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The Fisk-Vanderbilt Masters-to-Ph.D. Bridge Program is a model for substantially increasing the number of underrepresented minority students earning doctoral degrees in the physical sciences. The program presently leads the nation in master's degrees in physics for African-Americans, and is one of the top ten producers of physics master's degrees among all U.S. citizens. The program is on pace to become the nation's top producer of underrepresented minority Ph.Ds. in physics, astronomy, and materials science. We summarize the main features of the program, including two of its core strategies: Partnering a minority-serving institution and a major research university through collaborative research, and using the master's degree as a pathway to the Ph.D. We discuss our methods for recognizing and selecting for unrealized potential in students during the admissions process, and for cultivating this potential to develop successful scientists and leaders.
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I. INTRODUCTION

Universities and foundations in the United States have embraced the goal of increasing the participation of underrepresented minority students in science, technology, engineering, and mathematics (STEM). Yet, this goal has been elusive. Graduate physics and astronomy programs in the U.S. are effective at educating the next generation of scientific leaders for the rest of the world. In physics and astronomy, as in most other STEM disciplines, American citizens and permanent residents no longer earn the majority of Ph.Ds. awarded by U.S. institutions. At the same time, a large segment of the domestic talent pool remains grossly underutilized. From 1999–2006, underrepresented minorities[1] constituted just 4% of all STEM Ph.Ds. awarded by U.S. institutions (see Fig. 1), whereas these groups comprise more than 30% of the U.S. Ph.D.-age population and earn 17% of STEM baccalaureate degrees in the U.S.[2] In physics and astronomy the proportion of Ph.Ds. awarded to under-represented minorities in 1999–2006 was just over 2%. In 2006, U.S. institutions awarded 12 physics Ph.Ds. to African-American U.S. citizens (0.8% of the total 1,562 physics Ph.Ds.).[3]

Graduate degrees are earned one student at a time, each within a department at one institution. It is at this level of granularity that the challenge of broadening participation must be met. For example, in physics the statistics imply an average of one under-represented minority Ph.D. awarded per Ph.D.-granting institution every 5 years, and in astronomy, one minority Ph.D. every 13 years.[4]

One consequence of this low Ph.D. production rate is that there continues to be a very small number of underrepresented minority faculty whom can serve as mentors and role models for the next generation of under-represented minority physics and astronomy graduate students. A recent survey of all 51 astronomy and astrophysics Ph.D.-granting programs in the U.S. counted a total of just 17 full-time faculty who identify themselves as a member of an underrepresented minority group (2% of all astronomy and astrophysics faculty).[5] Over the past 20 years the share of physics and astronomy Ph.Ds. awarded to underrepresented minorities has remained roughly flat at 2%, while the proportion of underrepresented minorities in the U.S. has grown by 33% (from 20.9% in 1988 to 27.0% in 2008). Thus we have been losing ground and currently under-produce underrepresented minority Ph.Ds. in physics and astronomy by a factor of

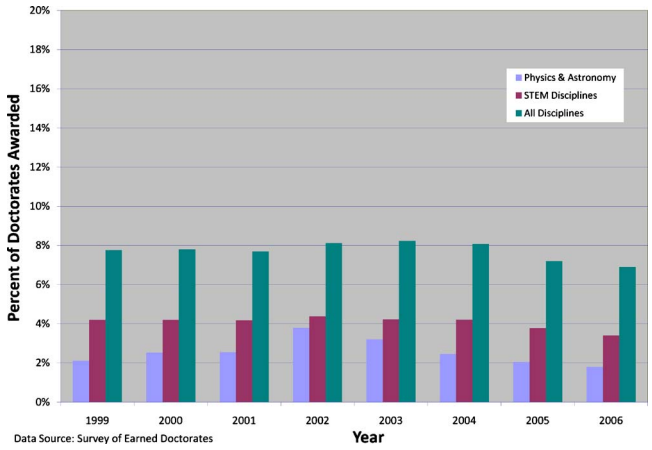

Fig. 1. Percentage of Ph.D. degrees awarded to under-represented minority students, 1999–2006, compared to Ph.Ds. awarded to all students in the U.S. (domestic plus foreign). Source: Survey of Earned Doctorates (Ref. 21).

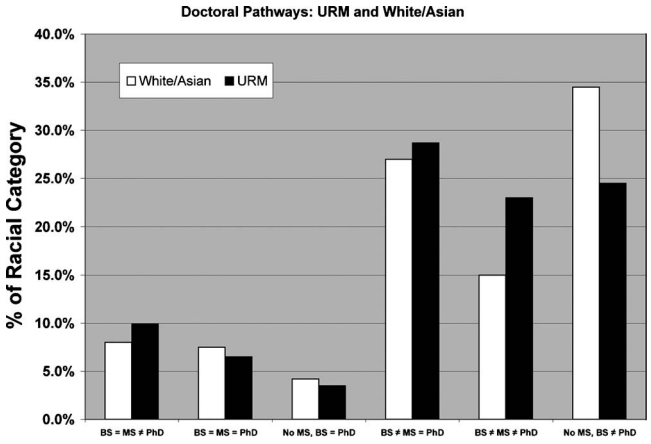

Fig. 2. Comparisons between underrepresented minority and White/Asian students, based on different permutations of the educational pathway to the Ph.D. An equals sign indicates degrees earned from the same institution. The fourth and sixth columns show the percentage of students who take a traditional path to the Ph.D., in which the student earns a bachelor's degree from institution A, and either receives both a masters degree and a Ph.D. from institution B or else forgoes the masters degree entirely. The fifth column shows the percentage of students earning the bachelors degree at institution A, a "terminal" masters degree at institution B, and Ph.D. from institution C. Minority students are much more likely to take this path than non-minorities. Based on analysis of 80,739 Ph.Ds. earned in science and engineering fields, 1998 to 2002. Results adapted from Lange (Ref. 9).

about 15. Given that the physics faculty turns over roughly 3% of its ranks each year, changing the demographics of the workforce is a project on a generational time span. Although faculty demographics can change dramatically over 30–35 years, we need to increase the number of under-represented minority faculty by a factor of 15 to achieve parity by 2040, starting today and continuing indefinitely. This calculation unrealistically assumes that there is no attrition of underrepresented minority Ph.Ds. from the field; that is, even an enormous increase in Ph.D. production is not enough without retention.

Minority-serving institutions[6] are important for producing domestic minority science students. Roughly one-third of all STEM baccalaureate degrees earned by African-Americans are earned at historically Black colleges and universities, and the top 15 producers of African-American baccalaureates in physics are all historically Black colleges and universities. Just 20 historically Black colleges and universities were responsible for producing 55% of all African-American physics baccalaureates in the U.S. for 1998 to 2007.[3,7] Over the past 20 years these institutions have also become increasing producers of Master's degree students. For example, between 1987 and 2006, the number of underrepresented minorities earning Master's degrees in the physical sciences from minority-serving institutions increased by 533%.[8] Recent research on the educational pathways of underrepresented minority students in STEM disciplines indicates that these students are about 50% more likely than their non-minority counterparts to seek a master's degree en route to the doctorate[9] (see Fig. 2). Thus the master's degree is a critically important stepping stone for many underrepresented minority students in physics, and a critical educational juncture at which students without suitable mentoring and guidance may be lost from the Ph.D. pipeline. Institutional partnerships with minority-serving institutions are thus a promising avenue for broadening participation in the physical sciences, particularly if the partnership taps into the master's degree.[10]

These facts motivated faculty at Vanderbilt University and Fisk University to develop the *Fisk-Vanderbilt Masters-to-Ph.D. Bridge Program*,[11] aimed at preparing underrepresented minorities for success as they traverse the critical Masters-to-Ph.D. transition. The program has been developed in partnership between Vanderbilt, a Ph.D.-granting R-1 university, and Fisk, a research active historically Black university, which are both located in Nashville, Tennessee. The Bridge Program is intended for students who have completed baccalaureate degrees in physics, chemistry, biology, or engineering, and who are motivated to pursue a Ph.D. but who require additional coursework, education, and/or research experience. By completing a Master's degree at Fisk under the guidance of faculty mentors, students develop the strong academic foundation, research skills, and one-on-one mentoring relationships that will foster a successful transition to the Ph.D. at Vanderbilt. The program is flexible and individualized to the goals and needs of each student. Courses are selected to address gaps in undergraduate preparation, and research experiences are tailored that allow students to develop and demonstrate their scientific talent and potential.

Since 2004, the Bridge Program has attracted 42 students, with 88% under-represented minorities, and 55% females. As of 2010, the retention rate is 90% (the average retention rate for underrepresented minorities in mathematics and physical sciences Ph.D. programs is 45%, and is 52% for non-underrepresented minority students).[12] The first Bridge Program Ph.D. was awarded in 2009, just 5 years after the program's inception.[13] The Bridge program is on track to award Ph.Ds. to underrepresented minorities far above the U.S. average—by a factor of 10 in astronomy, 9 in materials science, 5 in physics, and 2 in biology.[14] In 2011, Vanderbilt will become the top research university to award Ph.Ds. to under-represented minorities in astronomy, physics, and materials science, and the program will increase by roughly 50% the annual U.S. production of under-represented minority Ph.Ds. in astronomy. As of 2006, no U.S. institution awards more Master's degrees in physics to African-American U.S. citizens than Fisk, which is also one of the top 10 U.S. institutions awarding physics Master's degrees to U.S. citizens of any ethnic background.[15] Extramural grants

supporting Bridge graduate students, faculty, and related undergraduate research now exceed $25 million. NSF CAREER awards have been awarded to five Vanderbilt junior faculty leaders and mentors associated with the program, including the largest CAREER grant ever awarded in astronomy.[16] The Bridge students are highly successful as well, and several have been awarded the nation's top graduate National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) fellowships.

The aim of this paper is to describe how the concept of unrecognized potential has shaped the Bridge Program in two critically important ways: How we identify and select students for the program, and how we support and mentor students to maximize their success.

II. THE FISK-VANDERBILT MASTERS-TO-PH.D. PROGRAM

A. Overview

The program's basic structure has been described in Ref. 17. In brief, students are first admitted into the 2-year terminal Master's degree program at Fisk University, during which time they receive mentoring, tailored graduate coursework, research training, and professional development to enable a successful transition to the Ph.D. program at Vanderbilt. One goal of the program is that students emerge from the Master's degree with solid preparation for entry into any world-class Ph.D. program. So far six of the 42 Bridge students have chosen to accept offers from other highly ranked Ph.D. programs. No matter where students choose to pursue a Ph.D., they have the ongoing support of a network of mentors who are dedicated to the students' success. The funding model is to provide a full fellowship (tuition, stipend, and insurance) for 3 years while the student completes the Master's degree at Fisk, and during the first year in the Vanderbilt Ph.D. program. Thereafter, the program at Vanderbilt provides full support through a combination of teaching and research assistantships, and fellowships until completion of the Ph.D.

Admission begins with application to the Fisk Master's degree program in physics, chemistry, or biology, which includes undergraduate transcripts, letters of recommendation, a personal statement, and general Graduate Record Examination (GRE) scores. Once admission to the Fisk Master's program has been decided by the Fisk faculty following their standard admissions procedures, the applicant can indicate that they wish to be considered for the Bridge program. The applicant then submits an additional information form to the Fisk admissions package. Bridge applicants are interviewed by a subset of the Bridge program steering committee (the full steering committee consists of three faculty members each from Fisk and Vanderbilt). The entire steering committee reviews the application materials, and discusses the impressions gained from the interviews and any prior informal interactions. Upon the recommendation of the steering committee, the successful applicant is formally designated as a Bridge student.

A formal multi-tiered mentoring structure provides each Bridge student with "scaffolds of support" that help to ensure retention and a successful transition across the bridge. This structure includes the following:

- Two co-directors, one appointed by each of the provosts of the two universities, formally direct the Bridge program. The directors are accountable to their respective provosts, and together are primarily responsible for obtaining internal and external funding and for articulating the goals of the program.
- A Steering Committee, with at least one faculty leader from each university in each of the disciplinary tracks. These faculty provide oversight, guidance, and continuous tracking of student progress.
- Assignment of two faculty mentors, one from Fisk and one from Vanderbilt, for each student.
- A monthly professional development seminar[18,19] aimed at demystifying the process of reaching the Ph.D. (The students, almost without exception, are the first-generation in their families to pursue higher education).
- A pair of peer mentors—one from Fisk and one from Vanderbilt—to help guide the students at both universities.
- A "mentoring management console" for careful tracking of individual student progress, enabling Bridge faculty to identify potential problem cases early and to intervene quickly with additional support/resources to prevent students from slipping through the cracks.
- Dedicated administrative coordinators at both universities, providing an additional layer of mentoring support and a one-stop go-to person on each campus to help students solve bureaucratic/logistical problems that may arise.
- A Bridge student government with regular meetings with the Steering Committee to bring up issues and new ideas.
- A social club to facilitate camaraderie among all levels of the group.

B. Facilitating a Successful Transition to Ph.D.

Admission to the Bridge program does not constitute admission to the Vanderbilt Ph.D. program, nor does it carry with it a promise of admission to Vanderbilt in the future. Program leadership did not want to create the appearance of a "back door" into the Ph.D. program, and we were also concerned that a guarantee of admission at the outset might encourage passivity both in the students admitted and in the faculty mentors responsible for preparing them.

The bridge from Fisk to Vanderbilt has been formalized so as to establish clear guidelines by which a student successfully "crosses the bridge" and to ensure clear lines of responsibility, accountability, and support. Each of the disciplinary tracks within the program (astronomy, biology, physics, and materials science) has explicit requirements for students to successfully make the transition from the Fisk master's program to the Vanderbilt Ph.D. program. These guidelines were approved by the respective deans at both universities:

- Graduate courses at both Fisk and Vanderbilt. Rationale: Demonstrating competency in core courses is essential to show promise for Ph.D. study. Requirement of at least B grades in all graduate courses, with at least one course a core Ph.D. course taken at Vanderbilt. Typically, Bridge students take several core Ph.D. courses at Vanderbilt. Together with a judicious selection of courses taken in fulfillment of the Master's degree at Fisk, many Bridge students complete most of the course requirements for the Ph.D. by the time they apply to the Vanderbilt doctoral program.
- An individual interview of each student by the Vanderbilt Director of Graduate Studies to supplement the student's Ph.D. application package. We find this interview gives

successful students a chance to impress the admissions director with their research achievements and career goals.
- Letters of support from the Bridge co-directors and from the Vanderbilt research mentors, to give a complete in-house picture of the transitioning student.

The single most important requirement is student-faculty research, and thus the program works to carefully match students with an appropriate pair of research co-mentors. Faculty research mentors provide key guidance on course selection and research topics, and also become the student's most important advocates in the Ph.D. admissions process. Students who are well known to the faculty of the admitting Ph.D. department are more likely to have their potential for success evaluated on the basis of direct and sustained faculty interaction, and not only on how the student appears "on paper." The resulting publication-quality Master's thesis develops these faculty relationships, and also demonstrates a readiness for Ph.D.-level work that is far more predictive of success than metrics such as the GRE.

Fostering individual research-based mentoring relationships between Bridge students and the graduate faculty is at the very heart of the Bridge program, and is the guiding principle for all other programmatic design considerations. Orchestrating these mentoring relationships requires strategic, ongoing effort at multiple levels. At the institutional, departmental, and individual faculty levels, we work continually to build, fund, and sustain research-based partnerships between Fisk and Vanderbilt faculty. At the student level, the Program monitors the research progress of students through a joint research advisory committee of both Fisk and Vanderbilt mentors. In addition, each student meets with the entire Bridge Program steering committee at least twice a year to review progress and receive guidance beyond the day-to-day interactions with primary joint faculty advisers. These meetings help to keep key personnel abreast of student progress, and helps Ph.D. program directors to plan for the needs of each year's incoming Ph.D. class.

III. THEORY OF THE PROGRAM

Members of the Fisk-Vanderbilt Bridge program participated in a collaborative research project with the Center for Institutional and Social Change at Columbia University, which helped us to identify, name, and expand on two concepts that are at the core of the Fisk-Vanderbilt Masters-to-Ph.D. Bridge Program. The first concept is that we must identify and enlist "unrealized or unrecognized potential" in students, which guides our recruitment and admissions policies. The second concept is that we can "cultivate potential" in students by supporting and emphasizing individual progress at critical junctures in the pathway to the Ph.D.

A. Identifying unrealized or unrecognized potential in students

Passively waiting for that rare candidate who stands out on paper by all of the usual metrics will not net a high yield of promising new students. As discussed by Dr. Richard Tapia in his 1999 address[20] to an NSF-sponsored summit on "Promoting National Minority Leadership in Science and Engineering," the usual approach, particularly in admissions, will not achieve the goal of broadening participation. He suggested that instead of merely competing with other highly ranked schools for the best students, truly broadening participation requires that we identify and support the "diamonds-in-the-rough that don't look like traditional candidates."[20] This pool consists of individuals who are talented and capable and can succeed given proper guidance, but who either have not been properly developed or properly evaluated. It is this pool that our traditional graduate programs have been missing. As Dr. Tapia pointed out, "They take special effort. They require mentoring, guiding, and sometimes remediation. They may make a slower start."

We have abandoned the usual mindset of filtering applicants on the basis of proven ability to one that identifies applicants with unrealized or unrecognized potential that can be nurtured. Recognizing this unrealized potential is not easy, because it takes a number of forms. For example, a student's undergraduate transcript might show a low grade point average (GPA) that, on closer inspection, reveals a slow start but a clear upward trajectory. Another might have an excellent GPA but is missing upper-level courses in the major because there were none available at the undergraduate institution. Still another might only have made a strong positive impression in person on a faculty recruiter during a poster presentation at a conference.

We have formed strong, positive relationships with colleagues at numerous minority-serving institutions who advise students to apply to our program. As we get to know these undergraduate programs better, we are able to make more informed evaluations about the strengths and weaknesses of incoming students. In a report studying strategies for building effective partnerships with minority-serving institutions, Stassun[10] found that undergraduate mentors at these institutions take a very active role in advising their students, and will actively steer their students away from graduate programs that they do not trust will nurture their students' success.

The Bridge program's focus on identifying and nurturing unrealized potential forces us to develop concrete knowledge, gained through experience and reflection, about the qualities that are needed to succeed as a research scientist, criteria for identifying those qualities, an awareness of the limitations of conventional merit criteria in selecting for these qualities, and an intuitive process for identifying and attracting candidates with these capabilities.

To select candidates with unrealized potential requires answering the question "Potential for what?" The Bridge admissions process explicitly searches for the qualities that will produce excellent researchers who will obtain Ph.Ds. and join university faculties, and/or will become high quality teachers who can teach diverse students, and/or will become leaders within the higher-education and scientific communities. Through reflective inquiry and extensive conversations with colleagues, we have identified the following markers for success in the Ph.D. program: Passion, strong motivation to succeed, intense drive, hard worker, willingness to take risks, ability to overcome hardship, leadership capabilities, collaboration skills, and the ability to succeed in the classes that serve as gatekeepers to the Ph.D. Many of these "soft" qualities take time to gauge.

One approach to identifying and recruiting promising students occurs at national professional meetings that attract minority students. At these meetings, Bridge program leaders seize the opportunity to organize and speak at research-oriented workshops, which positions us to identify potential candidates, interact with them about their research interests,

assess their potential, encourage promising students to pursue a Ph.D., and foster their interest in the Bridge program.

In this way the program uses face-to-face recruitment and selection as a common first step in the admissions process. We build relationships with potential students, grounded in research and premised on assessing the potential of motivated students to succeed as scientists. Once faculty members meet students who appear to be strong applicants for the Bridge program, we urge the students to apply, and then follow up with them at a later date. This effort to recruit and encourage candidates with potential is an extension of the program's dedication to redefining merit. We have also begun to use current Bridge students as recruiters at conferences. Bridge students attending conferences are given fliers and faculty cards to distribute to potential applicants, which serves to empower current students to recruit and connect.

As mentioned, the Bridge program evaluates students for admission holistically; the admissions committee does not use filters such as set cutoffs on GRE scores or GPAs. The Committee receives application packages from Fisk and meets to discuss the impressions of each candidate. The selection process includes:

- Direct interaction with a candidate, when feasible, through an interview, observation at a conference or workshop, or prior knowledge of the candidate as a student;
- Review of personal statement and letters of recommendation to determine whether the student has the work ethic and what one faculty member described as the "initiative, focus, and perseverance" to pursue a Ph.D.;
- Evaluation of performance in specific physics courses, rather than overall GPA and the GRE; and
- The applicant's community service, outreach, and interactions as an indicator of motivation, leadership, and long-term goals.

To better systematize the process of assessing applicants—especially in terms of their potential—we developed an outline of the process (see Appendix A in the online supplement[22] together with a worksheet that is used by the faculty during discussions of the applicant and especially during the critically important interview (see Appendix B in the online supplement[22]).

B. Cultivating potential in students

Having identified in each admitted student a potential for success, the program works to ensure that this potential is developed at or above that of the typical direct-admit Ph.D. student, thus ensuring student readiness and competitiveness for the transition to the Vanderbilt Ph.D. program. Because many under-represented minorities are first-generation Ph.D. students and are new to academic research culture, their success in academic science often requires more than just academic counseling. Hence, we provide mentoring in a variety of ways that might seem odd from the perspective of traditional graduate student advising, but which we have found are critical to student success. Specifically, we provide the following:

- Strong relationships with faculty mentors. The program actively develops, and the students report that they strongly value, faculty mentor relationships, particularly one-on-one discussions about research. These relationships serve to develop students' self-confidence, and open up professional networks and research opportunities. Students seek out faculty mentors about some or all of the following: Whether they should be in the program, identifying a research topic, selecting courses, asking for substantive help in a subject, getting feedback on presentations, finding summer internships, seeking guidance on research methodology and techniques, learning time management, and developing long-term goals. Faculty mentors do not limit their involvement to academic skill development. They identify and continually respond to the range of challenges facing their advisees, including existential and confidence crises.
- Peer mentoring and support. For incoming Bridge students, the program emphasizes the importance of a peer cohort and formal peer mentor relationships with more experienced Bridge students to help them gain access to informal knowledge, provide day-to-day accountability, help each other with skills development, and receive support at critical transition points.
- Research and presentation opportunities. The Bridge program provides an opportunity to develop research skills in the laboratory of a potential Ph.D. advisor at Vanderbilt. The emphasis on active learning, and presenting and receiving feedback about research is a crucial mechanism for skill development. Success in real research also is a mechanism to instill confidence, which Bridge students often report as one of the program's most important effects on them.
- Focus on integrating intellectual, time management, logistical, emotional, and social skills. The program leaders and staff also play a crucial role in developing actionable plans to achieve student and faculty goals; organizing, sharing, and linking information and activity; counseling and mentoring students, particularly in feeling supported, learning time management, and managing faculty relationships; pooling information and monitoring student progress; troubleshooting; and creating opportunities for interaction, collaboration, and social networking.
- Tools to share tacit knowledge. Students' participation in courses and research at Vanderbilt during the master's stage fosters creation of knowledge networks enabling students to navigate in a predominantly white research-based institution and to learn the unwritten rules of what makes for a successful Ph.D. student and scientist.
- Special attention to navigating critical junctures. The program guides students through critical junctions in the Masters-to-Ph.D. process, including orientation, successful completion of gate-keeping classes, defining a research focus, obtaining fellowships, presenting at academic conferences, and entry into the Ph.D. program.

IV. SUMMARY AND DISCUSSION

The two key strategies employed by the Fisk-Vanderbilt program—tapping the Master's degree as an important stepping stone to the Ph.D. for under-represented minority students and leveraging institutional partnerships with minority-serving institutions—can be emulated and adapted in other settings. The Program uses a variety of mechanisms to cultivate a truly mutual institutional partnership between Vanderbilt and Fisk:

- Research collaborations linking Fisk and Vanderbilt faculty and Bridge students are at the program's center. Faculty and department level partnerships are developed over

time, often from research collaborations that produce shared funding. These mutual relationships create the context for long-term commitments, learning from mistakes, explicitly stating and revising assumptions, and grappling (at least to some extent) with structural inequalities among the partners. Considerable time and energy has been devoted to cultivating working relationships between Fisk and Vanderbilt faculty.

- A combination of bottom-up and top-down support. The program leadership enlisted the support of high-level university leadership from the outset, while maintaining individual responsibility and accountability.

The Program has also begun a practice of reflective inquiry, in collaboration with the Center for Institutional and Social Change, to elicit and articulate the underlying "theory" concepts that have guided the program's design and that informs its evolution. In this paper we have focused on the concept that the Bridge Program is aimed at identifying, enlisting, and cultivating "unrealized potential" in its students. This concept has proved useful at both the philosophical level—what are we trying to accomplish with this program?—and at the operational level, leading to a process for identifying specific traits in students whose strengths we seek to nurture toward the development of successful scientists and future leaders (see Appendices A and B in the online supplement[22] for process guidelines and worksheets used in student admissions).

We are continuing to explore, identify, and articulate additional theory concepts that undergird the Fisk-Vanderbilt Bridge approach. One of these relates to the critically important challenge of day-to-day monitoring, trouble shooting, and crisis intervention. Building on the Center's concept of intervening at inflection points, we have termed this process as tracking the "second derivative" of student performance. The Bridge program has an informal but robust system for monitoring the progress of students' upward and downward trends in academic performance, research, and presence. We strive to intervene and bring resources to bear as early as possible. We do not wait until the level of performance has dropped below some critical threshold, nor do we wait for the slope of a student's trajectory to have changed downward. Rather, we look for the "inflection point" when we first detect evidence that performance may start trending downward. In a future paper we will describe our techniques for monitoring the second derivative.

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[1] As defined by the National Science Foundation, underrepresented minorities are U.S. citizens and permanent residents who identify as African American, Hispanic/Latino, and/or Native American.

[2] National Science Foundation, Division of Science Resources Statistics, "Women, minorities, and persons with disabilities in science and engineering: 2009," NSF 09-305 (2009), ⟨www.nsf.gov/statistics/wmpd/⟩.

[3] K. G. Stassun, Congressional testimony delivered to the U.S. House of Representatives Science and Technology Committee, 16 March 2010, ⟨http://people.vandervilt.edu/~keivan.stassum/KGStassun_Congressional Testimonty_30Jul2010_ revised.pdfscience.house.gov/publications/Testimony.aspx?TID=15370⟩.

[4] K. G. Stassun, "Building bridges to diversity," Mercury **34**, 22–27 (2005).

[5] D. Nelson and L. Lopez, "The diversity of tenure track astronomy faculty," American Astronomical Committee on the Status of Minorities in Astronomy, Spectrum Newsletter, June 2004.

[6] Minority-serving institutions include Historically Black Colleges and Universities, Hispanic Serving Institutions, and Indian Tribally Controlled Colleges and Universities, Native Hawaiian Serving Institutions, and Alaska Native Serving Institutions. See ⟨www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html⟩.

[7] D. Norman *et al.*, "Underrepresented minorities in astronomy: Higher education," A position paper submitted to the Astro2010 National Academy of Sciences decadal survey in astronomy and astrophysics (2009), e-print arXiv:0903.4506v1.

[8] Data from NSF WebCASPAR, ⟨caspar.nsf.gov⟩.

[9] S. Lange, "The role of masters degree transitions on Ph.D. attainment in STEM disciplines for students of color," Ph.D. thesis, University of Washington (2006).

[10] K. G. Stassun, "Enhancing diversity in astronomy: Minority-Serving institutions and REU programs: Strategies and recommended actions," Bull. Am. Astron. Soc. **34**, 1448–1452 (2003).

[11] See ⟨www.vanderbilt.edu/gradschool/bridge⟩.

[12] Council of Graduate Schools, "Ph.D. completion and attrition: Analysis of baseline demographic data from the Ph.D. completion project," (2008), ⟨www.PhDcompletion.org/information/book2.asp⟩.

[13] An article about the first Fisk-Vanderbilt Bridge Program Ph.D. recipient is available at ⟨sitemason.vanderbilt.edu/vanderbiltview/articles/2010/02/26/crossing-the-bridge.108290⟩.

[14] The biology track was added in 2008.

[15] Data source: American Institute of Physics, ⟨www.aip.org/statistics/⟩.

[16] See ⟨sitemason.vanderbilt.edu/myvu/news/2009/12/21/astronomer-receives-nsf-award-to-study-black-hole-evolution-and-to-support-fisk-vanderbilt-minority-PhD-program.102746⟩.

[17] K. G. Stassun, A. Burger, and S. E. Lange, "The Fisk-Vanderbilt Masters-to-Ph.D. Bridge Program: A model for broadening participation of underrepresented groups in the physical sciences through effective partnerships with minority-serving institutions," J. Geosci. Educ. **58** (3), 135–144 (2010).

[18] Each 90-minute seminar is divided into a formal presentation by a faculty leader followed by a social time for fellowship and informal mentoring. Topics covered in the formal presentations include time management, organization, and prioritization; setting and meeting goals; developing a network of mentors; milestones on the road to the Ph.D.; as well as other topics led by occasional guest speakers who are prominent scholars of color. In addition, postdoctoral researchers associated with the Bridge Program lead a reading group based on the book *The Art of Being a Scientist* (see Ref. 19).

[19] R. Sneider and K. Larner, *The Art of Being a Scientist: A Guide for Graduate Students and Their Mentors* (Cambridge U. P., New York, 2009).

[20] Available at ⟨ceee.rice.edu/meetings/LEADCON/⟩.

[21] See ⟨www.nsf.gov/statistics/srvydoctorates/⟩.

[22] See supplementary material EPAPS Document No. E-AJPIAS-79-004103 for Appendices A and B. This document can be reached via a direct link in the online article's HTML reference section or via the EPAPS homepage (http://www.aip.org/pubservs/epaps.html).