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Why STEM? Factors that Influence Gifted Students' Choice of College Majors

Phu Vu, Dena Harshbarger, Sherry Crow, Shelby Henderson

Abstract

The purpose of this study was to examine talented/gifted students' choices of college majors and what factors most likely affected their decision. By utilizing a data collecting technique called Knowledge Discovery in Databases (KDD) or data mining, we identified and collected data pertaining to 109 talented/gifted students with perfect SAT and/or ACT scores in Nebraska, USA between 2011 and 2016. The results showed that STEM majors were the most common choice of gifted students when they entered colleges (71%). It appears that only gender had a significant difference in terms of STEM major choices. These findings may be helpful to higher education institutions in their recruitment efforts, especially if they are targeting students with interest in potential STEM majors. In addition, when supporting students on their path to major selection, it is important to ask them about what factors are influencing them to select a certain area.

Keywords: Gifted students, Talented students, STEM major, College major.

Introduction

When thinking of successful students in this country, one automatically thinks that gifted or talented students would be among the most successful of all students in pursuing a college degree. It is also a forgone conclusion that those students who are pursuing careers in STEM fields would be the most focused and driven of these talented students; and therefore, be most capable of completing academic degrees. However, is this perception based on assumptions of STEM gifted students' success in K-12 schools, or on empirical evidence? Research shows that several external variables may factor into whether or not gifted students will actually complete their STEM degrees (Soria & Stebleton, 2013).

Consider the following high school senior student scenarios. They have two things in common. First, all are talented learners who have earned a perfect ACT or SAT score. Second, all are planning to attend college and pursue a STEM degree for their undergraduate program. Which of these gifted students are most likely to complete their STEM degree?

Max is a confident and highly-capable student. He comes from a family that is considered to have a low Socioeconomic Status (SES). Neither of his parents attended college but both model a strong work ethic. Max is accustomed to working hard inside and outside of the classroom. He currently works a part-time job at a local restaurant. Max has three very close friends who also plan to pursue a STEM field. These three friends will be attending the same college as Max in the fall.

Simone is an African American student who has been interested in STEM since she was in elementary school. At a young age, she would go to the library to check out books about various science topics and read them just for fun. When she was in 7th grade, she signed up for an after-school STEM club that met once a week. Simone became so excited about STEM, that she enrolled in every advanced level science and math class offered at her high school. She is eager to begin college.

Similarly, Li Wei consistently excelled in his advanced-level STEM related-courses throughout middle and high school. His extended family moved to the United States from China when he was five years old. Throughout his schooling, he has always been encouraged to put in the time and effort needed to be successful whenever he encounters a challenge. As a high school senior, Li Wei wants to pursue a high-paying medical position so he can support his family and contribute to the community.

Which of these students are more likely to complete their STEM degree? Which are more likely to change their degree? What variables are most influential in their decision and why?

Literature Review

Student Choice of College Majors

There have been many studies examining factors that impact the choice of a student's college major. Motivation is a key factor in selection of this choice. Some of these motivations might be extrinsic, such as pressure from advisors to choose a major on future income, while others can be intrinsic, such as interest in the subject and an internal satisfaction when working in a particular area (Deci & Ryan, 1985). Studies have shown that when looking between extrinsic and intrinsic motivational factors, intrinsic ones lead to more satisfaction and students are less likely to change their majors in the end (Soria & Stebleton, 2013). When students select majors that they are interested in and feel a connection to, they have the motivation to continue working for their degree, even when it might become challenging for them. One key internal motivation is having self-efficacy, which is the belief in one's ability to succeed (Porter & Umbach, 2006). Students who have self-efficacy have the drive and belief that they can succeed in anything they wish to accomplish, leading them to choose their major based on their interests, rather than on subjects that might be easiest for them. Factors that can harm a student's self-efficacy and their ability to select the appropriate major for them include: discrimination, lack of adequate education at a young age, gender biases, socioeconomic status, and past failures in a particular subject. Consequently, building up a student's self-efficacy can be extremely important in helping guide the selection of a college major.

Most students entering college will end up changing their major at least once throughout their undergraduate career. Studies have found that the most common reason that students change their major is because they develop an interest in another subject (Malgwi, Howe, & Burnaby, 2005). The change in interest from the original major to the new major often comes about because students enroll in a class separate from their major, and while taking this class realize that they have a stronger interest in that subject. Interest for this new subject may be fostered by the material presented in the class, and/or by the professor's teaching style. When professors are able to successfully engage students and make their lessons connect to real life, it is more likely that students will gain interest in the subject, even to the extent of changing majors.

People's cultural backgrounds can affect the way they approach choosing their major and the major itself. It has been found that Chinese, Filipino and Southeast Asian women are more likely to choose college majors that lead to lucrative employment than are white women (Song & Glick, 2004). This may be due to the fact that in Eastern cultures, children are expected to go to college to gain an education and career that will best support their families and communities. There is much less emphasis on the self and more on their community at large. Asian American students are highly influenced by their families' values when they select a major (Song & Glick, 2004). It has also been found that Filipino and Southeast Asian women are more likely to select majors in business and health-related areas due to the higher salary that these majors are likely to bring about. For these students, salary is important in order to bring honor and wealth to their family.

Relating to the importance of family, studies have looked into the influence of parental occupation and socioeconomic status on a student's choice of major. According to Leppel, Williams, and Waldauer (2001) male students coming from high socioeconomic homes were more likely to major in sciences, while females with the same socioeconomic standing were more likely to explore different majors. This is believed to be due to the fact that these female students did not feel like they needed to worry about their future salary. They were also more likely to end up in less traditional majors for women. Connecting to this idea, this study also found that women who have fathers in higher-paying occupations are more likely to choose male-dominant careers and majors. In general, students who have fathers in higher level occupations are more likely to major in engineering and the sciences due to paternal influence and motivation. When looking at the influence between mothers and fathers, it was found that a father's occupation influenced female students' choice of major more, while mother's occupation influenced male students' choice more.

When examining past findings, there are several factors that become evident. Overall, the main drive that leads to the selection or changing of students' major is their interest in the subject. This can be influenced by important teachers and professors in their lives. The way the information is presented and reinforced by these influential educators can greatly influence a student to select that major. When examining the major choices of diverse students, it is important to look at their cultural background to recognize what is most likely to motivate

them to select a certain major. For Eastern cultures, the role of family provider is a huge motivator for selecting a more lucrative major, as compared to Western cultures. For all students, it is important to recognize how socioeconomic status, early education, and adequate information on various majors can influence the path that a student takes while in college.

Students Choice of College STEM Majors

With regard to choosing STEM majors in particular, past research has shown that a key characteristic in the student is persistence (Mau, 2016). Students who learn early on that perseverance during tough times can lead to success are more likely to pursue and keep a STEM major because they feel prepared and competent in their abilities to be successful in a difficult major. Students who start out with a STEM major and lack persistence are likely to change majors as they feel overwhelmed by the rigorous nature of these majors. If a student can develop persistence, they are likely to feel much more competent in the courses for their major. This persistence is what leads STEM students to continue their education and pursue a masters or doctorate degree to expand their career options in the STEM field.

Research also supports the belief that early intervention is an important factor influencing a student's choice in STEM majors (Harwell, 2012). Having adequate training and knowledge of STEM in grades K-12 fosters STEM involvement. An important aspect to include in early interventions is fostering higher educational goals (Lichtenberger & George, 2013). Instilling high goals can reinforce a student's self-efficacy and motivation to pursue a STEM major. Offering a wide variety of mathematical and science courses can increase the probability of sparking interest in the students. By offering many courses, schools are also projecting the message that these courses are important to success in life later on. Students will learn early that having knowledge in these subjects will benefit them for years to come. Also, by offering programs outside of school, students can engage in social activities that challenge their abilities and increase their knowledge in the STEM field (Adams, Chamberlin, Gavin, Schultz, Sheffield, & Subotnik, 2008). The use of career and technical education (CTE) courses in early childhood development can foster interest in STEM. Using these various interventions as early as possible can help increase the number of college students that select a STEM major.

Interest in STEM courses is the highest motivator for selecting a STEM major (Mitchell, 2016). This interest can be stimulated by taking mathematical and scientific courses early on in school. This indicates the necessity for schools to foster a child's interest in these subjects by making a wide variety of courses available to them and by using engaging and creative activities to present the information (Chen, 2013). Sparking a student's interest increases the probability of them entering a STEM career in the future. Colleges that include STEM courses in their requirements increase the likelihood that more students will gain interest in the field. Students enrolled in more STEM courses were more likely to have interest in the field as it allowed them to gain more knowledge on the key aspects of STEM careers (Mitchell, 2016). Additionally, having peers and using peer mentors in a STEM major can help to increase a student's interest in STEM (Soria & Stebleton, 2013). Using interventions like peer mentors and creative presentation of information are easy ways to foster interest in STEM majors.

Lastly, parental knowledge of the STEM field increases the likelihood of a student having a STEM major (Harwell & Houston, 2012). Research continuously finds that students who have at least one parent in the STEM field has a higher likelihood of pursuing a STEM major. This is due to the fact that students become aware at a young age what STEM is, are encouraged to take courses related to STEM, understand they have the abilities to succeed, and learn about the future career options and high pay they could receive with a STEM major. For students without parents in the STEM field, it is imperative that their parents' knowledge of STEM programs be increased and that schools work to increase parental knowledge of STEM courses offered to students. Parental knowledge and support can allow students to feel like they have the options and the necessary abilities to pursue STEM majors. Parents who talk to their children about the need for STEM majors in our society and the high salary potential for STEM careers, increase the likelihood that their children will enter into the field (Harwell, 2012). Increasing parental knowledge in the STEM field should be a key aspect of recruiting students into STEM majors.

Gifted/Talented Students choice of college STEM Majors

Recent research has focused on how to foster and facilitate gifted students choice in a STEM major. Many studies have concurred that in order to foster this interest in the STEM field, it is imperative to create out-of-

school programs in middle and high school to develop interest and knowledge in the STEM field (Adams, Chamberlin, Gavin, Schultz, Sheffield, & Subotnik, 2008). The use of these programs can increase a student's self-efficacy related to their ability in the STEM subjects early on as they develop more knowledge and understanding of these subjects. This self-efficacy is related to the ability to maintain motivation for pursuing STEM majors and careers in a student's future. The use of out-of-school programs allows all students' from diverse backgrounds to gain knowledge in what STEM is. These programs should emphasize science and mathematical skills and allow for hands-on experiences. It is believed that this hands-on experience that students gain from various programs allows the students to get the best sense of what a STEM career would be like and allows them to develop the necessary skills early on. Gifted students are more likely to pursue and stick with a STEM major if they have experiences in how their interests and knowledge can be facilitated in a STEM career. In the past, there have been few out-of-school programs related to the STEM field, however, increasing efforts have been made to make these opportunities available to all students who are interested, purportedly in an attempt to close the gap between the needed workers in the STEM field and those who actually pursue this career.

Studies that focus on Black students' motivation for pursuing a STEM major have shown that it is important that these students develop the abilities to solve problems, advance humanity, be challenged, and be actively involved in leadership (Coleman, 2014). These abilities lead Black students to feel competent in STEM fields, and this competency motivated them to continue on with STEM even when it was challenging. Although there have been efforts to improve the enrollment of Black students in gifted education programs, there has been little effort toward retaining these gifted students in these programs (Singh, Granville, & Diak, 2002). This suggests that more effort needs to be made to make sure that gifted Black students are motivated and given the resources necessary to remain in gifted educational programs, as these programs have an effect on the probability that these students will remain in the STEM field. Some of these resources should include positive school environment, belief in self, and social support, as these all increase motivation. This social support must include parental support, as it is the most important kind of support to Black students (Coleman, 2014). It should also include community support because Black students who believe they are helping out their community were more likely to persist within the STEM field even in challenging times (Coleman, 2014). When Black gifted students were supported by positive mentors, educators, and administrators within the school setting, they felt linked to their school community and remained in the gifted programs.

One of the most common indicators for success in the STEM field at an early age is performance on the SAT, especially in the mathematical category (Price, 2010). It is imperative that the SAT is administered early within a child's academic career, even before high school, so as to indicate high abilities. It is possible to use the SAT to indicate which students would be good candidates for gifted educational programs. This will allow teachers to shape a student's strengths and abilities early on. For those who perform especially well in the mathematical category, it is advised to place them in educational programs that stimulate interest in the STEM field. Having these gifted student programs and courses can increase the number of students that can succeed within STEM courses (Price, 2010). By allowing for administration of the SAT in middle school, it is more likely that students can be appropriately selected for the gifted courses that lead to success in the STEM field. It can also increase the diversity of students in the programs, as some students might be shy in the classroom and be overlooked by teachers for these programs. However, their performance on the SAT can cue teachers in on the necessity to have various students in gifted courses.

Other key factors that motivate gifted students to pursue a STEM major include learning how to balance all their tasks and adequate exposure to science and math courses (Heilbronner, 2011). An important ability that leads to success in STEM majors is learning how to balance and prioritize school and life tasks. Taking time to enjoy significant people in students' lives is also important, as it keeps them connected to their outside environment and gives them a positive outlet when they are lacking motivation to continue on in their STEM major.

In summary, there are many factors that may affect the choice of STEM majors of students in general and, in particular, gifted students. These factors include: intrinsic and extrinsic motivation (Soria & Stebleton, 2013), after-school programs (Adams, Chamberlin, Gavin, Schultz, Sheffield, & Subotnik, 2008), self-efficacy (Porter & Umbach, 2006), gender (Keck, 2016), interest in STEM (Mitchell, 2016), family background (Leppel, Williams, & Waldauer, 2001), persistence as a characteristic (Mau, 2016), and race or ethnicity (Coleman, 2014). Within the scope of this study and the types of collected data via the Knowledge Discovery in Databases (KDD) or data mining technique, four factors, include: race/ethnicity, gender, school type (public/private), and living location (urban, rural and suburban). These factors were included to examine whether they had any impact on STEM major choices of gifted students with perfect ACT/SAT scores. While the first two factors,

race/ethnicity and gender, have been investigated in many studies, the last two factors, school type (public/private), and living condition (urban, rural and suburban), have rarely been explored in previous studies.

Method

We utilized a data collecting technique called Knowledge Discovery in Databases (KDD) or data mining to collect data for this research project. As described by Baker (2010), data mining is a research technique of discovering new and potentially useful information from large amounts of existing data available and accessible to the public. In the realm of educational research, an area of inquiry termed educational data mining (EDM) has increasingly been attracting researchers' interest in employing data mining to collect and analyze student models representing information relevant to their characteristics, using a vast amount of information about the target population.

In our project, we were interested in mining the data about gifted students with perfect SAT and/or ACT scores in Nebraska between 2011 and 2016 to examine their choices of colleges' majors and what factors mostly likely affected their decision. Our identification of gifted or talented students was grounded on the three criteria of gifted students. The first one is a definition of gifted students by the National Association for Gifted Children (2010):

Those who demonstrate outstanding levels of aptitude (defined as an exceptional ability to reason and learn) or competence (documented performance or achievement in top 10% or rarer) in one or more domains. Domains include any structured area of activity with its own symbol system (e.g., mathematics, music, language) and/or set of sensorimotor skills (e.g., painting, dance, sports). (p. 2)

The second one is from the Nebraska Department of Education Guideline for Identification of Gifted/Talented Students (2015) which added "high-ability learners" into the category of giftedness with its description:

Learner with high ability shall mean a student who gives evidence of high performance capability in such areas of intellectual, creative, or artistic capacity or in specific academic fields and who require services or activities not ordinarily provided by the school in order to develop those capabilities fully. (p.9)

For our last resource, we gathered testing statistics from the SAT and ACT administration. According to the College Board which administered SAT test, the percentage of earning a perfect score of SAT is 0.018% (Out of the 1.7 million students who take the test every year, only about 300 get the highest possible SAT score.) Correspondingly, according to data from the American College Testing which administered ACT test, the percentage of earning a perfect score of ACT is 0.14% (Out of the 2,030,038 students who take the test, only about 2,760 get the highest possible ACT score.)

Our mining resulted in a complete list of 109 gifted students with perfect ACT and/or SAT perfect scores in Nebraska between 2011 and 2016 from five major sources comprising the website of Nebraska Department of Education, the website of Nebraska government, local newspapers, social networking/media websites, and websites and/or newsletters of schools that had gifted students with perfect SAT or ACT scores. All of those sources were available via the Internet and accessible to the public. The utilization of different data sources also helped us triangulate and validate the data in the process of data filter, category and analysis.

The focus of our research was to examine whether STEM majors were the most popular choice of gifted students and what factors affected their major choices. To answer the first research question, we employed the Classification of Instructional Program Codes developed by the Department of Education (National Center for Education Statistics, 2008) and commonly used by the National Science Foundation to categorize college majors as either STEM or non-STEM. The undergraduate major variable was then assigned a value of 1 if the gifted student selected a STEM major and a value of 0 if he or she did not for our descriptive data analysis. As previously described in the literature review, the factors that may affect the choice of STEM majors of students in general and gifted students in particular, include intrinsic and extrinsic motivation (Soria & Stebleton, 2013), after-school programs (Adams, Chamberlin, Gavin, Schultz, Sheffield, & Subotnik, 2008), self-efficacy (Porter & Umbach, 2006), gender (Keck, 2016), interest in STEM (Mitchell, 2016), family background (Leppel, Williams, & Waldauer, 2001), persistence as a characteristic (Mau, 2016), and race or ethnicity (Coleman, 2014). Within the scope of this study and the types of collected data via the Knowledge Discovery in Databases (KDD) or data mining technique, four factors, including: race/ethnicity, gender, high school type (public/private), and living location (urban, rural and suburban) were included to examine whether they had any

impact on STEM major choices of gifted students with perfect ACT/SAT scores. We ran a factor analysis in SPSS to identify which factor affected their STEM major choice.

Results

Research Question 1. What College Majors Are Gifted Students Most Likely to Pursue?

To find the answer to this research question, we employed the Classification of Instructional Program Codes developed by the Department of Education (National Center for Education Statistics, 2008) which is commonly used by the National Science Foundation. Using this program, college majors were coded or categorized as either STEM or non-STEM. For our descriptive data analysis, the undergraduate major variable was then assigned a value of 1 if the gifted student selected a STEM major and a value of 0 if he or she did not select a STEM major. The mean of undergraduate major selection by gifted students was .73 (*Median* = 1, *SD* = .44) as shown below.

Table 1. Undergraduate STEM major descriptive statistics

Mean	.73
Median	1
SD	.44
SE	.04

Overwhelmingly, STEM majors were the most common choice of gifted students when they entered colleges (77 out of 109, or 71%).

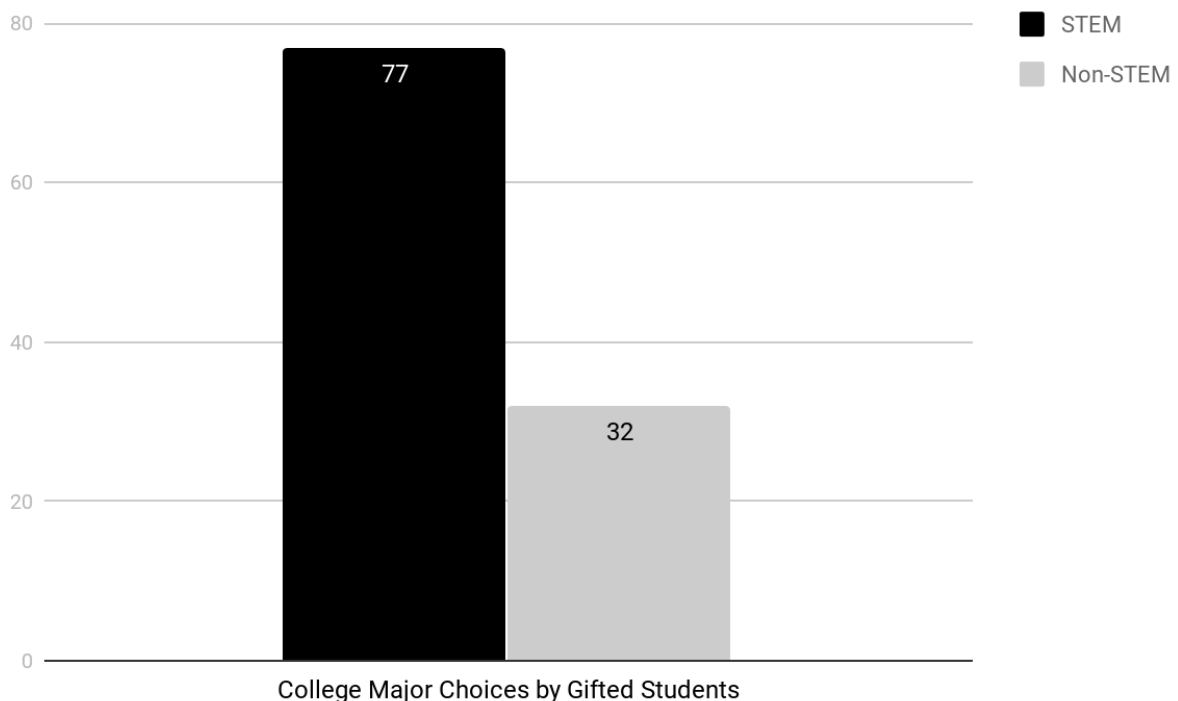


Figure 1. STEM major choices

Research Question 2. What Factors Affected Gifted Students' Choices of College Majors?

Looking at the main effects for the variables (school type, living location, gender, and race), it appears that only gender had a significant difference in terms of STEM major choices. When running a basic crosstabs, we find a significant chi-square value. The table shows that females were almost a 50/50 split, while males were about

80/20 for STEM majors versus non-STEM majors. Running a logistic regression analysis with the four aforementioned variables as our independent variables and STEM major as the dependent variable, we again see the main effect of gender as the only significant predictor of STEM major. The odds ratio of 5.124 tells us that the odds of STEM majors for males is 5.124 times that of females.

Table 2. Chi-Square tests of factors affecting gifted students' choices of college majors

Pearson Chi-Square	Value	df	Asymptotic Significance (2-sided)
School Types	1.244	1	.265
Living Locations	1.933	2	.380
Gender	11.603	1	.001
Race	.558	1	.455

Discussion and Conclusion

Our finding of research question 1 indicated that STEM majors were the top pick of gifted students when they entered college. The finding from this current study aligns with previous research on students' STEM major selection in college (Moakler & Kim, 2014; Radunzel et al., 2015; Raines, 2012; Wiswall, Stiefel, Schwartz, & Boccardo, 2014). Specifically, data from those early studies indicated that students with high academic performances in STEM-related subjects in their high schools were more likely to pursue STEM majors in colleges. However, there is also a slight difference between our study and previous studies in the fact that while previous studies examined the relationship between high school students with high academic performances in STEM-related subjects and their choice of college majors, our study focused on only students with perfect scores in either ACT or SAT, including not only STEM-related subject (Math), but also language arts (Reading and/or English). Within the scope of this study, we did not attempt to find out the reasons why high school students with perfect scores in ACT/SAT tended to pursue STEM majors in college, which leaves potential research directions for future investigation. The finding of this study is encouraging news to STEM advocates because it is a clear indication that STEM majors can attract some of the brightest high school students. Finally, this finding may be helpful to higher education institutions in their recruitment efforts, especially if they are targeting students with interest in potential STEM majors.

The finding of research question 2 suggested that among the four factors (school type, living location, gender, and race), gender was the only variable that contributed to gifted high school students' choices of college majors in STEM. The gender factor in high school students' major choice has consistently been reported in the literature (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011; Dickson, 2010; Rainey, Dancy, Mickelson, Stearns & Moller, 2018; Riegle-Crumb & King, 2010). However, unlike most of previous studies showing that along with the factor of gender, race and/or ethnicity was also a significant factor in students' decision of college majors, the finding of this current study revealed race and/or ethnicity was not an important factor in gifted high school students' choices of STEM majors. This seemed counterintuitive, but there may be a plausible explanation to this phenomenon. While previous studies included high school students from diverse race and/or ethnicity backgrounds, students in this particular study involved only 109 gifted students who achieved perfect SAT/ACT scores in Nebraska, and by chance, there were only two groups of races and/or ethnicities: White and Asian Americans. Also, early studies already indicated that White American and especially Asian American students tended to choose STEM-related majors in college. It was the small pool of students' backgrounds in this study that made race and/or ethnicity a rather insignificant contributor to gifted students' choices of STEM majors in college.

The results of this study provide insight regarding factors that may influence whether gifted students such as Max, Simone, and Li Wei (discussed in the introduction of our study) will complete their STEM degrees. When supporting students on their path to major selection, it is important to ask them about what factors are motivating them to select a certain area. Directing students to select majors based on intrinsic goals may lead to more success, happiness, and satisfaction and prevent them from changing their major. Key role models can affect the ideas and beliefs about certain majors, so it is important that professors, parents, advisors, and peers realize their influence on a student's choice of major. The findings may be used to help inform educational and career guidance strategies aimed at fostering STEM exploration, interest, and readiness among student groups from different race and/or ethnicity backgrounds, and gender.

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