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Predicting Retention of Mathematics and Science Majors

At a Research One Institution and Suggested Advising Tools

Rising Above the Gathering Storm **(2007) raised serious questions about America's future based on the waning interests in science, technology, engineering, and mathematics (STEM). This book, authored by the National Academies of Medicine, Engineering and Science, described the critical role of STEM in the global economy and the shrinking number of college graduates in these fields. The America Competes Act was signed into law by President George W. Bush in 2007 in partial response to the looming shortage of professionals in the fields of mathematics and science.**

The problem appears to be systematic, first appearing among middle and high school students, but impacting the selection of a college major and subsequent career choice and graduate school opportunities after receipt of the bachelor's degree. According to the National Science Board (1986), the US trails all but one of the nations surveyed in terms of proportion of STEM majors compared to all other majors. Initially, about 30 percent of US incoming college freshmen intend to major in these fields.

Compounding the problem is the trend that a vast majority of students are not retained in these fields and transfer to other majors. Less than 6 percent of 24-year-olds in 2000 possessed degrees in STEM disciplines. Also disturbing, most of the high-achieving students that are lost are female or from historically underrepresented populations. As demographics shift in border states and throughout the country, without serving historically underserved populations, there is no hope of avoiding the predicted future shortage of scientists (National Science Board 1986; Oakes 1990).

In this study an entering cohort of freshmen majors in mathematics and science at a land grant, research one institution was examined to first determine if a group of students who persisted in science and mathematics disciplines were different in terms of pre-college characteristics from a group of students who dropped with grade point averages (GPAs) less than 2.0 and another group of students who dropped with grade point averages equal to or above 2.0. In particular, rank in high school graduating class, math SAT and verbal SAT were examined. Secondly, these three variables were examined as predictors of group membership for students retained in math and science, students who changed from mathematics and science with GPAs less than 2.0, and students who changed from math and science with GPAs equal or greater than 2.0. This study informs admission counselors about SAT and high school performance for would-be STEM majors. Whether admission decisions or intrusive academic advising might be based on such factors is a decision for individual institutions.

History

"The SAT Reasoning Test is the nation's most widely used admissions test among colleges and universities. It tests students' knowledge of subjects that are necessary for college success. The SAT assesses the critical thinking skills students need for academic success in college…" (College Board 2008). Some researchers have pointed to the positive correlations of using SAT scores to predict college success (Burton et al. 2001; Fleming 2002; Moffat 1993).

However, caveats to the reliance on those tests alone abound. Some studies found that these exams predicted only 10 to 30 percent of the first-year college GPA (Linn 1990; Naumann et al., 2003). Linking SAT performance to high school performance was pointed to as a stronger model of predicting success than either variable alone (Astin 1993; Kim 2002; Ramist et al. 1993;

Tross et al. 2000; Waugh et al. 1994; Wolfe and Johnson 1995; Zheng et al. 2002). Abdel-Salam et al. (2005) found that high school GPA was a stronger predictor of college success for freshmen engineering students at East Carolina University (NC).

Other researchers have pointed to factors which may impact the amount of variance accounted for in predicting success in certain sub-populations. Hoffman and Lowitzki (2005) found limitations in predicting success for minority students. Ransdell (2001) included gender and award of financial aid in addition to race in impacting the SAT predictive value. Zwick and Sklar (2005) reported language background in addition to minority status as lessening the predictive value of the SAT. Rothstein (2003) made the strongest case for repudiating the SAT predictive value across the board in his study and claimed that the test's predictive value was really tied to its strong correlation with high school characteristics.

At most institutions of higher education across the country, admission and financial aid decisions are tied to students' high school records and their achievement levels on college entrance exams (ACT or SAT). In many cases, the ACT or SAT score provides a nationally-normed benchmark for students regardless of high school size, whether it was public or private, or the student was homeschooled.

As the focus on STEM pipeline production increases, there is not only increased pressure to find more students interested in pursuing these fields, but determining attributes and characteristics that can signal future success in navigating these majors and/or careers has become more critical. Knowing pre-college characteristics, which may be linked to successful retention, may help target recruiting and admission efforts.

Materials and Methods

The sample consists of 630 entering freshmen majoring in biology (BIOL), microbiology (MBIO), molecular/cellular biology (BMCB), zoology (ZOOL), chemistry (CHEM), applied mathematics (APMS), mathematics (MATH), and physics (PHYS) at a research one university in the South. Males comprise 41.3 percent of the group and 58.7 percent of the group is female. Caucasians constitute 71.6 percent of the group, 15.1 percent are Hispanic and 4.3 percent are African American.

The researchers sought to answer the following questions:

1. Are pre-college characteristics (rank in high school graduating class, math SAT score and verbal SAT score) different for students retained through their junior year in mathematics and science v. students who change out of mathematics and science with less than a 2.0 GPA?
2. Do pre-college characteristics lend themselves to predicting placement of students into groups (retained in mathematics and science through the junior year v. not retained in mathematics and science majors after earning less than a 2.0 cumulative GPA)?
3. Are pre-college characteristics different for students who changed from mathematics and science majors with a cumulative GPA equal to or above a 2.0 v. students who remained in mathematics and science?
4. Do pre-college characteristics lend themselves to predicting placement of students into groups (retained in mathematics and science through the junior year v. students who changed from mathematics and science majors with a cumulative GPA equal to or above a 2.0)?

The independent variable for questions 1 and 3 was retention status as mathematics and science majors through the junior year. The dependent variables include: rank in high school graduation class, math SAT score and verbal SAT score. For research questions 2 and 4, the role of dependent and independent variables was reversed from that of questions 1 and 3.

In relation to questions 1 and 3, the three groups examined for statistical differences among rank and SAT performance were:

1. students retained in mathematics and science through the junior year,
2. students who changed out of mathematics and science with a cumulative GPA less than a 2.0 at the time of change, and
3. students who changed out of mathematics and science with a cumulative GPA equal to or greater than a 2.0 at the time of change.

Results

In terms of the original group, 59.5 percent dropped their initial mathematics or science major by the end of the third year. After tracking these students for three years, four groups of data were identified: 255 students (40.5 percent) were retained in math and science, 123 students (19.5 percent) changed out of math and science when their cumulative GPA was less than 2.0, 243 students (38.6 percent) changed from math and science when their cumulative GPA was equal to or greater than a 2.0, and nine students (1.4 percent) had incomplete or missing data. The latter group was not used in the analyses.

All three independent variables were judged to be significantly different for all three student groups. In each case the students retained in math and science had higher means for all three variables and students who changed from math and science majors with a GPA less than a 2.0 at the time of the change had the lowest means across the board (Figures 1, 2 and 3).

In terms of group membership prediction, the three pre-college measures could be used to correctly place 75.5 percent of the students into the appropriate student group (students retained to math and science v. those who changed from math and science with a GPA less than 2.0 at the time of change). Using the same Binary Logistic Regression model, the pre-college characteristics used could be used to correctly place only 61 percent of the students into the retained in math and science group or the changed from math and science group with a GPA greater than a 2.0 at the time of change. In neither analyses was one independent variable shown to be more useful than another in predicting placement in appropriate student groups.

Discussion

Previous research was used to inform the model, combining SAT scores with high school rank (Astin 1993; Kim 2002; Ramist et al. 1993; Tross et al. 2000; Waugh et al. 1994; Wolfe and Johnson 1995; Zheng et al. 2002). Significant statistical differences are noted for all three student groups (students retained in math and science majors through their junior year, students who changed from math and science with a 2.0 or higher GPA, and students who changed from math and science with less than a 2.0 GPA). Further, a fairly strong prediction can be made based on these pre-college characteristics, especially when placing students in either the retained group or in the group that changes out of math and science with less than a 2.0 at the time of change. Factors other than rank in high school graduation class, math SAT and verbal SAT account for only 24.5 percent of the information needed to properly place students into either the retained group or the group not retained with less than 2.0 GPA at time of change. Significant differences among retained math and science majors and students who changed with a 2.0 or better GPA at the time of change also exist, though the differences are obviously smaller than the group that changed majors with less than a 2.0 GPA. The prediction based on the model is less accurate in placing students into appropriate groups (retained in math and science v. changed from math and science with greater than a 2.0 at the time of change), and other factors besides the three independent variables examined account for 39.2 percent of the information needed for proper student placement into the respective groups.

Given the strong correlation of some pre-college characteristics and retention in science, several different options exist to advise students. Some programs have begun requiring a minimum math SAT score to pursue a major in one of the science, technology, engineering or mathematics majors. This action does not allow for students near the minimum to prove themselves and can diminish recruiting and matriculation of targeted subpopulations. Another option is to inform students and parents at orientation to make them aware of usual attributes of successfully retained students (Fig. 1, 2 and 3). This informs all students but also allows them the opportunity to attempt the major, work hard and possibly be the exception to the rule. This technique, combined with intentional advising, customized scheduling and small class sizes can be effective in assisting at-risk students with the transition, retention and appropriate selection of a major early in their college career. Perhaps the best policy might be routing all admitted students into a general studies like curriculum, utilizing pre-college characteristics and diagnostics to better advise them and letting them demonstrate their abilities in a given major through specific course work.

Figure 1. High School Rank and Retention in Mathematics and Science Majors

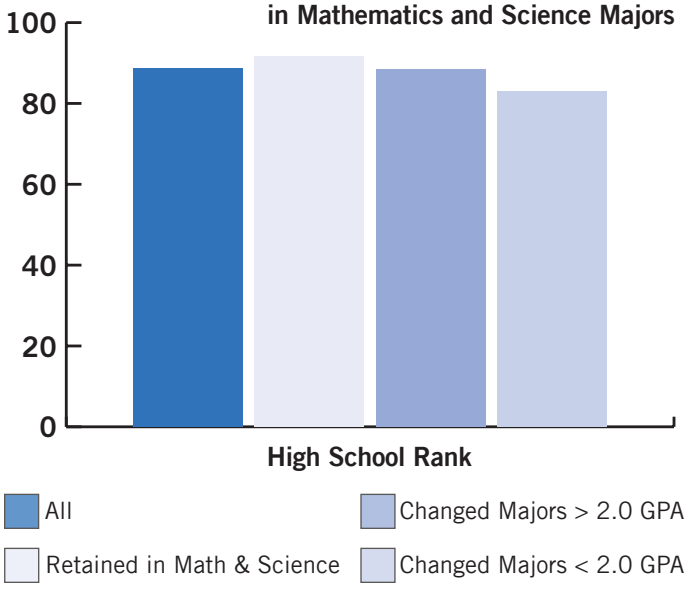


Figure 2. Math SAT Scores and Retention in Mathematics and Science Majors

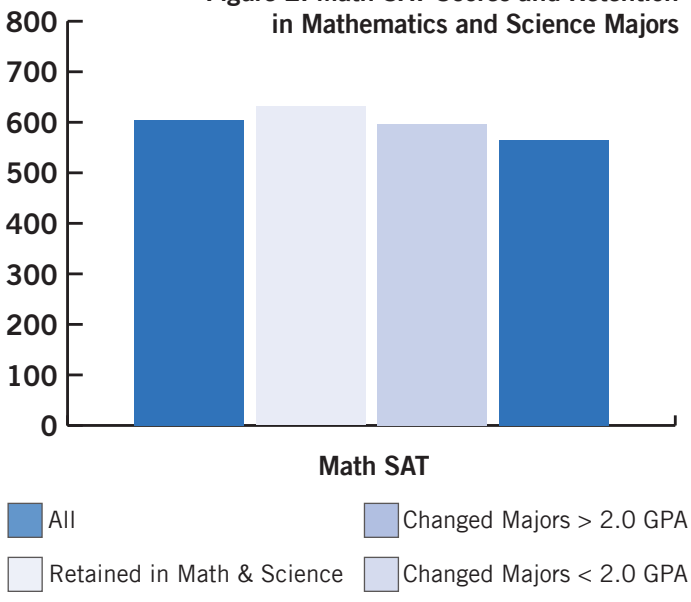
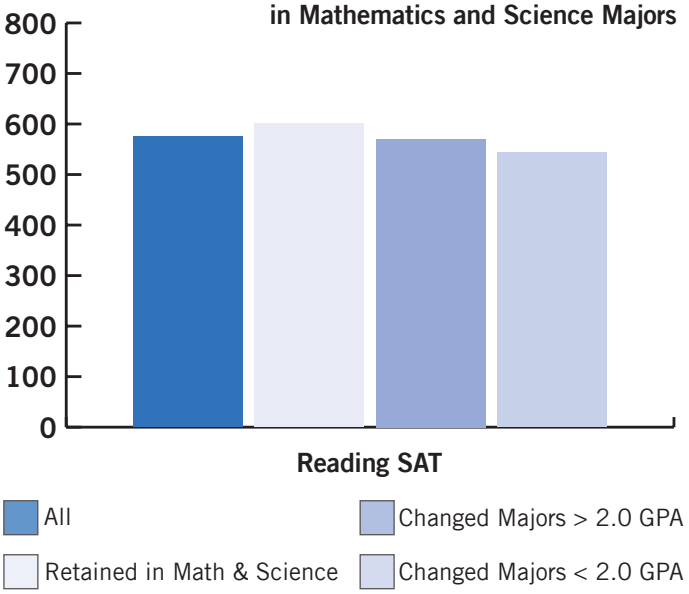


Figure 3. Reading SAT Scores and Retention in Mathematics and Science Majors



While the findings are significant, more research should be performed. Statistical analyses, for example, should be disaggregated based on gender and ethnicity, where possible. While important, it does not diminish these findings based on the relatively low enrollment of underrepresented minorities at this institution. Also, an additional year of tracking would result in inferences on graduation and the length of time to degree. Lastly, qualitative studies to determine other factors perceived to impact student performance and retention are also needed. In keeping with the logic of this study, it is suggested that future work focus on specific high needs majors/fields, as this study suggests that one size does not fit all in terms of retaining students in particular majors based on certain pre-college characteristics.

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