non-STEM major					
Very sure	0.608*	0.678*	0.720*	0.391*	0.544*
Fairly sure	0.772*	0.793*	0.893	0.642*	0.738*
Not sure					
Intended major and measured interest by major sureness					
Very sure about major intentions					
STEM / Measured	26.977*	35.695*	7.996*	30.908*	28.163*
STEM / No measured	17.619*	15.472*	10.433*	30.296*	19.356*
Non-STEM / Measured	2.757*	4.059*	1.153	1.861*	2.898*
Non-STEM / No measured					
Undecided / Measured	7.745*	10.392*	3.532*	9.974*	7.374*
Undecided / No measured	3.013*	2.936*	2.036*	5.023*	3.040*
Fairly sure about major intentions					
STEM / Measured	14.253*	19.240*	4.865*	15.348*	12.268*
STEM / No measured	9.309*	8.339*	6.347*	15.044*	8.432*
Non-STEM / Measured	2.757*	4.059*	1.153	1.861*	2.898*
Non-STEM / No measured					
Undecided / Measured	6.098*	8.882*	2.849*	6.080*	5.441*
Undecided / No measured	2.373*	2.509*	1.642*	3.062*	2.243*
Not sure about major intentions					
STEM / Measured	7.286*	10.155*	2.998*	6.600*	5.686*
STEM / No measured	4.759*	4.402*	3.912*	6.469*	3.908*
Non-STEM / Measured	2.757*	4.059*	1.153	1.861*	2.898*
Non-STEM / No measured					
Undecided / Measured	4.707*	7.043*	2.545*	3.904*	4.015*
Undecided / No measured	1.831*	1.990*	1.467*	1.966*	1.655*

Note. Italics indicate the referent group. The adjusted ORs are the exponential of the sum of the relevant predictors in relation to the referent group holding all other predictors in the model constant; they were estimated using the ESTIMATE statement within the GLIMMIX procedure in SAS 9.2 (see Appendix B for more details).

* $p < .01$ indicates that the adjusted OR is significantly different from 1.0 at the .01 significance level.

Table A4. Parameter Estimates from Multinomial Regression Model of STEM Major Cluster Choice (vs. Non-STEM)

	Science	CS & Math	Eng & Tech	Med & Hlth
Intercept	-3.292**	-2.594**	-3.013**	-3.711**
ACT STEM score[1]	0.059**	0.137**	0.202**	-0.017
Avg ACT English & reading score[1]	-0.020	-0.040**	-0.068**	-0.043**
HSGPA[1]	0.308**	-0.151	0.277	-0.017
Took Calculus in HS	0.198**	0.355**	0.394**	-0.040
Took Physics in HS	-0.069	-0.010	0.382**	-0.332*
Took advanced HS math courses	-0.009	0.105	0.272**	-0.044
Took advanced HS science courses	0.113	-0.128	-0.002	0.015
Beyond bachelor's degree goal	0.619**	-0.487**	-0.209**	-0.183
Intended major				
STEM (expressed interest)	1.482**	1.364**	1.867**	1.363**
Undecided	0.688**	0.383**	0.676**	0.504**
Measured interest in STEM	1.401**	0.142	0.621**	1.064**
Intended major by Measured STEM interest interaction				
STEM / Measured interest	-0.565**	-0.408*	-0.601**	-0.689**
Undecided / Measured interest	-0.137	0.409*	0.065	-0.178
Major sureness[2]				
Very sure	-0.389	-0.328	-0.938*	-0.608
Fairly sure	-0.232	-0.113	-0.443	-0.304
Intended major by Major sureness interaction[2]				
STEM / Very sure	1.257**	0.981**	1.544**	1.600**
STEM / Fairly sure	0.639**	0.484**	0.844**	0.769**
Female	0.110	-1.001**	-1.379**	1.310**
Race/ethnicity				
Minority	0.121	0.442**	0.341*	-0.403
Other	-0.002	0.086	0.101	-0.398*
Need help with improving math skills	0.012	-0.228**	-0.284**	0.102
Annual family income				
$36,000 to $80,000	0.031	-0.208**	0.043	-0.007
> $80,000	-0.087	-0.427**	0.055	-0.144

Note. HS stands for high school.

* $p < .01$; ** $p < .001$

[1] Continuous variables were grand-mean centered. The means (standard deviations) were 22.4 (4.5) for ACT STEM score, 23.1 (5.4) for average ACT English & reading score, and 3.46 (0.50) for HSGPA.

[2] Major sureness was examined for students with an intended major only; it was not evaluated for undecided students. An additional indicator for whether the student had an intended major (coded as 1) compared to undecided students (coded as 0) was multiplied by the major sureness main effect and the intended major by major sureness interaction terms to ensure the inclusion of the undecided students in the STEM major choice models.

Appendix B—Additional Details Regarding the Calculations of the Adjusted ORs

Adjusted ORs are presented in Tables A2 and A3. The adjusted OR for an individual predictor not included in any interaction term was calculated as the exponential of the corresponding logistic regression coefficient from Table A1 for overall STEM vs. non-STEM or the corresponding multinomial regression coefficient from Table A4 for each STEM major cluster compared to non-STEM. For example, the logistic regression parameter associated with taking Calculus in high school was estimated to be 0.263 in the multiple-predictor STEM major choice model. Therefore, the corresponding adjusted OR was EXP(0.263) or 1.301 (shown in Table A2). This means that the odds of declaring a STEM major for those taking Calculus in high school was estimated to be 1.301 times that of those who did not take Calculus in high school.

Given that the model included interactions (intended major by measured STEM interest and intended major by major sureness), the adjusted ORs for measured STEM interest and major sureness depended on intended major. Hence, for the three predictors included in the interactions, three different sets of adjusted ORs were examined that included: (1) measured interest by intended major, (2) major sureness by intended major, and (3) intended major and measured interest by major sureness (results presented in Table A3). For these three different sets of combinations, the adjusted ORs were calculated as the exponential of the sum of the relevant predictors in relation to the referent group holding all other predictors in the model constant. The adjusted ORs were estimated using the ESTIMATE statement within the GLIMMIX procedure in SAS 9.2.

For an example from set #1, the adjusted OR for STEM major choice associated with having measured interest in STEM (vs. no measured interest) among students who intended to major in STEM was calculated using the sum of the measured interest coefficient and the intended STEM major by measured interest interaction coefficient (adj-OR = EXP(1.014 – 0.588) = 1.531 based on the coefficients from Table A1). For an example from set #2, the adjusted OR for STEM major choice associated with being very sure about one's intended major (vs. not sure) among students who intended to major in STEM was calculated using the sum of the very sure coefficient and the intended STEM major by very sure interaction coefficient (adj-OR = EXP(–0.498 + 1.309) = 2.250 based on the coefficients from Table A1). For an example from set #3, the adjusted OR for STEM major choice associated with having STEM major intentions and measured interest (vs. having non-STEM major intentions and no measured interest) among students who were very sure about their intended major was calculated using the sum of the STEM intentions coefficient, the measured interest coefficient, the intended STEM major by measured interest interaction coefficient, and the intended STEM major by very sure interaction coefficient (adj-OR = EXP(1.560 + 1.014 – 0.588 + 1.309) = 26.977 based on the coefficients from Table A1).

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