LSAMP Bridges to the Doctorate: Preparing Future Minority Ph.D. Researchers through a Holistic Graduate Student Development Model

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NCLSAMP Bridges to the Doctorate: Preparing future minority Ph.D. researchers (PFMPR) through a holistic graduate student development model

Introduction

While there are initiatives, such as the Alliance for Graduate Education and the Professoriate (AGEP) embedded in universities across the country that focus on preparing the next generation of science, technology, engineering, and math scholars who are prepared to enter the STEM (Science, Technology, Engineering, and Mathematics) professoriate, there are fewer that include elements that focus on the STEM workforce beyond academia. The North Carolina Agricultural and Technical State University (N. C. A&T) is an active partner in the North Carolina AGEP, however, the BD (Bridge to the Doctorate), while supporting underrepresented minority (URM) students as they pursue a PhD, also supports the development of skills critical to career paths not focused solely on the academy. The BD, while supporting the development of URM students as they pursue a PhD in a STEM discipline, simultaneously focuses on career development and preparation in the first two years of the PhD journey, thereby putting in place a solid foundation that undergirds the academic experience with exposure to resources to strengthen personal and professional development. What is unique with respect to other programs such as the AGEP, the BD is not narrowly focused on PhD scholars who have decided to enter the professoriate. Thus, the BD in addition to providing opportunities to develop skill sets critical to the professoriate, also includes elements that focus on professional development skills and career exploration. This combined focus will allow BD fellows to broaden their perspective of career opportunities and develop professional skills that will be critical to their career success. To our knowledge this is one of the few initiatives that has this bilateral focus for graduate students across STEM disciplines. With less than 30% of STEM PhD's entering the professoriate, we are intentionally assuring that BD Scholars are also aware of the breath of opportunities that are available beyond the professoriate.

The goal of this preparing future minority Ph.D. researchers (PFMPR) BD Program is to prepare a cohort of 12 LSAMP BD Fellows to persist in STEM Ph.D. programs at N. C. A&T. Three core objectives include: (1) Enroll a cohort of 12 verified LSAMP scholars into STEM graduate degree programs at N.C. A&T; (2) Implement a comprehensive program that prepares, retains, and enables BD Fellows to successfully undertake STEM doctoral programs; and (3) Provide support to BD Fellows beyond BD funding in preparation for graduation and career. This program integrates culturally reflective mentoring and professional development specifically designed for Black, Latinx, and Indigenous Ph.D. students. This holistic graduate student development model includes academic and professional skill-building for STEM careers alongside targeted support for pursuing fellowship opportunities, including the NSF Graduate Research Fellowship.

The theoretical framework for our model is based on social cognitive career theory (Lent et al., 1986). This is foundational to our program because it builds on the idea that the higher the perceived self-efficacy to fulfill educational requirements and occupational roles, the wider the career options people will seriously consider pursuing (Lent et al., 2004; Lent et al., 2010). The greater the interest in these career opportunities, the better people will prepare themselves

educationally for succeeding in challenging career pathways (Bandura and Locke, 2003; Maton et al., 2016).

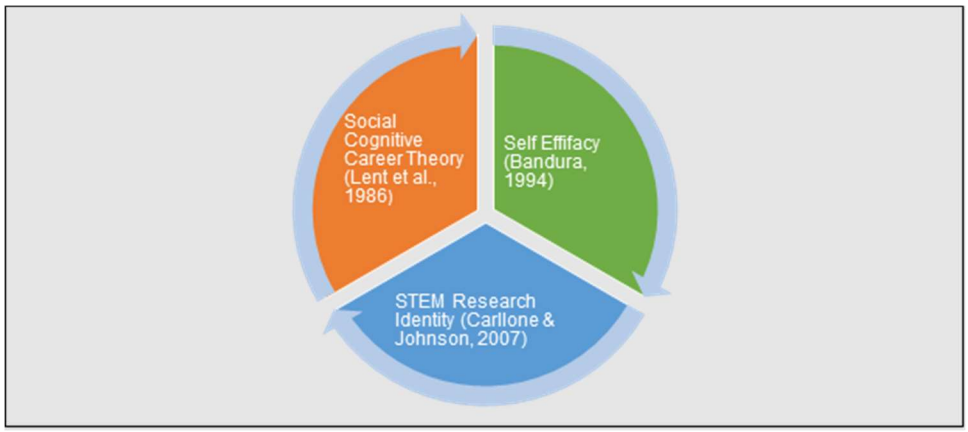

Figure 1: The Bridge to the Doctorate theoretical framework. Each component has defined actions which will accomplish the goals of each domain.

N.C. A&T, a member of the North Carolina Louis Stokes Alliance for Minority Participation STEM Pathways and Research Alliance (NC-LSAMP SPRA) — a senior alliance (founded in 1992) comprised of eight University of North Carolina (UNC) system institutions—is pleased to submit this proposal to serve as a 2022-2024 Bridge to the Doctorate (BD) site. The largest historically black college and university (HBCU) in the nation, N.C. A&T has invested considerably in its Graduate College in recent years, from launching new doctoral degree programs across STEM disciplines to establishing wraparound support initiatives that help our graduate students build science identity and competencies for careers both within and beyond academia. An 1890 land-grant doctoral research institution with a distinction in STEM and commitment to excellence in all disciplines, N.C. A&T faculty, staff, students, and alumni create innovative solutions that address the challenges and economic needs of North Carolina, the nation, and the world. With an enrollment of more than 13,000 students, it is the largest HBCU in the country, the number one producer of degrees awarded to African Americans in North Carolina and is nationally recognized for excellence in STEM education. N.C. A&T brings a considerable track record in helping students feel that they truly belong and can participate fully as high-achieving scholars engaged in transformative learning, interdisciplinary research, and civic outreach. Our legacy has been especially powerful among Black students at the undergraduate level, and in recent years, as the institution repositions itself to strategically pursue the R1 Carnegie research classification by 2030, N.C. A&T has strengthened the student experience for graduate students and for students from other underrepresented minority backgrounds. BD students will be recruited into this culture and challenged to excel in all aspects of the graduate school experience in cross-campus collaboration with departments and programs in the College of Agriculture and Environmental Sciences, College of Science and Technology, College of Engineering, and the Joint School of Nanoscience and Nanoengineering.

N.C. A&T has played an important role in increasing the number and enhancing the quality of URMs in STEM academic and workforce communities. The University is committed to the success and sustainability of our professoriate training model and is working to significantly

increase the number of students completing doctoral degrees. During the 2019-2020 academic year, 387 master's and 66 doctoral degrees were awarded. Forty-three (65.2%) of the doctoral degrees were awarded in STEM, of which 39.4% were awarded to URMs and 35% to women. Over a six-year period, N.C. A&T has awarded a total of 314 doctoral degrees, including 204 doctoral degrees in STEM, 134 to women, and 139 to URMs. Building on past strategic successes, the University's current strategic plan—*A&T Preeminence 2023: Taking the Momentum to 2023*—sets several goals relevant to developing competitive graduate student training programs. Of note are Goal 3, "Position the university to be a national, premier research-intensive, doctoral, science and technology-focused learning institution," and Goal 5, "Foster a more diverse and inclusive campus community by promoting cultural awareness and collegiality, and by cultivating respect for diverse people and cultures." To that end, the University has committed resources—in the form of tuition awards, faculty positions, mentorship training, and career readiness competency-based professional development initiatives—to enable the Graduate College to double the number of students enrolled in and graduating from our doctoral programs by 2023.

Recruiting Strategy

Historically strong in engineering, N.C. A&T has made strategic investments in graduate programming supporting our efforts to recruit students working in several STEM fields and at their intersections. We now have nationally notable strengths in nanotechnology, data analytics, data science, computational data science, artificial intelligence, machine learning, cybersecurity, entrepreneurship, advanced manufacturing, and more. Most of our doctoral programs are in STEM, including Computational Data Science and Engineering, Computer Science, Electrical Engineering, Industrial and Systems Engineering, Mechanical Engineering, and Nanoengineering. N.C. A&T also offers a doctoral program in Applied Science and Technology with available concentrations in applied chemistry; applied physics; atmospheric, environmental and energy science; bioscience; data science and analytics; information technology; STEM education; and technology management. N.C. A&T continues to expand its doctoral programs; in January 2021 the University of North Carolina System Board of Governors approved our request to establish a Ph.D. in Agriculture and Environmental Sciences, slated to enroll its first students in Spring 2022. Three key recruitment strategies that have proven to be useful are described below:

Strategy 1: Navigate students to enroll in target doctoral programs. BD Fellows are recruited to matriculate in Ph.D. programs in four N.C. A&T colleges: The College of Engineering, College of Science and Technology, Joint School of Nanoscience and Engineering, and College of Agriculture and Environmental Sciences. These colleges were selected because they all have Ph.D. programs in STEM disciplines. Target doctoral programs in the College of Engineering include:

- Computational Data Science and Engineering
- Computer Science
- Electrical Engineering
- Industrial and System Engineering
- Mechanical Engineering.

BD Fellows in the College of Science and Technology will pursue a Ph.D. in Applied Science and Technology with concentrations in:

- Applied Chemistry
- Applied Physics
- Atmospheric, Environmental, and Energy Science
- Bioscience
- Information Technology
- STEM Education,
- Technology Management

JSNN is a joint school with N.C. A&T and UNCG offering graduate degrees in Nanoscience and Nanoengineering. BD Fellows from the Joint School of Nanoscience and Nanoengineering (JSNN) will enroll in the Ph.D. in Nanoengineering housed at N.C. A&T. The new Ph.D. program in Agriculture and Environmental Science, beginning Spring 2022, is also available for BD Fellow enrollment.

Strategy 2: Targeted recruitment activities. Considering past lessons learned regarding the additional pressures faced by master's to doctorate students who are juggling coursework and graduate school this program has recruited students who are interested in entering a doctoral program directly from their baccalaureate degrees. Anecdotal data has shown us that students who enter Ph.D. programs from their B.S. degree, have a strong commitment to completing the Ph.D. and therefore do not discontinue their studies after the M.S.

N.C. A&T's national recruitment plan is currently underway and leverages the recruiting infrastructure of our alliance institutions and others in our national network of LSAMP programs to ensure that our BD cohort reflects both disciplinary and demographic diversity. Thus far, we have leveraged personal connections with LSAMP students through outreach to LSAMP administrators at N.C. A&T, across our alliance, in the region, and in the nation. Our recruitment materials and communications emphasize the benefits of graduate education at N.C. A&T and the unique opportunities in the Bridge to the Doctorate program.

In the light of our institution's strategic plan to both grow graduate enrollment and to create an environment supporting diversity, equity, and inclusion, we are actively working to attract Latinx and Indigenous students. Recognizing that we have limited experience in recruiting and mentoring Latinx and Indigenous students, we are leveraging partnerships with two minority serving institutions to undergird our efforts and to improve the effectiveness of our activities. These institutions are assisting with our recruiting activities but also advising on our student support and retention strategies. While these institutions are potential direct sources of Latinx and Indigenous students for the PFMPR BD program, they also engage with our project team to improve our overall understanding of how to best serve students from these populations. These collaborative relationships are vital to the well-being of students and success of the program. We want to ensure that the relationship is mutually beneficial.

Strategy 3: Broad spectrum and digital recruitment activities. In addition to leveraging the institutional relationships described above, we will infuse LSAMP recruiting across N.C. A&T's many existing recruiting activities. These activities include attendance at approximately 57 Graduate Career Fairs (in-person or virtually) each year to connect with potential students. In the state of NC, recruiting happens at approximately eight public or private institutions and several peer institutions from the UNC System. Our recruiting activities typically span approximately 17 states and include HBCUs, R1, and R2 institutions. We also recruit at discipline-specific events,

i.e., the ACM Richard Tapia Celebration of Diversity in Computing, the National Society of Black Engineers Conference, and the Society of Women Engineers Conference. We also attend the annual NC LSAMP Research Symposium and engage in NC-AGEP events.

Each year, The Graduate College hosts an event called "Visit A&T Graduate College Day." This is a major recruiting activity (held on campus or virtually) in which we invite outstanding students from other institutions to come to our university to learn more about our programs. When it is conducted on campus, the Graduate College covers the cost of travel for prospective students to attend the event. For this event, we target academically gifted students enrolled in the Honors programs at their institution of higher education. Selected participants in this event are offered an application fee waiver, expedited application processing, and an assistantship which covers the cost of tuition, fees, health insurance, and a monthly stipend to attend graduate school. We will leverage this event and the BD funding to recruit students from other LSAMP programs for the PFMPR program.

In addition to direct, in-person recruitment activities, we will expand our reach to prospective students by promoting our program heavily through our websites and social media. A dedicated website for the BD program will provide details about eligibility requirements, the application process, and the benefits of the program (along with the general strengths of N.C. A&T's graduate programs, research activity, and professional development). The website will include an interest form so prospective applicants can leave their contact information for personalized follow-up. We will use information from this form along with contact information gathered from in-person recruitment events to generate a BD listserv, which can be used to continue to inform prospective students and faculty/administrators about the program.
Social media campaigns launched on platforms such as Twitter™, Facebook™, and Linked-In™ will provide other channels of connection with prospective students and other stakeholders. We will leverage the services of our existing external vendor, which directs our graduate-level social media marketing efforts, to continue to build ads and other collateral that attract potential students to our programs. In addition to the social media marketing campaigns that will be launched, we will leverage other recruiting strategies of The Graduate College to promote the PFMPR program. During each recruiting cycle, The Graduate College teams with the Office of University Relations and other external vendors to use search engine optimization, graduate program aggregator websites, text messaging, and targeted ads for increasing enrollment.

Students interested in the program will be given a QR code or web address to our application portal and a website with more information about the program. As well as a website that has more information about the program. Once the student has found the portal, they enter demographic and contact information (e.g., Name, email address, etc.). Students are also asked to answer questions regarding their participation in the LSAMP program during their undergraduate matriculation. The student is asked to upload a copy of a resume or CV, an unofficial transcript, a letter of recommendation and submit a three-page maximum personal statement. Application assessment procedures include reviewing the materials to ensure that the student is a US citizen, they did participate in LSAMP as an undergraduate student, that they are eligible for direct entry into one of the STEM PhD programs outlined in the grant and a review of their personal statement to gauge interest in graduate studies. If all the criteria have been met

the prospective student is sent an offer letter detailing the award and noting that the funding is contingent upon them being accepted to one of the eligible STEM Ph.D. programs.

Workshop descriptions

Table 3: Core Competencies for Academic Success and Career Readiness (adapted from National Association of Colleges and Employers)

Competency	**Description**
Career Development	Preparing yourself for the job market; understanding how to position yourself for success; understanding how to market yourself to potential employers.
Communication	Developing skills in oral and written communication; strengthening communication skills across informal and formal settings.
Disciplinary Expertise & Interdisciplinary Connections	Gaining command of the core content of your discipline; understanding how disciplines relate to one another (including potential opportunities for collaborative research).
Entrepreneurship	Learning how to turn your interests/knowledge into new entrepreneurial ventures.
Global Awareness and Cultural Sensitivity	Seeing the big picture on a global scale; understanding political and economic trends and their impact on your field/career; learning to understand and respect cultural differences.
Leadership and Management	Honing your ability to effectively lead others to perform at their best; developing skills in managing teams and breaking down complex tasks.
Personal Development	Finding the balance between school/work and home life; learning more about yourself (your personality/nature); developing coping mechanisms and strategies for being your best self.
Research	Understanding the best practices and ethical implications of advanced research.
Teaching	Developing skills in relaying knowledge/information to others; understanding how people learn; using assessment tools to track successful learning.

Professional Development Activities for BD Fellows. Table 4 presents the workshops planned for BD Fellows to support professional development as they progress through each year of a doctoral program.

Table 4: PFMPR Workshops/Seminars

Year	**Title**	**Competency**	**Deliverable**
1	Summer Fellowship Application Preparation Program	Research	NSF GRFP Research Proposal
	Creating an Individual Development Plan	Disciplinary Expertise & Interdisciplinary Connections	Individual Development Plan
	Managing Time and Priorities	Personal Development	Weekly Schedule

	Effective Research Presentation	Communication	Poster for Graduate Research Symposium
2	Strategies for Publishing Your Dissertation Work	Communication	Dissertation chapter or conference publication submission
	Cultural Competency	Global Awareness & Cultural Sensitivity	Report discussing global impacts of the student's research
	How to Prepare for a Job in Academia	Career Development	CV and cover letter
3+	Effective Teaching and Learning	Teaching	Serving as a teaching assistant
	Change Management	Leadership & Management	Leadership Assessment Results
	Lab Notes for Clarity and Intellectual Property Protection	Entrepreneurship	Invention disclosure or description
	Preparing Future Faculty Symposium		Develop an e-portfolio promoting the student's research.

BD Fellows have access to a myriad of additional professional development opportunities offered by the Graduate College at A&T. They can participate in workshops offered as a part of the Strengthening Historically Black Graduate Institutions (HBGI) grant program sponsored by the Department of Education, the Accelerate to Industry (A2i) program, the North Carolina Alliance for Graduate Education and the Professoriate sponsored by the NSF, and other activities and workshops offered by the Graduate College. The HBGI program hosts an annual symposium covering topics specifically related to Ph.D. students in engineering and the sciences. The A2i program hosts a series of workshops promoting "Job Search Strategies" throughout the academic year and "Industry Immersion Week," involving several days of direct student interaction with our corporate sponsors. At the end of the week, the Graduate College hosts a mini career expo for graduate students only. Each spring the Graduate College sponsors a symposium titled "Preparing Future Faculty." Finally, BD Fellows can participate in the Annual Graduate Research Symposium and compete in the Three-Minute Thesis (3MT) competition for a cash award.

Student support (finance)

An important aspect of this program is the support students will receive financially. This is of critical importance because one of the key factors or influences that prevents students from completing graduate degrees is the shortfall of financial packages provided. This often leaves students with an outstanding bill and requires them to seek additional employment, often away from their laboratory or campus in general. Such jobs can in fact reduce the critical time spent working on research or studying. To address this problem, the program will offer a stipend and funding applied towards educational costs for the first two years the student is in the program. It is expected that after those first two years, the student will be supported by funds from their adviser or by securing additional fellowships. We believe participants in this program will have improved chances of securing additional fellowships due to the workshops provided.

Goals of assessment methods.

Our assessment plan maps on to the three core objectives of this intervention and our theoretical framework. Our program objectives are (1) Enroll a cohort of 12 verified LSAMP scholars into STEM graduate degree programs at N.C. A&T; (2) Implement a comprehensive program that prepares, retains, and enables BD Fellows to successfully undertake STEM doctoral programs; and (3) Provide support to BD Fellows beyond BD funding in preparation for graduation and career. Our theoretical framework, further described above, values (1) self-efficacy, (2) science/research identity, and (3) social cognitive career theory model to recruit, enroll, and graduate 12 LSAMP Fellows with STEM doctoral degrees. Our goals, then, are to (1) evaluate our intervention's success on the three stated objectives and (2) measure the stated constructs within the theoretical framework to test our theory of change.

Approach to assessment.
Evaluation of the BD Program will utilize both internal and external expertise. This collaboratively managed evaluation will have a mixed-methods approach emphasizing the design of several survey instruments administered at regular time intervals for both formative and summative assessment of program outcomes. Data will be analyzed specifically to the two goals previously stated and presented to NC-LSAMP SPRA Governing Board annually for review and input. The project leadership team will form an internal team charged with collecting and analyzing both formative and summative measures to assess overall success.

To complement these efforts and ensure legitimacy and rigor of the evaluation plan, we have also secured a local external evaluation firm with extensive expertise in evaluating science training grants. Strategic Evaluations, Inc. (SEI) has committed to serving in this complementary capacity to ensure the design and implementation of our evaluation is highly effective. This external evaluator was chosen for several reasons, including the fact that they are also the lead evaluator for the NC-LSAMP SPRA, giving them a strong understanding of the context in which our BD training efforts sit. In a similar approach to our internal evaluation efforts, and to provide feedback in a manner that allows the project leaders to assess and make necessary mid-project adjustments, the external evaluation team will prepare formative summaries in the years in which the team collects survey and interview data. The formative summaries will include stakeholders' recommendations for improvement, as well as broader suggestions based on the evaluation team's experience. In addition to working with the project staff to ensure appropriate measures are being tracked, the external evaluation team will also assist the project staff in structuring quasi-experimental design studies to better document the summative impacts outlined above, particularly those helping to provide evidence that this intervention positively impacts student motivation, academic performance, and persistence.

Assessment procedures.
Questionnaires for collecting quantitative data from stakeholders will include an Internet-based feedback form for research mentors/PIs to complete as well as pre-, post-, and exit surveys for Fellows to rate the quality and usefulness of program components and to self-assess key constructs within our theoretical framework (i.e., growth in motivation, self-efficacy, and science identity). While these important program tenants will be evaluated internally, the mentoring components will be done with the external vendor Mentor Collective. Qualitative data will be collected to document the quality of the program's implementation and the magnitude of the outcomes, particularly the impact of mentoring and program support. When appropriate, these

data will be collected through focus group interviews with Fellows, program alumni, and bench mentors/PIs. All interviews will be guided by established protocols that our IRB will review and approve. Survey data will be stored and analyzed in SPSS, while all interview data will be transcribed, coded, and analyzed in Atlas.ti for themes.

Assessment measures.
The following subsections will detail individual measures and approaches by intervention objective and construct within our theoretical framework.

Objective 1: Enroll a cohort of 12 verified LSAMP scholars into STEM graduate degree programs at N.C. A&T. To measure our success on this objective, the internal team will document each recruitment effort that specifically engages NC-LSAMP and national LSAMP communities, including project year, date, location, costs, and reliance on partnerships and alumni networks. We will also analyze copies of all applications, including geomapping of addresses to determine where students reside, gender and ethnicity breakdowns, and if targets are being met. Finally, we will determine the total number of students who apply to be BD Fellows, disaggregated by recruitment events and analyze aggregate recruitment data across the entire project and perform logistic regression to determine which recruitment variables most contributed to the successful recruitment of Fellows.

Objective 2: Implement a comprehensive program that prepares, retains, and enables BD Fellows to successfully undertake STEM doctoral programs. Our internal team will analyze collected records to report the number of mentors, their approaches, and their specific efforts to make mentoring culturally reflective. This will include annually document topics, attendance, and duration for all project-sponsored training. We will also collect both surveys focus group data with mentors and Fellows to document the impact of the program on academic performance and persistence, including successes and challenges each group identifies. We will then utilize this mixed-methods data to determine the success of the culturally reflective mentoring efforts and their impacts on Fellow success. Finally, we will analyze (1) aggregate mentor/mentee data across the entire project, (2) aggregate lessons learned on preparation, matches, and effectiveness of support provided by mentors and (3) year-to-year persistence rates for Fellows and rates of acceptance to Ph.D. programs.

Objective 3: Provide support to BD Fellows beyond BD funding in preparation for graduation and career. The internal evaluation team will document both fiscal and mentoring that all Fellows receive, post time in BD Program. We will also survey alumni Fellows to document the extent to which they felt supported by the BD Program after they enrolled in a doctoral program. As previously described, we will collect both quantitative survey and qualitative data in the form of annual focus group interviews with Fellows to document the impact of the Summer Fellowship Application Preparation Program on leadership skills. We will analyze aggregate records for determining the percentage of Fellows and amount of support provided during doctoral candidacy and document year-to-year fellowship submission/acceptance rates

Construct within Theoretical Framework 1: Self-efficacy. Self-efficacy will be measured in concordance with previous research (Bandura, 1994) by focusing on the following

operationalizations: (1) mastery of experiences in overcoming obstacles, (2) Modeling and mentoring and (3) Physiological and emotional milestones. All operationalizations of self-efficacy will be measured with current Fellows via survey (Bandura, 2006).

Construct within Theoretical Framework 2: Science/research identity. Similarly, we will collect ongoing survey data from Fellows that focuses on competence, performance, recognition (Carllone & Johnson, 2007; McDonald et al., 2019)).

Construct within Theoretical Framework 3: Social cognitive career theory. Finally, key concepts within social cognitive career theory will be measured, specifically career interest development, actions to implement choices, performance outcome and assessment (Karcher, 2003; Dweck, 2006).

Anticipated Results

The N.C. A&T BD Fellows program will significantly impact the retention and graduation rates of underrepresented minority STEM graduate students in our doctoral programs, thus producing a diverse workforce of STEM professionals. As the largest HBCU in the nation, N.C. A&T educates a substantial number of URMs at the undergraduate level and thus has a tremendous opportunity to launch, test, and refine a framework of support for transitioning these students into doctoral programs. Through this intervention and evaluation of intervention, we are producing a model that can be evaluated, refined, and disseminated to other LSAMP BD institutions. Materials from the program recruiting, mentoring workshops, and the structured fellowship application process will be disseminated freely to contacts at other LSAMP institutions and other minority-serving institutions similar to N.C. A&T, located throughout the country. Materials will also be posted on the project website, along with videos and photographs from project events. It is expected that these results will be made available within one academic year after the closeout of this initiative. Also, we will develop and maintain a presence on social media to better leverage current and future partnerships (e.g., the Verizon IL program and the R2 HBCU Graduate Dean's Consortium). Strategies and outcomes of this project will also be published in peer-reviewed journals and shared in conference proceedings.

Conclusions

The N.C. A&T BD Fellows program is prepared to significantly impact the retention and graduation rates of underrepresented minority STEM graduate students in our doctoral programs. In the short term, this will increase the diversity of the workforce of STEM professionals within the US. Moving forward, this model can be evaluated, refined, and disseminated to other LSAMP BD institutions.