

A Bridge to the PhD for URM Students

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**North Carolina Central and North Carolina State Universities
Bridge-to-Ph.D. Program for Master's Underrepresented Minority Students**

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Abstract

The *Data-Enabled Science and Engineering of Atomic Structure (SEAS)* is an NSF-funded research traineeship program that focuses on training graduate students to do multidisciplinary research on materials characterization and production. SEAS is a collaboration between North Carolina Central University (NCCU), a historically black college/university, and North Carolina State University (NCSU), a predominantly white institution. The *Bridge-to-Ph.D. Program* is a component of SEAS that prepares underrepresented minority (URM) Master's degree candidates at NCCU for Ph.D. degree programs in STEM fields at NCSU or other doctorate-granting institutions. Bridge-to-Ph.D. supports academic and professional preparation of the trainees and includes elements in which trainees and doctoral candidates at NCSU jointly attend monthly seminars on selected technical and professional skills, multidisciplinary courses, and faculty-led mentorships, research studies, and laboratory rotations. Faculty advisors at NCCU and the SEAS program coordinator from NCSU work cooperatively to structure and provide additional professional development to the trainees, including sessions on succeeding in graduate school and successfully applying to Ph.D. programs. Relationships between the faculty and students at both institutions have been strong, and both doctoral candidates and trainees periodically present their research at meetings on both campuses. This presentation and paper will provide an overview of the challenges encountered and progress made in the first three years of the five-year Bridge-to-Ph.D. program.

Introduction

There are large disparities in the enrollment of African-American students in doctoral programs in the science, technology, engineering, and mathematics (STEM) fields, and consequent African-American underrepresentation in academia and the professional workforce. Historically black colleges and universities (HBCUs) play a significant role in producing African-American scientists. While in recent years African-Americans made up only 8% of STEM baccalaureate degrees awarded [1][2], approximately 20% completed their STEM undergraduate degrees at HBCUs [1], which constitute only 3% of the post-secondary institutions in the United States [3]. HBCUs have a rich history in training talented students in STEM disciplines and are important sources of future African-American science and engineering doctorate recipients [4]. Between 2009 and 2013, 24% of the African-Americans who earned doctorates in science and/or engineering received their bachelor's degrees from HBCUs. Additionally, recent studies have shown that African-American students are more likely than white students to matriculate through Master's degree programs before pursuing a Ph.D.[5][6]. Strategic partnerships between HBCUs few, if any, doctoral programs, and Ph.D.-granting institutions consequently have strong potential to increase the production of African-American STEM doctorates granted. Over the last two decades, several funding agencies have designated funding to specifically focus on broadening participation in STEM at the undergraduate and graduate levels, including National Science Foundation Louis Stokes Alliance for Minority Participation and Bridge to the Doctorate programs [7], Broadening Participation in Engineering [8], the National Aeronautics and Space Administration (NASA) Minority University Research and Education Program [9], and others. The NRT solicitation advances interdisciplinary research in data sciences and encourages projects that address underrepresentation in STEM. The NCSU-NCCU collaborative project utilizes NRT funding to expand on existing research collaborations and leverages resources to develop a formal inter-institutional pilot program that contributes to diversifying the STEM community.

The NCCU-NCSU Bridge-to-Ph.D. Program is inspired by the well-established, Fisk-Vanderbilt Masters-to-Ph.D. program, which aims to diversify enrollment in physical and biomedical science graduate programs [10][11]. Through it, Fisk students earn a Master's degree in biology, chemistry, or physics at Fisk University, a research-active HBCU, and along the way, gain research experience and are provided mentoring from Vanderbilt University faculty members. This program's success has been related to multiple interactions with Vanderbilt faculty in both research and coursework to facilitate successful transitions to Ph.D. programs at Vanderbilt and other institutions [12]. Other programmatic elements that have contributed to the success of this program include strong institutional commitments, good connections among faculty members at the partner institutions, and mentoring and social support of participating students [12]. Similarly, the NCCU-NCSU Bridge-to-Ph.D. program, hereafter referred to as *Bridge*, addresses the need for more diverse talent in STEM graduate programs at NCSU by capitalizing on current institutional relationships. NCCU Master's students in physics and mathematics are provided access to NCSU faculty, research experience, resources, and mentoring while completing their degrees. The program goal is to develop and pilot-test a model for preparing and successfully transitioning URM students into Ph.D. programs at research-intensive institutions. This is the first program of its kind between these two institutions. Herein, we briefly outline the programmatic elements along with successes and challenges in the first two years.

Program Model

The Bridge-to-PhD program is an extension of a collaborative project through the NSF Research Traineeship (NRT) on Data-Enabled Science and Engineering of Atomic Structure (SEAS). Managed at NCSU, the SEAS Traineeship is an interdisciplinary graduate research training program that immerses graduate students in multidisciplinary research at the intersection of statistics, data science, and materials characterization. Student participants (trainees) gain expertise in materials characterization and measurement and in the application of statistical methods to atomic-scale data generated from computational and analytical experiments. The program includes faculty and students in a number of STEM disciplines including, but not limited to, materials science and engineering, physics, chemistry, textiles engineering and chemistry, statistics, and mathematics. The traineeship consists of core courses and a suite of elective courses, co-curricular activities, professional development, and mentoring that supplement the research component of the program. The intent is to facilitate the development of the trainees' technical and communication skills, professional identities, and build professional networks. The NRT provides fellowship funding for trainees and strongly expects participation from non-funded trainees (students that participate in all programmatic activities and complete all requirements without NRT funding). Bridge trainees are integrated into all of SEAS activities and participate in specific programming that focuses of graduate school preparation and development. Some of the key elements that have worked favorably for this collaboration have been existing inter-institutional research collaborations and many of the enhancement activities. Conversely, challenges have been faced with recruiting students into the academic departments and maintaining consistent participation of STEM undergraduates as non-funded trainees.

NCCU is a research-active HBCU (~75% African-American) located in Durham, NC, with Master's degree programs in mathematics, physical sciences, and life sciences disciplines. In a 30-mile radius is NCSU, a research-intensive, Ph.D.-granting institution. As the largest university in the state, NCSU has top-ranked graduate programs in the Colleges of Engineering and Science. The two universities have other inter-institutional collaborations in 3+2 dual B.S. degree programs between the NCCU Physics Department and the NCSU Electrical and Mechanical Engineering Departments. Additionally, a number of NCCU physics and mathematics faculty members have collaborative research projects with NCSU's physics, materials science, and statistics faculty members, which is key to establishing and maintaining balanced and productive institutional relationships.

Recruitment. Internal and external recruitment efforts have been explored to garner interest in the Bridge program. Information sessions are held at the beginning of the year for NCCU undergraduate and Master’s students in math, physics, and chemistry programs. Though undergraduates are not eligible for funding through the Bridge program, they are able to participate as non-funded trainees given that the Master’s is the terminal degree offered in these disciplines. From the initial introduction seminar, two students applied to participate, and the following semester, an additional student joined the program. A seminar series was organized which hosts invited faculty and professional development workshops. Each seminar is advertised to students and faculty via posted flyers and email. It is our strategy to garner interest in the program by continuously hosting events and presenting opportunities students may take advantage of to advance their academic and professional careers. The number of students that have attended the seminar series activities are listed in Table 1.

Table 1: Cumulative number of participants in Bridge-related programs

Activity	SEAS Meeting at NCCU	NCSU Student Research Presentations	Faulty Research Seminars	Professional Development Seminars
Bridge Funded Trainees	3	2	3	3
Bridge Non-Funded Trainees	0	2	6	15
NCCU Faculty	2	2	9	3
NCSU Students	8	2	7	0
NCSU Faculty	2	0	1	0

External recruitment takes place at professional conferences targeted to URM students such as the Emerging Researchers National (ERN) Conference, National Society of Black Engineers (NSBE), and the National Organization for the Professional Development of Black Chemists and Chemical Engineers (NOBCCChE). Digital advertising is also published on websites that focus on broadening participation in STEM including pathwaystoscience.org, The National Alliance for Doctoral Studies in the Mathematical Sciences, and the National Society of Black Physicists (NSBP).

Financial Support. The availability of funding is important to the success of URM students in STEM degree programs [13][14]. Many URM students lack familial support or are impacted by responsibilities to provide for their families [15]. At the Master’s level, funding is limited and typically not competitive. Fortunately, through the NRT, fellowship awards support two (2) fellows per year at a \$34,000 stipend, tuition, fees, and support to present at professional conferences for a two-year term. Eligible students must have demonstrated a record of active engagement in Bridge activities for at least one semester. Additional graduate students can become Bridge trainees supported by non-NRT funding sources from the university or individual departments.

Curricular Activities. Bridge students complete coursework and graduate milestones as required by their respective programs. There is opportunity for students to enroll in the SEAS core courses in materials science and engineering, mathematics, and statistics as part of their curriculum through the Inter-Institutional Registration Agreement of the University of North Carolina System wherein dual credit is earned. This option is advantageous as we expect students to bridge to NCSU. Successful completion of courses at NCSU builds student confidence, increases awareness for their research, and demonstrates the student’s ability to handle doctoral requirements.

Research. Engagement in scientific research prior to Ph.D. studies strongly impacts academic achievement and persistence in doctoral programs [16]. Bridge trainees are required to pursue thesis Master's degrees. To foster faculty-student mentoring relationships, the thesis projects are co-advised with NCCU and NCSU faculty, which is a key element of the Fisk-Vanderbilt structure [10][12]. More of the mentoring relationships are described below. In addition to thesis research, Bridge trainees participate in the SEAS NRT Interdisciplinary Research Groups (IRGs), which are discussion groups that are utilized as research-based discussion groups for ongoing research projects, forums for invited speakers, tutorials, and workshops. Bridge trainees are expected to give presentations on data science applications of their projects. This exercise develops the student's communication skills in preparation for national conferences and other formal presentations.

Professional Development. To cultivate student skills beyond the laboratory, the Bridge program regularly hosts professional development workshops and seminars. Sessions occur during the academic year monthly at NCSU and bi-weekly at NCCU. Sample topics include:

- Exploring non-traditional careers and networking
- Communicating your science to diverse audiences
- Graduate student mental health and wellness
- Entrepreneurship
- Literature searches and library resources
- Writing personal statements
- Graduate school applications and fellowships
- Careers in Research and Development

Bi-weekly meetings held on the NCCU campus support one-on-one advising and mentoring of Bridge students. This allows us to focus on the development of students' identities in science and provide a safe space to ask questions or express concerns. Seminars and workshops have focused on the Bridge students' academic and research preparation for doctoral studies, as well as self-efficacy, study skills, time management, and preparation of graduate school and fellowship applications as mentioned above. NCCU faculty and staff co-facilitate these meetings and inform trainees of resources at their home institution.

Integration and socialization in the field is essential to the success of URM students in STEM disciplines [12]. Taking this into consideration, our Bridge students engage with their doctorate peers as much as possible and are members of professional societies in their fields. Bridge trainees have joined the National Alliance for Doctoral Studies in the Mathematical Sciences (Math Alliance). Through this Alliance, students are matched with faculty or graduate student mentors in the statistical sciences. Alliance mentees also attend the Field of Dreams conference where they meet their mentors face-to-face, and further establish the professional relationships.

Research Enhancement Activities. Providing role models has been identified as an effective mentoring strategy, particularly for students of color in STEM[16]. Therefore, research seminars showcasing faculty and researchers of diverse backgrounds are regularly hosted on the NCCU campus. The seminars are open to both universities and are co-sponsored with the NCCU Driving Research, Entrepreneurship, and Academics by Mastering (DREAM) STEM Project and funded by the NSF Historically Black Colleges & Universities Undergraduate Program (HBCU-UP). Faculty seminars have been given by a Georgetown University Associate Professor of Statistics, an NCCU Assistant Professor of Mathematics, and a Cornell University Associate Professor of Materials Science and Engineering. One seminar featured an impressive panel of African-American research faculty members from Duke (Clinical Research/Biostatistics), NC State (Industrial and Systems Engineering), and UNC Chapel Hill

(Operations Research), highlighting the various educational, research and career paths of STEM Ph.D.s and providing role models for the participating trainees.

Mentoring. A cornerstone of the Bridge program is the mentoring team that is assigned to each student, Bridge students benefit from having multiple mentors who may serve different roles, such as an advisor, advocate, or role model [17][18]. Each Bridge student forms an advisory committee, or mentoring team, that consists of a faculty member/thesis advisor from NCCU and an NCSU faculty member in the student's field of study, and the program coordinator. Extensive mentoring from multiple sources (peers, faculty at home and bridging institution, and staff) on a regular basis plays a significant role in the success of URM students when transitioning to large universities [11]. This committee meets at least once each semester to monitor the student's academic and research progress and identify areas of additional support. Informal interactions between the students and members of the committee also occur on a regular basis, which is an advantage of a smaller population of students.

Successes

Bridge trainees have had increased exposure and awareness of interdisciplinary research. These research experiences have resulted in a number of professional networking opportunities, including poster and oral presentations at regional conferences and symposia, access to academic and career professionals, and internship and research opportunities. One of our trainees completed a 10-week summer internship in data management, data science, machine learning and applications with industry partner Citrine Informatics. Trainees have presented at national and local conferences, networked with industry and academic professionals, and integrated with doctoral students at NCSU and beyond. The most notable success is the 100% acceptance rate of the Bridge trainees to Ph.D. programs. Two have been admitted to mathematics programs, and one to a biostatistics graduate program. The Ph.D.-granting institutions represent R1 and R2 institutions, including an HBCU, which can be related to the preparation efforts that have been taken for graduate school applications.

Challenges

There have been some challenges associated with recruiting students to the Bridge program and expanding its impact at NCCU. One issue has been the small size of NCCU's Master's programs in the mathematical and physical sciences. There are currently only eight mathematics and three physics students in those programs, some of whom are pursuing terminal Master's degrees. An increased focus has been placed to broaden participation beyond math and physics to chemistry Master's students and all physical sciences undergraduate students. The NCCU Department of Chemistry has an NSF-sponsored Partnerships in Research and Education in Materials (PREM) collaborative program with Pennsylvania State University, that engages in collaborative research throughout the academic year, and during the summer, NCCU students conduct summer research at Penn State. The Bridge program attended a PREM meeting to present on available opportunities to participate, particularly in the professional development workshops and research seminars. Additionally, we have initiated a STEM professional development series for all STEM undergraduates. Thus far, one seminar on Preparing Powerful Presentations has been held. This initiative is to motivate current undergraduates to pursue Master's degrees that could directly feed into the Bridge program. More seminars and an Open House are planned for the beginning of the Fall 2019 semester.

One Bridge fellow completed the Master's program at NCCU, and after being declined for admission to NCSU, was admitted to a Ph.D. program at another doctorate-granting university. His being denied admission to NCSU has alerted the project team to pay closer attention to expectations of targeted graduate programs and to help prepare the Bridge trainees correspondingly, including providing professional development in applying to Ph.D. programs, GRE preparation, developing and writing personal statements, and resume building. Additionally, the team will facilitate more direct interactions

between the Bridge students and the academic departments of the targeted Ph.D. programs earlier and more often.

Formative Project Evaluation

A professional program evaluator is conducting ongoing formative assessment of the project. The primary assessment mechanisms are (1) a pre- and post-program survey of all Master's level students at NCCU before the start of the project activities and at the end of Year 5, (2) yearly student feedback sessions to gather data on what is working well in the program and what could be improved, (3) exit interviews with funded Bridge students who complete the Master's degree from NCCU and go on to doctoral degree programs at NCSU or other research universities, or to employment in industry, and (4) interviews and surveys of faculty to determine their attitudes toward working with NCCU students.

The pre-program survey was completed in 2016 by 11 students from NCCU. More than half of the students indicated that family members were a major factor in the selection of their field of study and that financial support and location of the program were the main drivers of their selection of program and institution. Most indicated they had taken no coursework outside of their major discipline and that they had few contacts with faculty and graduate students outside of their home department. Most had never had the opportunity to present their research even at their own university or to mentor an undergraduate. In short, they were missing many of the opportunities that the Bridge program was designed to provide.

Yearly feedback sessions have yielded excellent comments from the Bridge students. In the most recent session in March 2018, three participating Bridge students provided face-to-face and written feedback. All three indicated that the Interdisciplinary Research Groups and support from the project coordinator were working well for them. They felt that they needed more support for the PhD admissions process and GRE prep, and the same sentiment was echoed in an exit interview with the first Bridge graduate who went on to another research university for doctoral work. When asked for comments about the program, they responded:

- *Overall super helpful and a great opportunity*
- *I feel like this program overall is a great opportunity. In both my years of graduate school my first year in SEAS has been amazing!!! SEAS keeps you busy and it's hard work, but it has been totally worth it!*
- *So far I have enjoyed my experience with the program. Though this is the end for me in the program, I feel that the program has potential to grow with both NCCU and NCSU.*

Conclusion

The Bridge-to-Ph.D. program component of the SEAS NRT has the potential to serve as a model of inter-institutional partnerships between HBCUs and R1 universities designed to increase the number of underrepresented minority students pursuing doctorates and academic careers in STEM. In three years, the program has experienced success in exposing students to interdisciplinary coursework, faculty, and professional interactions outside of their home disciplines. To date, all of the trainees have been accepted to Ph.D. programs, one at NCSU. It is too soon to discuss their progress in doctoral program at this point. Research enhancement, professional development, and mentoring have been integral to the success of the trainees. Adjustments were made in the GRE preparation and the graduate application process following the experiences of the first graduate. The acceptance rate of our current trainees represent those changes. We have begun to address recruitment into the program, by working with program directors of STEM programs and NCCU College of Arts and Sciences Academic Advisor to organize joint activities. Externally, we have advertised with organizations that focus on broadening participation in STEM.

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References

- [1] National Science Foundation, National Center for Science and Engineering Statistics. “Women, minorities, and persons with disabilities in science and engineering,” *Special Report NSF 17-310*. Arlington, VA, 2017. Available: www.nsf.gov/statistics/wmpd/ [Accessed March 8, 2019].
- [2] National Science Board. “Science and engineering indicators,” *National Science Foundation (NSB-2016-1)*. Arlington, VA, 2016.
- [3] M. Gasman and T-H. Nguyen, “Historically black colleges and universities as leaders in STEM,” Philadelphia, PA: Penn Center for Minority Serving Institutions, 2016.
- [4] National Science Foundation. “Baccalaureate origins of U.S.-trained S&E doctorate,” *InfoBrief NSF 13-323*. Arlington, VA: National Science Foundation, National Center for Science and Engineering Statistics. 2013. Available: <https://www.nsf.gov/statistics/infbrief/nsf13323/nsf13323.pdf> [Accessed: March 8, 2019].
- [5] S. Lange, “The role of Master’s Degree transitions on Ph.D. attainment in STEM disciplines for students of color,” Ph.D. thesis, University of Washington, 2006.
- [6] National Science Foundation, WebCASPAR. Available: <https://ncesdata.nsf.gov/webcaspar/> [Accessed: March 8, 2019]
- [7] <https://www.nsf.gov/pubs/2017/nsf17579/nsf17579.pdf>
- [8] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504870
- [9] <https://www.nasa.gov/offices/education/programs/national/murep/home/index.html>
- [10] K.G. Stassun, S. Sturm, K. Holley-Bockelmann, A. Burger, D.J. Ernst, D. Webb, “The Fisk-Vanderbilt Master’s-to-Ph.D. bridge program: Recognizing, enlisting, and cultivating unrealized or unrecognized potential in underrepresented minority students,” *American Journal of Physics*, 374(79), 2011.
- [11] <http://fisk-vanderbilt-bridge.org/>
- [12] S. Hurtado, J.C. Han, V.B. Saenz, L.L. Espinosa, N.I. Cabrera, O.S. Cerna, “Predicting transition and adjustment to college: Minority biomedical and behavioral science students’ first year of college.” *Research in Higher Education*, 48(7), 841-887, 2007.
- [13] V. Tinto, *Leaving college: Rethinking the causes of student attrition*. 2nd ed., Chicago, IL: The University of Chicago Press, 1993.
- [14] L. Horn and A.-M. Nuñez, *Mapping the road to college: First generation students’ math track, planning strategies and context of support*, Washington, D.C.: U.S. Department of Education, Project Officer Larry Bobbit, National Center for Education Statistics 2000-153, 86 p., 2000.
- [15] A. Hunter, S.L. Laursen, E. Seymour, “Becoming a scientist: The role of undergraduate research in students’ cognitive, personal, and professional development,” *Science Education*, 91(1), 36-74, 2007.
- [16] National Academies of Sciences, Engineering and Medicine. *Effective mentoring in STEMM: Practice, research, and future directions, Proceedings of a workshop - in brief*. Washington, DC. The National Academies Press. 2017.
- [17] D.J. Dean, “Getting the most out of your mentoring relationships,” *Vol. 3. Mentoring in academia and industry*, J.E. Bell, Ed. New York: Springer, 2009.

[18] National Academies of Sciences, Engineering and Medicine. *Adviser, teacher, role model and friend: On being a mentor to students in science and engineering*. Washington, DC. The National Academies Press. 1997.