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Premedical Students' Orientation toward Education: Challenges for the Pipeline into Medical School

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Abstract

This longitudinal study examined whether premedical students' educational orientation contributed to their chances of completing a STEM degree. Two different orientations were tested; a narrow one grounded by interests in obtaining status and a more expansive orientation grounded by interests in engaging with a broader set of learning goals and communities. The primary source of data came from the Cooperative Institutional Research Program's 2004 Freshman Survey (TFS) and 2008 College Senior Survey (CSS). The main analyses included 613 students who reported interest in pursuing a medical degree and identified physician as their probable career. The findings indicate that students who identified with a more expansive educational orientation were significantly less likely to persist in a STEM major four years after entering college, even after controlling for relevant student background characteristics and college experiences. Implications for the medical profession are discussed.

Keywords: STEM, premedical students, habits of mind, retention, medical school, college preparation, science education.

In 2009, the Association of American Medical Colleges (AAMC) and the Howard Hughes Medical Institute (HHMI) issued a report titled *Scientific Foundations for Future Physicians*. The report addressed concerns that premedical education has not kept pace with the rapid rate at which new knowledge and societal shifts revise the understanding and education of physicians, which has remained static for decades. Accordingly, the AAMC and HHMI worry that entering medical students are not developing the essential competencies to successfully practice medicine in the future. One of the key sources for this report was a committee of scientists, physicians, and science educators from small colleges, large universities, and medical schools around the United States. These experts were convened to determine the most important scientific competencies required of students graduating from college prior to matriculating into medical school. The report concluded that:

"The competencies for premedical education need to be broad and compatible with a strong liberal arts education. The work of the committee is based on the premise that the undergraduate years are not and should not be aimed only at students preparing for professional school. Instead, the undergraduate years should be devoted to creative engagement in the elements of a broad, intellectually expansive liberal arts education." (p. 2)

One important goal of the report was to shift the emphasis of premedical education away from the overemphasis on completing specific course requirements toward a focus on multiple competencies that would permit undergraduate institutions to develop more interdisciplinary and integrative science courses. The report recognized that physicians will increasingly provide care

in the context of coordinated multidisciplinary health care delivery teams and subsequently, will need to possess a wider range of skill sets, including an enhanced capacity for thinking critically, collaborating, synthesizing information, communicating, and making a broader range of decisions.

Although the report challenged institutions to alter their curricula and educational processes to better prepare future physicians, it remains to be seen whether or not this challenge will significantly alter the quality of students who are admitted into medical school. That is, while this AAMC and HMI report appears to value a broader range of skill sets and educational experiences, premedical students who are more likely to complete a science, technology, engineering, or mathematics (STEM) degree tend to be more singularly focused and narrowly driven in ways that are incompatible with what the report identified as being key for the future practice of medicine. As a result, those who possess attributes and stronger orientations toward other skill sets seemingly valued by this report have been departing from the sciences at higher rates as undergraduates (Chang, Sharkness, Newman, & Hurtado, 2010). This study examines the pattern of STEM degree completion for premedical students and considers those patterns in light of the concerns raised about premedical education. Thus, a central purpose guiding this study is to examine whether students' educational orientations that are consistent with improving the practice of medicine improve students' chances of completing a STEM degree, which would position them to enter medical school.

Background

Colleges and universities in the U.S. have seen, over the last 35 years, substantial volatility in the proportions of students initially reporting aspirations to major in an undergraduate STEM related discipline. According to an annual survey of freshman students administered by the Higher Education Research Institute (HERI) at UCLA, nearly 31% of all students who entered college in 1971 reported plans to major in a STEM discipline (Hurtado et al., 2005). Following this peak year, however, there was a steady decrease in STEM interest. Yet since 1986, when the lowest proportion of survey respondents indicated plans to pursue a STEM-related major, there has been a steady increase in students' interest in pursuing a STEM degree. Compared to the 1971 figures, approximately the same proportion of students in 2007 reported intentions to major in STEM.

Although the proportions of students interested in STEM in 1971 and 2007 are relatively similar, the breakdown across race has changed substantially according to the HERI report. In 1971, White and Asian American students far out-paced their underrepresented racial minority (URM) peers in STEM major interest, as 38.4% of White and Asian American students indicated plans to pursue a STEM major for their bachelor's degree program compared to just 27.9% of their URM peers. In 2009, these two groups of students were nearly identical in their proportionate interest in STEM, as 30.9% of URM students and 30.4% of White and Asian American students indicated that they planned to pursue a STEM major.

Despite the renewed interest in pursuing a STEM related degree, the rate of degree completion remains relatively low as fewer than half of those aspiring students completed their STEM degree within five years (Huang, 2000, Center for Data Exchange and Analysis, 2001). The rates of STEM degree completion are especially low for URM students. A recent HERI research brief (2010) reported that White and Asian American students who started as STEM majors have five-year STEM degree completion rates of 33% and 42% respectively. In

comparison, Latino, African American, and Native American students who initially began college as a STEM major had five-year STEM degree completion rates of 22.1%, 18.4%, and 18.8% respectively. These rates were significantly lower than the five-year degree completion rates for those students who decided to major in a non-STEM field (73.5% for Whites, 65% for Asian Americans, 67.6% of Latinos, 58% for African Americans, and 60.5% for Native Americans).

Curiously, those undergraduates who pursue a STEM major are generally better prepared academically than their non-STEM counterparts in terms of average high school grades, standardized test scores and the number of science and math courses completed (Hurtado et al., 2005 & 2006). Even the best-prepared STEM aspirants, those aspiring to enter medicine or premedical students, do not achieve their undergraduate degree aspiration at the same rate as their non-STEM counterparts. Prior research in undergraduate STEM education has shown that premedical students largely represent the strongest student interest and talent in the STEM pipeline. Premedical students have higher levels of academic achievement, self-efficacy, academic engagement, and interest in STEM fields than non-premedical students (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Larson, Bonitz, Werbel, Wu, & Mills, 2011).

While in college, premedical students further improve their educational advantage. Compared with non-premedical students, they more often pursue extra- curricular career related activities such as volunteering in health care and participating in internships, and subsequently demonstrate higher perceived levels of academic mastery (Larson, et al., 2011). Moreover, O'Connell and Gupta (2006) reported that premedical students often decide to pursue a medical career earlier in their academic career, emphasizing their commitment to obtaining a medical degree. Premedical students also have more exposure to pre-college health-science experiences as a result of higher parental income (O'Connell & Gupta, 2006). Despite these apparent advantageous qualities, some studies have found that premedical students leave STEM majors at a rate comparable to their non-premedical STEM counterparts (Chang, et al., 2010). The next section explores factors that contribute to this apparent underachievement among premedical students.

Premedical Education

Even though the Association of American Medical Colleges (Association of American Medical Colleges, 2006) anticipates a physician shortage in the near future, gaining admissions into a medical school is still highly competitive and contributes to the undergraduate experiences of premedical students. Nearly all of those who matriculate into medical school complete some sort of premedical curriculum consisting of gateway calculus, physics, biology, and chemistry courses. Given this, approximately 70% of medical school applicants and matriculants come from undergraduate majors in STEM disciplines (Association of American Medical Colleges, 2011). While the coursework for premedical students overlap with their STEM peers, they also differentiate themselves from their counterparts in unique ways shaped by their desire to attend medical school.

According to Gross, Mommaerts, Earl, and De Vries (2008), the premedical student experience can largely be summarized by the tension between *demonstrating* and *developing* character. *Developing* character reflects the improvement of traits needed to be a good physician, which are consistent with the desired patient-centered philosophy of medical care (Woo, May-June 2010). Conversely, *demonstrating* character emphasizes qualities that would

satisfy an admissions committee (Gross, et al., 2008). Because gaining admissions into medical school is highly competitive, Gross and colleagues argue premedical students are guided more so by *demonstrating* character than by *developing* character.

De Vries and Gross (2009) observed, for example, that among premedical student-oriented websites, students were advised to avoid courses that might harm their GPA, to participate only in clinical and research experiences that would look good on their application, and to build relationships with professors with the sole purpose of obtaining positive letters of reference. This emphasis on gaining admissions into medical school contributes to the perception of premedical students as being excessively hard- working, competitive, grade-conscious, less sociable than others, and more interested in money or prestige (Hackman, Low-Beer, Wugmeister, Wilhelm, & Rosenbaum, 1979). According to Thomas (1978, p. 1181), premedical students "live for grades" and "concentrate on science with a fury." Those attributes are fueled by a "weeding" process that attempts to sort the "wheat from the chaff" by identifying students who are weak or not committed to the sciences (Barr, 2010). Performing well in gateway courses such as organic chemistry is key to succeeding in this process. In fact, many scholars have pointed to organic chemistry as the "defining premedical course" (Brieger, 1999) for "weeding out" future physicians (Lovecchio & Dundes, 2002) and negatively influencing medical school aspirations (Barr, Gonzalez, & Wanat, 2008), even though very little organic chemistry is used by practicing physicians (Smith, Danoff, & Szenas,1998).

According to Muller and Kase (2010), the competitive nature and need to excel academically among premedical students "induces [premedical students] to cram for grades without appreciating the science being studied" (p. 1381). Subsequently, success in gatekeeper courses does not necessarily predict success as a physician (De Vries & Gross, 2009). Collectively, those attributes may also foster unwelcoming climates for students (Baldwin, 2009), which may unintentionally undermine the interest and progress of promising students who might otherwise make outstanding medical care professionals (Barr, 2010). Alexander, Chen, and Grumbach's (2009) study provides one example of how such an academic environment might affect the chances of success among premedical students from underrepresented racial minority (URM) groups. After statistically controlling for differences in pre-college characteristics such as academic preparation, they found that Black and Latino students still earned significantly lower grades in premedical gateway courses. In other words, the lower grades earned in those courses was explained not only by academic preparation but also by other environmental factors which contributed significantly to those race differences.

Although metrics that refer to academic achievement and a *demonstration* of character such as GPA and MCAT scores often drive medical school admissions (Johnson, Mitchel, Boyd, & Solow, 2009), personal qualities such as interpersonal skills, commitment to serve others, leadership ability, self-confidence, awareness of community, and conscientiousness have been widely noted by medical scholars as being desirable traits for a physician (Albanese, Snow, Skochelak, Huggett, & Farrell, 2003; Collins, White, Petrie, & Willoughby, 1995; Meridith, Dunlap, & Baker, 1982; Nowacek, Bailey, & Sturgill, 1996; Shaw, Martz, Lancaster, & Sade, 1995). Such important qualities can be showcased in the admissions process by using, for example, a circuit of 8-12 short structured interviews called multiple mini interviews (Uijtdehaage, Doyle, & Parker, 2011). However, only 15% of medical schools have implemented practices that identify and emphasize compelling personal characteristics and non-academic traits in the selection process (Johns Hopkins University, n.d.). Unless more medical schools emphasize those qualities when admitting students and premedical education programs

intentionally cultivate them, aspiring physicians will not actively seek to develop those important attributes that improve the practice of medicine. Worse yet, those with a propensity toward developing those qualities and attributes may opt to pursue other fields.

Purpose

As long as the medical school admissions process continues to favor those who are more narrowly focused by emphasizing "high MCAT scores and exceptional grade achievement," Muller and Kase (2010, p. 1378) argued, the *demonstration* of character will trump the *developing* of character. Premedical students will continue to seek higher MCAT scores, higher college GPAs, and other "boxes to be checked" (Gross, et al., 2008, p. 519) on a medical school application in the hopes of maximizing their chances of medical school acceptance. Such a narrow approach to one's undergraduate education seems at odds with the principles advanced in the *Scientific Foundations* report, which called for a more expansive educational orientation. Given what it currently takes to be admitted into medical school, those who approach their undergraduate education in more narrow ways seem to have a distinct advantage over those who approach it more expansively, seeking a broader set of learning outcomes. If so, are medical schools losing out on potential applicants who possess valued qualities that will improve the future of medicine?

Accordingly, this study examined whether premedical students' educational orientation contributed to their chances of completing a STEM degree. Specifically, we tested two different orientations. One is a more narrow orientation that is grounded by interests in obtaining status. Another is a more expansive orientation that is grounded by interests in engaging with a broader set of learning goals and communities. If premedical education is emphasizing "engagement in the elements of a broad, intellectually expansive liberal arts education" as recommended in the *Scientific Foundations* report, then having a more expansive educational orientation should improve premedical students' chances of completing a STEM degree.

While the solutions for improving STEM retention tend to stress academic preparation and achievement and certainly this has been shown repeatedly to make a significant difference (Nora, Barlow, & Crisp, 2005), this study is more interested in identifying non-academic factors and personal characteristics, especially those qualities that are valued by medical practitioners. After all, premedical students tend to be better prepared than their STEM counterparts yet are underachieving in terms of obtaining an undergraduate STEM degree. This may suggest that other non-academic issues *push* those highly prepared students away from completing their degree aspiration. By empirically examining the retention of premedical students in STEM majors, considered the best-prepared group of students, this study can also provide unique insights into attributes and experiences that more broadly enhance undergraduate STEM degree completion.

Methods

To address the above questions, this study utilized a student sample set derived from The Freshmen Survey (TFS) and the College Senior Survey (CSS). These two nationwide surveys were conducted by the Higher Education Research Institute (HERI) at UCLA. The TFS was administered to first-time freshman students during freshman orientation or during their first term in college and targeted demographic information and information about students'

precollege experiences, attitudes, values, goals, self- perceptions, and expectations for college. College seniors completed the College Senior Survey (CSS) in the spring of their fourth year, and this instrument queried information about the experiences students had while in college as well as their self-perceptions, values, attitudes, career aspirations, and post-graduation plans. The longitudinal response rate for the 2004 TFS and 2008 CSS was approximately 23%. The full longitudinal dataset includes information from 6,224 students at 238 institutions.

Two different samples were utilized for analyses. The first one included 4,122 students who had declared in 2004 that they intended to pursue a STEM major[1]. This sample enabled us to test for differences in retention rates between those entering freshmen, who aspired to pursue medicine (premedical students) and their science counterparts. The second sample included only those who had medical degree aspirations and identified physician as their probable career (n = 613). This sample was used to test for factors that contributed to retention among premedical students.

Variables

Since the outcome of interest for this study was STEM retention, the central dependent variable measured whether or not the student was still a STEM major four years after entering college. This information was collected on the 2008 CSS and asked students for their most recent or final major. A binary outcome (1 = No, 2 = Yes) was recoded from these results and grouped students based on whether or not they selected a STEM major[1].

Per our research question, the key independent variables were two constructs that approximated students' educational orientation. One construct was based on the drive to achieve status, which we adopted from Astin's (1993) *status striver* typology. According to Astin, a status striver's personal values and life goals are driven by the commitment to succeed in his or her endeavors. Other attributes of a *status striver* included assuming the responsibility for the work of others, being well-off financially, and obtaining recognition and authority status from colleagues for noteworthy contributions in a specialized field. In essence, a student with a *status striver* orientation is committed to career success, especially financial independence, and is very goal-oriented. We replicated Astin's typology with items from the TFS (see Table 1) to test if this kind of narrowly focused orientation contributes to premedical students' chances of persisting in a STEM major.

The other orientation was inspired by the idea of *developing* character, which was aligned with the core competencies, roles, and domains desired in physicians (Reiter & Eva, 2005). To assess this orientation, we conducted principal axis factoring with promax rotation and developed a factor composed of eight items from the 2004 TFS, which included self-ratings of understanding of others, cooperativeness, intellectual self-confidence, social self-confidence and the importance of influencing social values, becoming a community leader, participating in a community action program, and improving understanding of other countries and cultures (see

[1] STEM major was defined as identification with any of the following majors on the 2004 TFS and 2008 CSS: General Biology, Biochemistry/Biophysics, Botany, Environmental Science, Marine (Life) Science, Microbiology/Bacterial Biology, Zoology, Other Biological Science, Aeronautical/Astronautical Engineering, Civil Engineering, Chemical Engineering, Computer Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Other Engineering, Astronomy, Atmospheric Science, Chemistry, Earth Science, Marine Science, Mathematics, Physics, Statistics, Other Physical Science, Health Technology, Medicine/Dentistry/Veterinary Medicine, Nursing, Pharmacy, Agriculture, and Computer Science

Table 1). Because this factor approximated a student's desire to pursue an expansive education that would enhance their capacity to be more engaged with shaping values and community, we termed this factor *engagement striver*.

Lastly, the selection of control variables was guided by Nora, Barlow, and Crisp's (2005) student engagement model framework. Based on previous research, this framework accounts for key factors that contribute to undergraduate science retention. Consistent with this framework, we selected items from the TFS and CSS that represented pre-college factors, educational aspirations and commitments, experiences throughout college, and other cognitive/non-cognitive attributes for the analysis. Altogether, seventeen variables were selected (see Table 2), with most serving as statistical controls to assess better the effect of educational orientation on STEM retention.

Analysis

We first conducted several descriptive analyses to better understand the extent to which premedical students differ from their STEM counterparts. These crosstabs were conducted with the larger sample of students who had identified as a STEM major in 2004 on the TFS. Two groups were compared within the 2004 STEM major sample: premedical students and non-premedical students. Premedical students were defined based on three conditions: students who identified as a STEM major in 2004, intended to pursue a medical degree, and intended to pursue a career as a physician.

To address our main research question regarding STEM retention, we employed logistic regression because this approach permits the researcher to analyze more effectively how a particular set of variables in a logical model influences an educational choice, while simultaneously controlling for confounding factors (Cabrera, 1994). According to Hosmer and Lameshow (2000), logistic regression is the standard and accepted regression method to estimate the probability of a certain event occurring that is coded as a dichotomous variable. Only premedical students were selected for these analyses (n = 613).

Per our framework, we tested three distinct models (see Table 2). The first model contained only background variables that controlled for underrepresented minority status, gender, income, high school GPA, and number of years studied in high school of mathematics, physical science, and biological science. The second model included those variables in the first model but also added variables consistent with Nora, Barlow, and Crisp's (2005) student engagement framework. These variables included the likelihood of changing career choice, the perceived level of competition amongst students, participation in undergraduate research programs, the frequency of studying with other students, the importance of improving the health of minority communities, satisfaction with coursework as it related to career plans, self-rating of preparedness for graduate education, and self-rating of academic ability. The third and final model included all variables and tested the two key independent ones for this study, namely *status striver* and *engagement striver*.

Limitations

This study has several limitations. First, the findings from this study were a product of secondary data analysis. The two nationwide surveys were not designed specifically to examine premedical students so certain key experiences could not be tested. For example, the role of

weeder courses could not be examined, which is known to play a key role in the retention of STEM students. Certainly, a richer account of students' experiences in the classroom would improve this study. Additionally, we relied on the accuracy of students' responses to the questionnaire. Thus the study also depended on the reliability of their responses, especially regarding the outcome.

Results

The results reported in Table 3 show differences between premedical students in STEM and non-premedical students in STEM. Premedical students are generally better prepared academically than their counterparts, entering college with higher SAT scores and high school GPA. Also, a larger percentage of premedical students reported that they enrolled in college to prepare for graduate or professional school and were less likely to change either their major or career choice during college. These findings signal the early and strong commitment of premedical students toward their degree aspiration. Despite these advantages, premedical students were less likely than their STEM counterparts to persist in a STEM major four-years after entering college. Whereas 64.6% of non-premedical students persisted, only 57.9% of premedical students did the same. The next set of analyses further examines the factors that contribute to retention among premedical students.

Logistic Regression Analyses

For these analyses, we tested three models to predict premedical student's chances of persisting in a STEM major. The initial model included key background characteristics that have been shown to affect STEM retention. The Cox & Snell R-squared value for this Model, which approximates the statistical strength of the model in predicting the outcome, was 0.055. The second model that included additional variables guided by Nora, Barlow, and Crisp's (2005) student engagement framework was slightly stronger than the first, improving the Cox & Snell R-squared value substantially to 0.162. The final Model that included the *status* and *engagement striver* factors was the strongest, with a Cox & Snell R-squared value of 0.173, suggesting that those two factors contribute to the overall prediction of STEM retention among premedical students.

Given that Model 3 was the strongest model, Table 4 reports the logistic regression results from this model. To provide a sense of the practical significance for each variable in the final model, the table also reports the calculated odds ratios or the percentage increase or decrease in the chance of STEM retention for each unit increase of the corresponding variable. The variables are listed by Model and asterisks indicate critical levels of statistical significance.

Of most interest is the effect of the *status striver* and *engagement striver* variables. Table 4 shows that even after controlling for background characteristics, student attributes, and college experiences, those who identified with an *engagement striver* orientation were less likely to stay in a STEM major four-years after entering college. In other words, premedical students who rated themselves highly in their understanding of others, cooperativeness, intellectual self-confidence, social self-confidence and deemed influencing social values, becoming a community leader, participating in a community action program, and improving understanding of other countries and cultures as very important were less likely to persist in a STEM major.

Conversely, the *status striver* orientation did not contribute significantly toward predicting retention.

Table 4 also shows that other student background characteristics, attributes, and experiences, contribute to STEM retention. Two background characteristics, underrepresented minority status and high school GPA, both had significant main effects. Premedical students who identified as an underrepresented minority were 38% less likely to stay in STEM four-years after initially declaring a STEM major. Conversely, the higher a premedical students' high school GPA, the more likely that student would persist. Additionally, participation in undergraduate research programs, strong concern for improving the health of minority communities, and high self-ratings of academic ability are all positively related to STEM retention. Conversely, increasing the likelihood of changing one's future career is negatively related to persisting in a STEM major. Of these four variables, participating in an undergraduate research program yielded the strongest effect, doubling premedical students' chances of persisting.

Discussion

This study examined premedical students' orientation toward education to test if such nonacademic factors might contribute to their persistence in a STEM major. We found that those premedical students with a more expansive educational orientation that seeks to improve their understanding of other people and cultures and is grounded in broader interests in engaging with communities and influencing society, are significantly less likely to persist in a STEM major than their premedical counterparts with a weaker commitment toward this type of orientation. Premedical students with a more expansive educational orientation also tend to be more intellectually and socially confident, yet are departing from the sciences at a higher rate and thereby signaling indifference toward attending medical school. This effect was observed after controlling for a wide range of student background and college experience variables. So, for example, given similar academic preparation, attributes, and key college experiences, those premedical students with a stronger orientation toward broader educational engagement are still less likely to persist in a STEM major than their peers with a weaker orientation.

This finding is especially alarming given the call in the 2009 Association of American Medical Colleges (AAMC) and the Howard Hughes Medical Institute (HHMI) report, *Scientific Foundations for Future Physicians*, to shift the emphasis of premedical education toward "creative engagement in the elements of a broad, intellectually expansive liberal arts education." According to this report, this educational shift would better prepare future physicians as the practice of medicine is rapidly transforming in ways that require a different orientation that builds a broader skill set. In other words, the practice of medicine stands to benefit from physicians who are not narrowly driven but possess a more expansive educational orientation that will more broadly engage their practice. However, those premedical students who are more inclined to engage in their education in ways that would enhance the practice of medicine appear to be less interested in pursuing medicine as they progress through their undergraduate studies.

It is unclear from this study why premedical students with a more expansive educational orientation are less likely to persist in a STEM major. Although the *Scientific Foundations* report raised concerns about the inflexibility and narrowness of premedical education, its effect on STEM retention was not assessed directly in this study. Still, a shift in premedical education as recommended by the report would more likely benefit than hurt the science commitment of

students with a more expansive educational orientation. If so, then a key practical question would be to what extent are colleges adopting the report's recommendations to reinvigorate the undergraduate preparation of future physicians?

When it comes to other factors that contribute to STEM persistence, our findings are consistent with previous studies (Nora, et al., 2005). Of concern, however, is that underrepresented minority premedical students were nearly 40% less likely than their White and Asian American counterparts to persist. This is particularly troublesome given that students who identify with an underrepresented race or ethnicity are much more likely to practice medicine in underserved communities (Ko et al., 2005; Xu et al., 1997). Although examining this problem was not the purpose of this study, this finding suggests that more needs to be done to address calls for improving access to physician care, particularly in minority communities (Association of American Medical Colleges, 2006). One encouraging finding toward that goal, however, was that premedical students who were more concerned about improving the health of minority communities were more likely to persist.

Conclusion

In conclusion, there is no shortage of talented and bright undergraduates applying to medical schools and admissions will continue to be highly competitive. An issue facing medical schools, however, is whether the quality of applicants will keep pace with the transformative shifts taking place in the practice of medicine. The quality of the applicant pool depends not only on undergraduate institutions adopting a broader approach to premedical education that focuses on a wider range of competencies but also attracting and retaining students who are more inclined to develop certain "habits of the mind." According to Epstein (1999) in an article in the *Journal of the American Medical Association*, competence depends on habits of mind that allow the practitioner to be attentive, curious, self-aware, and willing to recognize and correct errors. While those attributes are essential for the future of health care, they are not being intentionally developed during a physician's educational training. Instead, it may be the case that undergraduate training tends to be approached in a way that turns away premedical students with an inclination toward developing those habits of the mind. While the findings from this study imply this possibility, future studies should more closely examine the effect that premedical education has on students with more expansive educational orientations. If promising aspiring physicians with certain highly valued qualities lose their interest in pursuing medicine as undergraduates, this would reduce the capacity of medicine to keep pace with transformations in health care specifically and society more generally.

Beyond the interest of improving medical practice, educators will also need to look harder at the high attrition rates of premedical students from the sciences, especially those with minority backgrounds. On average, premedical students are the best-prepared and committed science students but curiously, those advantages do not translate into higher STEM retention rates. Our findings show that over forty percent of those who aspired to attend medical school and become a physician do not persist in a STEM major. That rate is nearly ten percentage points higher than for their non-premedical STEM counterparts.

While a realistic evaluation of gaining admissions into medical school certainly contributes to this problem, it seems that much talent is being lost here at the expense of other areas in the sciences. That is, if STEM departments do a better job retaining premedical students who decide not to pursue medicine, might other science related fields benefit in the long run?

After all, premedical students are on average among the best prepared groups of high school graduates in the nation. If a key interest is to retain top talent in the sciences more broadly than in just medicine, educators will need to counsel premedical students better about the wider range of options for them in the sciences beyond just going to medical school. As it stands, this highly talented pool of students is abandoning science altogether at a troubling rate and educators need to understand better how the limited career aspiration of those students contributes broadly to this underutilization of talent in the sciences.

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Sylvia Hurtado is Professor and Director of the Higher Education Research Institute at UCLA (HERI) in the Graduate School of Education and Information Studies. She has served on numerous editorial boards for journals in education, and is past-President of the Association for the Study of Higher Education (ASHE). Dr. Hurtado has published numerous articles and books related to her primary interest in student educational outcomes, campus climates, college impact on student development, STEM education, and diversity in higher education.

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Table 1
Educational Orientation Factors

	Loading
Status Striver (Cronbach's alpha = .697)	
Goal: Obtaining recognition from colleagues	.765
Goal: Be very well-off financially	.578
Goal: Have administrative responsibility for the work of others	.777
Goal: Become an authority in my field	.709
Goal: Be successful in a business of my own	.550
Engagement Striver (Cronbach's alpha=.726)	
Self-rating: Understanding of others	.568
Self-rating: Cooperativeness	.455
Self-rating: Self-confidence (intellectual)	.651
Self-rating: Self-confidence (social)	.699
Goal: Influencing social values	.624
Goal: Becoming a community leader	.592
Goal: Participating in a community action program	.508
Goal: Improving my understanding of other countries and cultures	.562

Table 2
Variables Included in the Logistic Regression Analysis
(n=613)

Model	Variable	Description	Scale
1	URMstud	Underrepresented minority student	1=No; 2=Yes
	SEX	Student's gender	1=Male; 2=Female
	INCOME	What is your best estimate of your parents' total income last year?	1=Less than $10,000; 2=$10,000 to 14,999; 3=$15,000 to 19,999; 4=$20,000 to 24,999; 5=$25,000 to 29,999; 6=$30,000 to 39,999; 7=$40,000 to 49,999; 8=$50,000 to 59,999; 9=$60,000 to 74,999; 10=$75,000 to 99,999; 11=$100,000 to 149,999; 12=$150,000 to 199,999; 13=$200,000 to 249,999; 14=$250,000 or more
	HSGPA	What was your average grade in high school?	1=D; 2=C; 3=C+; 4=B-; 5=B; 6=B+; 7=A-; 8=A or A+
	YRSTUDY2	Years Study: Mathematics	1=None; 2=1/2; 3=1; 4=2; 5=3; 6=4; 7=5 or more
	YRSTUDY4	Years Study: Physical Science	1=None; 2=1/2; 3=1; 4=2; 5=3; 6=4; 7=5 or more
	YSTUDY5	Years Study: Biological Science	1=None; 2=1/2; 3=1; 4=2; 5=3; 6=4; 7=5 or more
2	FUTACT02	Future Act: Change career choice	1=No chance; 2=Very little chance; 3=Some chance; 4=Very good chance
	INSOPN07	There is strong competition among most of the students for high grades	1=Disagree strongly; 2=Disagree somewhat; 3=Agree somewhat; 4=Agree strongly
	COLACT20	Participated in an undergraduate research program (e.g. MARC, MBRS, REU)	1=No; 2=Yes

	CSSOBJ22*	Goal: Improving the health of minority communities	1=not important; 2=somewhat important; 3=very important; 4=essential
	CSSACT08	Studied with other students	1-not at all; 2=occasionally; 3=frequently
	INSSAT06	Relevance of coursework to future career plans	1=Very dissatisfied; 2=Dissatisfied; 3=Neutral 4=Satisfied; 5=Very satisfied
	SLFCHG12	Preparedness for graduate or advanced education	1=much weaker; 2=weaker; 3=no change; 4=stronger; 5-much stronger
	RATE0401	Self-rating: Academic ability	1=Lowest 10%; 2=Below average; 3=Average; 4=Above average; 5=Highest 10%
3	DEMscale	Status striver	1=not important; 2=somewhat important; 3=very important; 4=essential
	DEVscale_new	Engagement striver	Scale varies

* Because this variable was pulled from the 2008 CSS, an argument could be made that this effect was a result of students leaving STEM. However, due to the scope of this variable and its absence from the 2004 TFS, the 2008 CSS variable was included for analysis as a reasonable proxy for a 2004 TFS variable.

Table 3
Differences between Premedical and Non-Premedical Students in STEM
(n=4,122)

Variable		STEM, Premed	STEM, Non-Premed
Average HS GPA	A- to A+	87.2%	74.8%
SAT Math	700+	37.0%	34.1%
SAT Verbal	700+	29.1%	21.2%
To Prepare for Grad/Prof School	Very Important	96.5%	69.6%
Change Major Field	Some or Very Good Chance	33.3%	40.9%
Change Career Choice	Some or Very Good Chance	32.5%	49.2%
STEM Retention	STEM major in 2008	57.9%	64.6%

Table 4
Summary of Logistic Regression Analysis for Variables Predicting STEM Retention (n=613)

Model	Variable	Coefficient	Standard Error	Odds Ratio
1	Underrepresented minority student	-0.486*	.195	.615
	Student's gender	-0.119	.207	.887
	Income	-0.043	.029	.957
	What was your average grade in high school?	0.250*	.100	1.284
	Years Study: Mathematics	0.219	.173	1.244
	Years Study: Physical Science	0.000	.071	1.000
	Years Study: Biological Science	0.113	.087	1.120
2	Future Act: Change career choice	-0.274*	.114	.760
	There is strong competition among most of the students for high grades	-0.086	.115	.918
	Participated in an undergraduate research program (e.g. MARC, MBRS, REU)	0.813***	.222	2.254
	Goal: Improving the health of minority communities	0.536***	.103	1.709
	Studied with other students	0.272	.158	1.313
	Relevance of coursework to future career plans	0.052	.106	1.054
	Preparedness for graduate or advanced education	0.074	.137	1.077
	Self-rating: academic ability	0.608***	.165	1.837
3	Status striver	0.059	.050	1.061
	Engagement striver	-0.135**	.045	.874

* $p < .05$. ** $p < .01$. *** $p < .001$.