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Abstract

The Texas A&M University System (TAMUS) received funding from the National Science Foundation (NSF) for a Louis Stokes Alliance for Minority Participation (LSAMP) project in 1991 as one of the six initial awardees. As part of these efforts and upon reaching eligibility, the TAMUS LSAMP applied for and received additional funding to support a Bridge to the Doctorate (BTD) program. BTD programming provides financial, educational, and social support to incoming STEM master's degree and PhD students for the first two years of their graduate study. BTD cohorts consist of up to 12 fellows who participate in a program of academic and professional development seminars and workshops. In project evaluation, annual interviews were conducted with the TAMUS BTD participants, the vast majority of whom were underrepresented minorities (92%). During the interviews, the BTD students were asked to discuss ten topics some of which addressed concerns specific to the implementation of the BTD project. This report considers answers provided in the five topic areas which have broader applicability: 1) the learning achieved by participants through participation in BTD, 2) the personal impact of participation in BTD, 3) the influence of BTD on informants' educational goals, 4) the influence of BTD on informants' career goals, and 5) barriers the BTD participants perceived to pursuing a PhD. Eighty project participants responded to the questions between 2009 and 2018. They were from eight distinct cohorts of BTD students and represented 32 different areas of STEM specialization. Qualitative analysis of their responses confirmed that students perceived the elements of the TAMUS BTD project to be efficacious and that there was a set of nine seminars from which participants consistently reported benefit. Additional findings were eight key areas in which learning was reported by participants, four areas in which the programming had personal impact, five influences on educational goals, nine impacts on career goals, and a detailed list of barriers graduate students who are underrepresented minorities (URM) perceive to pursuing a doctoral degree. The proven and easily replicated pattern of support programming, the demonstrated results of this programming, and insight into barriers URMs perceive to pursuing a STEM doctorate are immediately applicable to URM graduate student support at many institutions of higher education.

Introduction

"The underrepresentation of people of color in science, technology, engineering, and mathematics (STEM) has become a crisis of significant proportion" (Alfred, Ray & Johnson, 2018, p. 114). This circumstance led Sharkawy to describe the limited presence of degreed members of minority groups in the STEM workforce as "one of the most challenging problems for science education researchers and policymakers" (2015, p. 657). Federal agencies offer grant programs targeting this concern like the National Aeronautics and Space Administration's Minority University Research and Education Project programs (2018) and the United States Department of Education's Hispanic-Serving Institutions – Science, Technology, Engineering or Mathematics and Articulation Program (2019). The National Science Foundation (NSF) has also sought to address this situation in a number of ways including sponsoring Louis Stokes Alliance for Minority Participation (LSAMP) programming since 1991. Longstanding LSAMP awardees may apply for Bridge to the Doctorate (BTD) funding. NSF describes BTD programming as:

> Two-year projects eligible only to existing alliances funded 10 or more consecutive years. These projects are focused on providing post-baccalaureate fellowship support to a cohort of 12 LSAMP students for the first two years of their STEM graduate studies and providing the necessary academic

> and research skills that will enable them to successfully earn STEM doctoral degrees and transition into the STEM workforce (National Science Foundation, n.d., para. 12).

As part of efforts to support the success of STEM minority students, Texas A&M University (TAMU) has conducted both LSAMP and BTD initiatives. This article addresses outcomes from the TAMU BTD project as areas of learning identified by participants, the personal impact of BTD participation, the influence of BTD on participants' educational and career goals, and degree completion rates. In addition, a group of barriers BTD participants perceived to continuing on to a PhD are described.

Applicable Literature

Need for STEM Professionals

According to the Bureau of Labor Statistics, computer and mathematical occupations accounted for 3.5 million jobs in 2010—with a projected growth of 778,000 new jobs by 2020; architectural and engineering occupations are expected to add 252,800 new jobs by 2020, and health care practitioners and technicians are expected to experience more growth than any other occupational group, adding 2 million new jobs by 2020 as the third fastest growing occupation group (Lockhart & Wolf, 2012). In addition, Robinson (2010) concluded there would not be enough professionals, especially minorities, to answer the call for this anticipated growth (Collins, 2018, pp. 144-145). These trends are the backdrop for the National Science Foundation, US Department of Education (US ED), and other federal agencies' programs to increase the number of students involved in STEM study, especially minority students (e.g., LSAMP, HBCU-UP, HSI STEM, NASA MUREP). NSF notes that addressing this concern is "critical to a nation's progress" (NSF, 2018, p. ii):

> It is the scientists, engineers, researchers, and scholars who create and share new knowledge and new ways of thinking that lead, directly and indirectly, to innovative products, services, and works of art. In doing so, they contribute to a nation's economic growth, cultural development, and rising standard of living (NSF, 2018b, p. ii).

In addition, "As highlighted in the 2018 Science and Engineering Indicators report, the number of non-STEM jobs requiring STEM skills is now on par with the number of STEM jobs" (NSF, 2018a, p. i). Therefore "broadening participation in the science, technology, engineering and mathematics (STEM) workforce" (NSF, 2018a, p. i) is a major commitment of the agency and other federal agencies (NASA, 2018; US ED, 2016).

Underrepresentation of Minorities in STEM Fields and Doctoral Programs

Even with the need for minority involvement in STEM to fill growing demand for trained workers, "White males make up the majority of individuals identified as scientists or engineers in the United States" (Collins, 2018, p. 145). Citing data from the National Center for Science and Engineering Statistics, Linley and George-Jackson note that in "the STEM fields, three racial and ethnic groups are underrepresented: African Americans, Native Americans, and Latinos" (2013, p. 97). "These…groups comprised 12 percent of life science doctorate recipients, 10 percent of engineering doctorate recipients, and 7.8 percent of physical science doctorate recipients in 2011" (Linley & George-Jackson, 2013, p. 97). Yet, 12.6% of the American population classified themselves as African-American in 2010 (Infoplease, n.d.) and the US Census Bureau noted that Hispanics became the "nation's largest ethnic or racial minority" (2012, para. 2) in 2011, reaching 16.7% of the total population.

This pattern of underrepresentation of minority students in STEM preparation at universities continues. A survey conducted for the Bayer Corporation, found that "URMs are still sorely underrepresented in both introductory and major/upper division STEM courses" (2012, p. 320) at the undergraduate level. These students represent the cohort of candidates from which graduate students would be recruited following 2011, the year of the statistics Linley and George-Jackson (2013) cited. The department chairs responding to the Bayer survey noted that "only 16% of the STEM degrees their departments will grant this year [2012] will be to African-American, Hispanic and American Indians students, compared to the 83% of STEM degrees that will go to majority STEM students" (Bayer Corporation, 2012, p. 320). Despite such a limited candidate pool, NSF reports (2017, 2018) chronicle increases in participation in STEM doctoral programs by minorities in the last ten years. The proportion of doctorates awarded to African Americans has increased by 1 percentage point, from 6% to 7%, awards to Hispanics are also up to 7% from 5%, and awards to American Indians remain under 1% of the total. Yet even with these increases, awarding less than 15% of all STEM doctorates to representatives of 32.8%

of the total population (US Census, 2018) is substantial underrepresentation. This circumstance exists despite the vast majority of STEM department chairs in the Bayer Corporation survey agreeing "that increasing the number of women (83%) and URMs (90%) in both STEM education and the country's STEM workforce is an important national need" (2012, p. 319) and while "most (84%) believe the issue is important to their institution's chancellor/president" (2012, p. 319).

Underrepresentation of Minorities in Faculty and Administrative Roles

The TAMUS LSAMP BTD program seeks to prepare participants for "academic careers" (Texas A&M University, 2017, 2017a, 2018, 2018a) at colleges and universities. This is due, at least in part, to the underrepresentation of persons of color in the professorial ranks and in administrative roles. For example, the percentage of Hispanic and African-American faculty and administrators at U.S. colleges and universities is not proportional to the percentage of Hispanics and African Americans in the nation's population. In August 2019, the Chronicle of Higher Education performed an analysis of figures from the U.S. Department of Education's Integrated Postsecondary Education Data System regarding full-time instructional faculty at U.S. two-year and four-year degree-granting institutions. In the fall of 2017, there were a total of 710,968 full-time instructional staff with faculty status in higher education (Chronicle of Higher Education, 2019). Of these, 77.0% were White, while 6.1% were African-American and 5.1% were Hispanic. In contrast, African-Americans and Hispanics accounted for 13.3% and 17.8% of the U.S. population, respectively, in the 2016 US Census figures (National Science Foundation, 2017), and were estimated to be 13.4% and 18.3% in 2019 (US Census Bureau, 2019). In recognition of these deficits, colleges and universities are actively striving to improve the ethnic diversity of their personnel, particularly in leadership positions (Bilimoria & Buch, 2010).

This concern is also frequently addressed in the literature of higher education. There is an on-going discussion of the underrepresentation of minorities and women in the professoriate and administration. The topics considered are diverse. Examples include statements of opinion (Knight, 2010; Poloma, 2014), reflections on experience (Peguero, 2018; Beard & Julion, 2016; Meyer & Warren-Gordon, 2013), the history of and theory relevant to the situation (Wolfe & Dilworth, 2015; Lewis & Olshansky, 2016), documentation of challenges within a discipline (Haizlip, 2012; Mowatt, Johnson, Roberts & Kivel, 2016), concerns related to an ethnic or racial group and/or gender (Gonzales, Murakami & Nunez, 2013; Murakami & Nunez, 2014), descriptions of proposed interventions and best practices (Lechuga, 2012; Zambrana, Ray, Espino, Castro, Douthirt-Cohen & Eliason, 2015; Lewis & Olshansky, 2016), and recommendations for advancing toward ethnic and racial diversity (Bilimoria & Buch, 2010; Greene, Lewis, Richmond, Stockard, 2011; Haizlip, 2012). The topics covered in the data and related findings of this study, as presented below, inform several of these categories but will be focused most strongly on the last three.

Barriers to Doctoral Study by Minority Students

Because minorities are underrepresented in STEM and in roles in higher education that require doctoral degrees, research has been completed regarding factors that might contribute. As Collins (2018) notes, researchers in this area attribute the inequity in representation and persistence to a complex web of factors. Weng and Gray summarize elements of this web as "structural inequalities, marginalization, discrimination, minority stress, and lack of support" (2017, p. 662). An example of how the first three of these factors can interact follows.

In higher education, "values, norms, ideas, perspectives, beliefs, and behaviors originated and spread from European countries are what are considered to be the norm that defines human reality despite the diverse backgrounds of members of the university community" (Weng & Gray, 2017, p. 664). This can leave students feeling marginalized (Longwell-Grice et al, 2016; Zamudio-Suarez, 2017) and pressured to conform to patterns they do not understand or value (Johnson, 2017). These feelings can be exacerbated by well-intentioned faculty and staff whose communication can include unintended biases (Lee, 2017), who assume students understand the culture of higher education (Lee, 2017), and that students' values align with the expectations of the system (Johnson, 2017). It is, in fact, possible for "first-generation students [to] get the message that they are not only less typical members of their college communities, but also less legitimate ones" (Lee, 2017, p. 30). The result can be perception of the institution's environment as stressful and unwelcoming (Lee, 2017; Weng & Gray, 2017). Along these lines, "Studies have also found non-dominant racial and ethnic students to be more likely to experience racism, discrimination, and prejudice" (Weng & Gray, 2017, p. 665), overtly (Garcia & Johnston-Guerrero, 2016) or as microaggession (Sue et al, 2007; Perez, Garcia-Louis, Ballysingh & Martinez, 2018), all

of which can lead to pronounced cognitive and cultural dissonance (Longwell-Grice et al, 2016) and even health problems (Lee, 2017; Ghose, Ali & Keo-Meier, 2018).

Many factors are believed to contribute to the underrepresentation of students of color in advanced STEM study including their being "overrepresented in schools and colleges that are unable to offer either the academic guidance or the classes that appropriately prepare students for admission tests and graduate careers" (Ghose, Ali & Keo-Meier, 2018, p. 266). Others suggested are the interplay of "gender, sexuality, class, and socioeconomic status" (Ghose, Ali & Keo-Meier, p. 266) commonly referred to as intersectionality (Charleston, Adserias, Lang, & Jackson, 2014; Pertuz, 2018), stereotype threat (Good, Aronson & Harder, 2008; Nguyen & Ryan, 2008), challenges with sense of belonging (Good, Rattan & Dweck, 2012; Grapin, Bocanegra, Green, Lee & Jaafar, 2016), the racial climate of the institution (Solorzano, Ceja & Yosso, 2000), an absence of mentors and role models due to low numbers of minority faculty and a related lack of support and mentoring (Weng & Gray, 2017; Ghose, Ali & Keo-Meier, 2018), the absence of a minority-student peer group (Ghose, Ali & Keo-Meier, 2018), institutional structures and programs that fail to address minority student needs (Bayer Corporation, 2012), lack of information about disciplines, specializations, and institutional supports (Hadinger, 2017; Lee, 2017), and a sense of growing experiential and relational separation from family (Marrun, 2015: Longwell-Grice et al, 2016; Patton, 2017). The sense of relational separation from family can be coupled with family members having limited understanding of and appreciation for students' purposes in attending graduate school, their commitments and accomplishments in graduate school, and the long-term benefit of a graduate degree (Longwell-Grice et al, 2016; Patton, 2017).

TAMUS LSAMP Bridge to the Doctorate Programming

The Texas A&M University System (TAMUS) received funding from the National Science Foundation for a Louis Stokes Alliance for Minority Participation project in 1991 as one of the six initial awardees. As part of these efforts and upon reaching eligibility, the TAMUS LSAMP applied for and received additional funding to support a Bridge to the Doctorate (BTD) program. The funding supports STEM graduate students during the first two years of their graduate studies. The TAMUS LSAMP has facilitated BTD programming since 2003, a total of 13 two-year awards. Texas A&M University was the host organization for 12 of these efforts.

While the TAMUS LSAMP BTD program had a continuous improvement orientation in the nine years under consideration, a general pattern was present. First, the program objectives remained uniform:

> (a) Retention of Fellows into doctoral programs with funding after completion of the NSF BTD program, (b) Preparation to meet the challenges of completing doctoral programs of study and for possible academic careers in higher education, and (c) Leadership skill development necessary to succeed as young URM professionals upon completion of doctoral programs of study (Texas A&M University, 2017, 2017a, 2018, 2018a).

There was also a uniform approach to project activities. Each year included:

> a focused set of activities designed to assist students in developing the skills needed to succeed in their courses, learning from participation in research activities, providing leadership and mentoring for undergraduate URM STEM students, and establishing professional and collegial networks (Texas A&M University, 2017, 2017a, 2018, 2018a).

In the nine years under consideration, the skill development activities consisted of 41 different learning initiatives, 31 of which were one-hour seminars. Between 12 and 15 seminars were offered each academic year and a core group of topics was achieved through a winnowing process. The initial offering of seminars was refined by maintaining seminars which BTD cohorts noted they found helpful. Seminars BTD cohorts continued to note as being of practical assistance or that they found particularly beneficial were updated as necessary and repeated with each successive cohort. New topics were added based on potential to fill gaps in information available to graduate students or expand the horizons of the participants. Seminars that were rated low for usefulness by the students, or for which suggestions for improvement were received from participants during annual evaluation activities, were addressed in three ways. Many were modified to improve the content, some were combined, and others were eliminated. This participant-informed process of winnowing and revision included practical (e.g., financial management), psychological (e.g., stress management and the QPR suicide prevention training), health and wellness (e.g., diet and exercise), resource (e.g., library services), and academic (e.g., scientific writing) emphases.

Most of the seminars were invited lectures by faculty, administrators, and staff from specialized TAMU programs and support centers. For example, a series of lectures were provided to participants to assist development of applications for fellowships and other awards to fund continued study following their two years of BTD support. This has been positioned in several ways in the program but for the most recent TAMU BTD cohorts, the fellowship application lecture series has been administered during the first summer of the BTD program. The summer series begins with lectures that highlight components of successful applications. Later sessions provide students with individual reviews of their application statements and subsequent revisions. After an extended period refining these seminars, they were recorded for playback and live-stream access to off-campus participants and use with students from other campuses.

In addition to invited speakers, project personnel for the TAMU BTD undertaking were among the TAMUS staff and administrators who conducted seminars. In particular, semester wrap-up and welcome back seminars were conducted by project leaders. The semester wrap-up seminars were interactive with BTD students discussing their research and course progress, successes, challenges, and plans for the upcoming semester. At welcome back seminars, BTD alumni (students who had completed two years in the BTD program and who were still enrolled at TAMU) were invited to join the active BTD cohort so that they might become a part of the personal networks of the active participants, to offer support and suggestions, and, in so doing, to strengthen the BTD community on campus.

Over time, a core set of seminars were identified. A group of nine seminars, the core set, were offered to each of the 13 cohorts. These were: (1) orientation, (2) time management, (3) financial management, (4) stress management, (5) the library as a research tool, (6) success in graduate school, (7) fellowship personal statements, (8) fellowship application packages, and (9) what I wish I knew (i.e., retrospective consideration by former graduate students). Combined with four other areas of emphasis, mentoring, active research, presentation at conferences, and a requirement to apply for fellowships and other awards to fund continued study following the two years of BTD support, they comprise the basis of the TAMU BTD efforts.

Mentoring, research, presentation of research findings, and pursuit of research funding function collectively in the program. "BTD Fellows [are] assigned a more senior graduate student mentor….the BTD alumni [provide]…guidance" (Texas A&M University, 2017, 2017a, 2018, 2018a) based on their experiences in graduate school and with the BTD program. A secondary motive was for the former participants "to groom the BTD Fellows to be mentors for…[the next cohort of] incoming BTD students" (Texas A&M University, 2017, 2017a, 2018, 2018a). Each BTD participant also had an official research advisor under whose supervision they conducted research as part of a team or on individualized projects as applicable. And in addition to research supervisors/principal investigators, each BTD participant sought out or was assigned a faculty mentor. Participants met with this party

> to get advice on their experience in academia and industry and to learn about the series of events that led…[the individual] to where they are currently. The goal of this informal mentorship…for the BTD students [is] to have an additional faculty member [from whom] to gain experience and direction other than their official research advisor (Texas A&M University, 2017, 2017a, 2018, 2018a).

This multi-party approach to mentoring (BTD staff also provided counsel to participants) was integrated into and paralleled the research, funding, and dissemination commitments of the students. Together, they formed a program providing opportunities for learning in a variety of settings and patterns about the expectations and processes of graduate study, resources available to graduate students, and best-practice approaches. The consistency in TAMUS LSAMP's underlying approach to BTD programming provided to first-and second-year STEM graduate students, some pursuing master's degrees and others PhDs, made it possible to assess learning achieved by participants, personal impact, influence on educational and career goals, and barriers to completing a PhD across multiple cohorts.

Research Focus and Method

Focus

A review of qualitative data from nine years of interviews sought to identify key areas of learning for minority students in STEM graduate study, specifically those resulting from BTD programming, and the impact BTD programming had on participants personally and on their educational and career goals. The review also aimed to identify barriers BTD participants, the vast majority of whom identified as underrepresented minorities (URM), recognized as they considered continuing study toward STEM PhDs. These topics are highly relevant for

colleges and universities across the United States because underrepresentation of racial minorities and women in science, technology, engineering, and mathematics disciplines is a national concern (Bayer Corporation, 2012; NSF, n.d.; NSF, 2018; US ED, 2016) and programming that can encourage them to persist in graduate programs would prove valuable to many institutions.

Student Informant Population

The TAMUS LSAMP BTD participant pool from spring of 2009 through spring of 2018 consisted of 98 persons. Eighty of these individuals participated in interviews, most in both years of their BTD participation. This resulted in 147 interviews in a nine-year period (several students withdrew from the program or did not complete an interview in one year). It was impossible to divide interviews into first- and second-year groups or to associate two interviews completed with one person based on the very limited demographics gathered and the purposeful disassociation of interview transcripts from the records of interview appointments. However, the researchers did not consider this a deficit in the data set as most students participated twice and those who did had a year of additional graduate and BTD program experience about which to comment when they reached their second interview. As a result, students had the opportunity to describe new experiences, additional learning, and new insights in the second conversation.

Among the 98 students participating in the TAMUS LSAMP BTD between 2009 and 2018, there were 50 males and 48 females. They were all science, technology, engineering, and mathematics graduate students in the first or second year of master's or PhD degree programs. The exact ethnic and racial distribution in the interview informant group is unknown, although they were drawn from the larger TAMUS LSAMP BTD pool with high participation levels every year. During the period under consideration, the program served 90 students who identified as members of minority groups (16 African Americans, 1 Asian, 69 Hispanics, 1 Native American, and 3 Hawaiian/Pacific Islanders) and five students who did not communicate a racial identity. This made the population from which the sample was drawn at least 92% underrepresented minorities. Thirty-two distinct STEM disciplines are known to have been represented in the interviewee group although more may have been present (this question was not asked in 2014-2015 and was dropped in 2016-2017).

Epistemological Stance

A social constructivist orientation (Liu & Chen, 2010) was taken regarding the data and its meaning. The intention was to access and communicate the TAMUS LSAMP BTD participants' point of view regarding the project in five areas of interest. Doing so required recognition that each informant's experiences, understanding of them, and assigned meaning(s) were influenced by factors unique to him/her. In hopes of accessing both individual and shared understandings in the BTD cohorts and then accurately portraying them, a broad spectrum of data was employed (material from interaction with 80 distinct individuals across nine years of project implementation) and the researchers adopted an observing orientation rather than an interpretative one (i.e., reliance on transcripts, quotes, and use of informant-generated phrases when coding and summarizing). Participants were asked about specific forms of meaning, value, and helpfulness found through participation in a set of experiences directly identifiable with the BTD project. These experiences were provided to eight cohorts in two-year cycles with two distinct cohorts operating in nearly every year of the study. This represents sampling in distinct bands of time and related to delimited experience. The presence of eight distinct cohorts and repeated cycles of activity suggest that the data is broad and can represent BTD relevant influences as multiple waves of participants acted as informants regarding participation in the same initiative. The ability of these adult participants to differentiate BTD activity from other experiences they had in higher education during the period under consideration supports the notion that the responses provided can be seen as BTD specific.

Data Gathering and Coding

External evaluation of processes and outcomes were part of the project activity with the West Texas Office of Evaluation and Research (WTER) providing the project evaluation services from 2009. These services included Institutional Review Board (IRB) approved human subject research, a significant portion of which was annual interviews with the BTD participants. Material generated documenting the interviews conducted with TAMUS LSAMP BTD participants from 2009 to 2018 were utilized to prepare this account.

The interviews conducted by WTER were scheduled with the participating master's and PhD students each year by the BTD leadership team. They usually occurred in April. In the nine-year period under consideration, the IRB-approved interview protocol was completed face-to-face on the TAMU campus and by telephone. The Executive Director of WTER conducted all the interviews. This was Judy Kelley for the first eight years and Dr. Michael Preuss in the ninth year. All interviews were recorded, following participant approval, so that subsequent qualitative analysis of the content could be completed.

One hundred and forty-seven one-on-one interviews were conduct with active TAMUS LSAMP BTD participants. Six interviews were conducted with BTD alumni in 2014-2015, but they were not included in the data set. The interviews were semi-structured using a scripted set of questions but allowing for follow-on questions as needed. The majority of the interviews, 136, were conducted by one person, Judy Kelley. Ms. Kelley was the Executive Director of WTER. She retired in the summer of 2017 and was replaced by Dr. Michael Preuss. He completed the interviews in the 2017-2018 school year, a total of 11. Both Judy Kelley and Dr. Preuss were third parties operating outside project-supported opportunities for participants eliminating the potential that informant responses were impacted by existing relationships with the interviewer or influence that person had at the student's institution.

Qualitative data from interviews with the TAMUS LSAMP BTD participants were analyzed on an annual basis to prepare a report in ten topic areas for the project team. Very limited demographic data was gathered as the intention was to provide opportunity for participant comment on processes and programming without allowing the project team to recognize the source of a comment or suggestion even though the informant pool in each year was small and all of the members interacted regularly with members of the project team. Demographics for the BTD participants from 2009 on were requested from the TAMU project leadership to prepare this presentation. The limited demographic material in the interview records was combined with the material provided by the TAMU team to arrive at a description of the informant cohort.

All the BTD STEM graduate students were asked to elaborate on ten topics, some of which address concerns specific to the implementation of the BTD project. This report considers answers provided in the five topic areas which have broader applicability. These topics are: 1) the learning achieved by students through BTD participation, 2) the personal impact of participation in BTD, 3) the influence of BTD on informants' educational goals, 4) the influence of BTD on informants' career goals, and 5) barriers the BTD participants perceived to pursuing a PhD. The answers in the interview transcripts to questions asked regarding these topics were reviewed by Dr. Preuss in the spring of 2018. This review involved sorting and recoding of data. The recoding was completed using NVivo software but was done inductively, rather than using the automated functions, was performed without reference to the prior categorization of the content, and employed a constant comparative approach (Kolb, 2012). Dr. Preuss utilized informant-provided phrases to code items communicated as having meaning or value related to each of the five topics above or created summarizing labels (codes). He regularly read and re-read the passages grouped by code and the coded texts themselves to verify consistency in sorting and categorization and to arrive at appropriate and accurate representations whether using words provided by informants or summaries of those. Student comments were considered in context and could include reference to more than one construct in a clause or sentence. When this was the case, the passage was assigned several codes.

The coding of the BTD material was performed by one person, Dr. Michael Preuss. Thus, inter-relater reliability concerns do not apply. Once completed, Dr. Preuss reviewed all his coding twice line-by-line to check for errors. Several were found and corrected. These were starting a duplicate thread and erroneous placement of statements. Following this, a control for personal bias was completed. All coded content was provided to two third-party reviewers who read it looking for incorrectly categorized content or apparent bias. None was reported.

Limitations

As the coding was completed by one person, his preferences and biases could have influenced the outcome. Third-party checks of the codebook against the coded texts were employed to address this concern. Two persons completed reviews independently and reported no evidence of bias. A second limitation is the information presented comes exclusively from the TAMUS BTD efforts rather than several BTD projects hosted by other LSAMP alliances. However, the TAMUS project was conducted like all other BTD undertakings with applicants accepted from across the United States, 32 distinct STEM majors were represented in the respondent pool, and the data set included a large number of informants (80) who were participants in the BTD cohorts

across a nine-year period. The informant data is sufficiently broad to represent TAMUS BTD, the TAMUS project is similar to other LSAMP BTD projects across the nation, and the graduate STEM education environment at Texas A&M University follows patterns common in education of STEM master's and PhD students in US higher education. Thus, the results of the investigation are generalizable to other colleges and universities.

Program Success: Degrees Completed

The TAMUS BTD program has had remarkable success in identifying URM candidates for advanced study and motivating them to complete STEM master's degrees and PhDs (Table 1). Eighty-six of the 133 participants between 2003 and fall of 2018 (65%) initiated PhD programs following their two years in BTD. For the 70 participants in the first nine cohorts who matriculated to PhD programs after BTD program completion, 52 have completed doctoral degrees with an additional 28 still progressing towards their doctoral degrees as of December 2019. That 80 out of 133 initial participants (60.2%) have completed or are still pursuing a doctorate is a remarkable success rate and, taken together with the interview statements regarding education goals, suggests that the TAMUS BTD programming pattern is efficacious.

Table 1. Master's Degrees and Doctorates Completed in the TAMUS BTD Program

		Master's Degrees		Doctorates	
Cohort	# in Cohort	MS in Progress	MS Completed	PhD in Progress	PhD Completed
2003-2005	10	-	-	-	10
2004-2006	13	-	12	1	3
2006-2008	12	-	11	-	7
2008-2010	13	-	1	-	10
2010-2012	12	-	7	-	6
2011-2013	12	-	7	-	5
2012-2014	12	-	3	2	6
2013-2015	12	-	6	3	2
2014-2016	12	-	6	2	3
2015-2017	12	-	6	8	-
2016-2018	13	1	4	8	-
2018-2020	12	7	-	4	-
Totals	145	8	63	28	52

In the table, combined counts of students completing master's degrees and PhDs in a row might total more than the initial number of cohort members (see 2004-2006 and 2006-2008). This is the result of some students completing master's degree programs and then advancing to PhD work rather than starting their involvement with BTD as a PhD student. There was one student in the 2004-2006 cohort who took time away from study but subsequently returned to pursue a PhD. Nearly all of the students in the most recent cohorts are continuing study.

Description of the Codebook

The codebook developed from the interview data consists of five primary categories of content: 1) academia, 2) career preparation, 3) impacts, 4) relationships, and 5) skills. This listing was generated through inductive, open coding (Kolb, 2012) of the interview transcripts. The categories, themes, and threads from the codebook are presented below in outline form. Within each of the broad categories there are a number of distinct themes (i.e., barriers, how to enter academe, perspective, and specific characteristics in the category Academia). Several of the themes also have associated threads (e.g., the listing of barriers identified). Each theme and thread employs verbiage provided by the informants. Several of the five categorical titles do as well.

The codebook was derived from comments made in response to queries regarding learning achieved in or through BTD, personal impact, influence of BTD on informants' educational and career goals, and perceived barriers to continuing on to a PhD. Yet, the breadth of content extended beyond those topics and makes this

outline of the BTD participants' comments an instructive finding in and of itself. It lists the support that was found helpful by 80 URM graduate students studying in at least 32 STEM fields across a nine-year period, the areas in which project participants felt they experienced significant learning or were impacted by the project programming, and barriers to successful completion of a PhD reported by the students. As such, it can be used as a planning tool for graduate school support programming with URM students studying in STEM fields.

I. Academia
- A. Barriers
  - i. Assumed knowledge or skill
  - ii. Confidence
  - iii. Continued funding
  - iv. Finding a location or sponsor
  - v. Gender
  - vi. Graduate Advisor
  - vii. Life balance
  - viii. Missing role models
  - ix. Motivation
  - x. Needed skills
  - xi. None
  - xii. Personal sacrifice
  - xiii. Publication
  - xiv. Qualifying exam(s)
  - xv. Relationships
  - xvi. Research and results
  - xvii. Rigor
  - xviii. Stress
  - xix. Time to complete
  - xx. Time management

B. How to enter academe
- C. Perspective
  - i. Expectations
  - ii. Possible roles and responsibilities
  - ii. Processes
- D. Specific characteristics
  - i. Competitive
  - ii. Underrepresented minorities and academia

II. Career Preparation
- A. CV/resume
- B. Funding
- C. Job seeking
- D. Planning
- E. Publication
- F. Reason for PhD
- G. Value of graduate degree

III. Impacts
- A. Change in perspective
  - i. Employment opportunities
  - ii. First-generation student gaps
  - iii. Life direction
  - iv. Underrepresented minority identity
- B. Confidence building
- C. Facilitation of important processes
- D. Hidden curriculum
- E. Inspiration
- F. Motivation
- G. New paths
- H. Personal learning

i. Regarding institutional resources
- I. Value of the scholarship

IV. Relationships
- A. Encouragement/support
- B. Interdisciplinary
- C. Learning from peers
- D. Mentoring
- E. Networking
- F. Relations to family
- G. Research advisor
- H. Role models
- I. Sense of community
- K. With other students

V. Skills
- A. Communication
- B. Financial management

C. Interview skills
D. Networking
E. Professional presentation
F. Publication
G. Stress management
H. Time management
I. Work life balance
J. Writing
    i. For publication
    ii. Proposal writing
    iii. Thesis/dissertation production

The outline above summarizes the ideas present in the transcripts but to construct an overall and less compartmentalized description, informant comments were grouped in the five topic areas about which the interview questions asked. Each theme and thread in the outline above is addressed employing, to the greatest degree possible, the words of the informants to facilitate accurate, authentic recounting. Quotes from several informants are interwoven to form or support the assertions made.

Findings Regarding Learning Achieved by Participants

Many of the BTD seminars focused on practical knowledge and skills necessary for PhD students and academicians. Of the skills discussed, participants identified eight as areas of key learning. These were, in alphabetical order: 1) communication, 2) financial management, 3) networking, 4) professional presentation, 5) publication, 6) stress management, 7) time management, and 8) writing.

The learning achieved in these areas was something the students had not anticipated would happen as part of their involvement in BTD. Some "had not given much thought to any of these things (i.e., the topics of the seminars) before BTD." Some had the feeling that they simply would not have time "to really develop those areas to be a well-rounded person" or that they might have to learn them "on my own." Others were encouraged to be active in ways they had not previous considered ("Before BTD, I would have never thought about doing that."). Of interest, participants stated that the learning achieved in these areas increased confidence in their abilities to represent themselves appropriately and well in a wide variety of settings, from interactions with peers to dinners with recruiters and prospective PhD advisors, in all forms of professional presentation, and in their ability to successfully navigate the various realms of activity for a graduate student. It is also worth noting that all of the areas of learning were, as one student said, "things I would not get from my department." Several students reported being envied by their departmental peers who came to rely on them for practical insights from BTD seminars that weren't available to the general graduate student population ("My peers just have not had that kind of support.").

That simple seminars on topics of practical concern to graduate students might receive such positive endorsement from eight cohorts of minority graduate students, and become the envy of their peers, is both an accolade for the project and a suggestive pattern. That students were confident they would not have been provided guidance in these areas without BTD is a clear condemnation of the support institutions of higher education provide to graduate students and aligns with one of the barriers to minority student success in graduate study in STEM the BTD informants identified, assumed knowledge or skill. Had the items noted been areas of interest or need for one or even several cohorts but not universally, there should have been a mixture of positive, hesitant, or even negative comments. That was not the case suggesting that a set of seminars in the eight areas noted by the TAMUS LSAMP BTD participants might prove to be an effective support system for minority graduate students in STEM fields. As one student stated, "it has still been very challenging to stay in a PhD program, and I might have quit without BTD and the tools they have equipped me with."

Findings Regarding Personal Impact of Participation in BTD

I Am Not Alone

Students noted that the TAMUS LSAMP BTD, a combination of a cohort of similar students (minimum 92% URM) and support programming, impacted them as minority and as first-generation college students. "I might have quit without BTD….I felt alone but realized that I really wasn't." "Minorities have a place [in

academia…BTD] helps me to feel like I am not alone. It's really good to be part of a network of students of diverse background." "I learned that having the opportunity to network with people who …were in the same situation as me was very helpful in staying motivated and focused on my goal." An associated result was a feeling that "My professors and my co-students are really a good team, and I feel comfortable here."

Revelations about Areas of Need and Interest

TAMUS LSAMP BTD participants noted being surprised by some areas of impact. "Some things that I didn't think would be helpful to me personally have turned out to be helpful. I was surprised that the…seminar actually turned out to be helpful." Statements of this type listed many different areas of learning, such as a stress management seminar, information about publishing research findings, information about specific practices or expectations in higher education, etiquette, interview skills, and the value of networking.

Participants experienced gestalt moments in respect to personal planning and long-term goals ("…BTD seminar that talked about planning your long-term goals which really opened my eyes to consider everything that I am doing now as the basis for my future"), "weakness[es] I have that would limit my research," "about career options," and even possible configurations for career trajectories ("I learned about professors who came back later for their PhDs and then became professors. So that helps me to know that going into industry does not close the door for getting a PhD in the future"). They stated that these revelations were "really…helpful." Many of the things they listed "focus on career development and…see[ing] all the different paths both before and after the PhD." However, revelations regarding interests also occurred.

One student realized "how much I enjoy research and being around other people doing research." A colleague expanded on this saying "BTD…allowed me to have my own project and that has showed me how much I love research. I wasn't that sold on research based on my experiences as an undergraduate. But I know now that I want to have a career in research." Other students concurred. "I didn't know much about research before BTD, but now I see myself as a researcher. Having the BTD funding to support a research experience has made the difference." The realizations extended beyond a general disposition toward research to specific topics, "I soon discovered that I really liked doing research and the topic we were studying."

BTD participation awakened interest in serving others. "Being part of BTD has opened my eyes to giving back through teaching. That was never in my mind to do, but I am now considering teaching in the future, even on a part time basis." "I felt that I had something to offer when I spoke to the undergraduates, and that made me believe that I will have something to offer to students…[as] a professor." "It is very important to take time to work with undergraduates so that they can learn more." For another student, "BTD opened up the idea of giving back to the community…work with minority students, and going to the…conference really impacted me about this idea."

Several students experienced revelatory learning regarding their academic interests. "When I began with BTD, I wanted to get a PhD. Now I still want a PhD, but in a different field." While another "came here not thinking I wanted to get a PhD and honestly was not even that sure about getting a Master's degree….But now life is going in a totally different direction than I expected…. BTD has helped me see what I could be and that is better than I could have ever imagined." For others BTD "showed…a different way to use my [previous] degree and how to channel it in a way to get a PhD related to my interests."

Communication Skill

Participants also noted advancement in communication skills applicable in a variety of areas:

> "BTD…provid[ed] me the opportunity to improve my communication with other students, both graduate and undergraduate students." "I have learned to talk with others outside my field about their research and also to put my research into layman's terms." "Having different types of communication at different scholarly levels…help[ed] me…to communicate better." "I am definitely more confident in my communication skills. I have learned how to communicate not just with people from my own department but from other very different departments." "Now, I am not afraid to go up to a professor or someone presenting and ask questions."
>
> "I learned that networking is very important. By just sending an email, you can open up lots of resources. Sometimes just asking for help can be really important." Another student indicated that "I

> learned how to network better. I learned how to meet new people and how to interact with them and how to keep in touch. This has been a big plus for me. It has really been important to get to meet people outside my field." This included overcoming shyness. "I am shy so networking is difficult for me. But being in BTD has helped me to network and be more effective doing it."

This learning was achieved in formal and informal settings. While formal guidance in communication was provided in seminars, BTD patterns also encouraged informal interaction with peers that "made me a little more social with fellow students…This is helping me a lot with my communication skills." This pattern of informal interaction extended to conferences attended, "meeting people from different universities at [conferences] is really good because it opens your eyes." A common result was that students "made friends in lots of different disciplines" and "learned how to network better."

BTD also facilitated learning about communication through activity around professional presentation, as a reviewer, as a presenter, and as a facilitator. BTD participants were able to "judge undergraduate presentations and that was a good learning experience. By judging, I got an edge for the next time I make a presentation." "It was really valuable to see what undergraduates did wrong in their presentations." There was also an expectation that participants would complete presentations of their research, a process "that is helping me to be more confident about making presentations." In addition, "Having to simplify my poster at the Symposium so that I could present it to an audience without basic knowledge about my topic really helped me learn to communicate my research better." BTD also

> emphasized that we should get involved in other things…. So I got involved in an outreach program in my department. I lead undergraduates in showing their projects to high school students. It has given me lots of experiences and improved my communication skills in explaining difficult concepts to people outside my field.

For a number of participants, BTD learning regarding communication extended to ways to address professional challenges and enact conflict resolution. "BTD has given me a place where I can talk about things that happen in my department and helped me to learn that others have problems with their advisors." This included, for one participant, "BTD help[ing] me with conflict resolution skills that I needed to address issues with my PI" (principal investigator).

Life Skill Development

As noted above, TAMUS BTD programming included focus on life skills. Participants reported learning in a wide variety of areas.

> "Because of the seminars, I think I have become a more professional and well-rounded person." BTD "made me more well-rounded and more professional because I learned things like proper etiquette, interviewing skills, and time management." "What I learned about time management was really useful because it helped me to see things in a different way. I gained insight about things I needed to change about my daily schedule." "I learned about…balancing a budget as well as developing PowerPoint presentations and how to network." "Almost anything having to do with paperwork or procedures I got from the BTD seminars….even about tax returns." "Being a full time graduate student, I didn't think I would take time to really develop those areas to be a well-rounded person."

Influence of BTD Participation on Participants' Educational Goals

Participants stated that the TAMUS LSAMP BTD programming broadened their perspective of educational opportunities and helped them refine their personal educational goals. Informants felt conference attendance and the active information gathering and network-building approach they were encouraged to take at conferences provided them "insight about what it might be like at another university" during future study. They also noted that their two years of study and support programming in BTD helped them clarify what they wanted to do and how to pursue it. In terms of educational goals, this resulted in: (1) confirmation of a desire to pursue a PhD ("reinforced that I should get a PhD"), (2) interest in completing both a medical degree and a PhD ("in med school…now, I am planning to take a leave of absence to complete my PhD;" "I really want both a Vet degree and a PhD"), (3) perception that a PhD was the ultimate goal but that pursuing it might be delayed ("I wanted a PhD, but in looking at the skills I still need, it may be that I need to work two or three years before pursuing it;" "who came back later for their PhDs and then became professors. So that helps me to know that going into industry does not close the door for getting a PhD in the future"), (4) recognition of greater interest in a different

academic field ("I still want a PhD, but in a different field"), and (5) understanding that education can continue as a post-doctoral researcher ("how you can continue after the PhD with a postdoc and then get funding to do research"). Related to the reported confirmation and reinforcing of educational goals, it has been normal for TAMUS LSAMP BTD participants to continue on to and complete PhD programs (see Program Success section and Table 1).Thus, the program appears to aid in confirmation, refining, and expansion of educational goals while grounding them in realistic patterns for realization. Many of the comments made about education goals by BTD participants related to statements made about changes in perspective they achieved in respect to career goals like "BTD has broadened my outlook about possible careers. It has raised my self-expectations."

Influence of BTD Participation on Participants' Career Goals

Change in Perspective

BTD informants reported changes in perspective that impacted their career goals. Perhaps the most significant of the general changes in perspective is that "Minorities have a place" in advanced STEM study. Being part of the BTD cohort allowed students to "feel like I am not alone" and they consistently expressed the value of being "part of a network of students of diverse background." This was particularly important to some of the cohort who sensed an absence of role models (see Barriers section below) or who were the first in their families to pursue advanced degrees. In fact, several informants noted that opportunities provided through BTD and pursuing their PhDs allowed them to act as role models for others at present or that they recognized they could fill this role in the future. Students who entered the BTD program hesitant about academia ("I had a negative attitude about academia;" "I wanted to…work in industry"), noted changes in perspective. Rather than believing that academia is limiting ("with a PhD all I could do was teach") they recognized there are "more…career opportunities with a PhD." The programming provided helped students "think about things and plan for the future," "know[ing] if I am on track and what I need to be doing to prepare for my future," and "open[ing] my eyes to consider everything that I am doing now as the basis for my future." This included recognition on the part of participants of their strong interest in "science and research." As several stated, it showed "me how much I love research."

New Paths

TAMUS LSAMP BTD informants reported developing interest in new career options. These fall in five broad categories: academia, industry, national labs, consultancy, and entrepreneurship. The new interests arose based on experiences realized in or through BTD participation ("But my pathway has changed because of the opportunity I have had with a national lab;" "because of experiences with BTD I now know what a professor's life is really like and it is something that I want to do"). "BTD made me think about other career options" and provided freedom for reflection, room for experimentation, and guidance from experienced professionals. Some students, as noted above, chose to switch fields, the sphere in which they intended to pursue employment, or to craft a sequence related to their perceived needs (see Needed Skills in Barrier table). All of these relate to expansion in perspective achieved through BTD ("I know more about employment and fellowship opportunities and about how to stay in academia; "I know more about career opportunities with a PhD"). Several students' perspectives expanded to include using their advanced skills and positions to contribute to society or their community of origin ("how research can make society better;" "the idea of giving back to the community…[through] work with minority students").

The BTD participants attributed their ability to strike out on some new paths to the BTD stipend they received. BTD participants noted that an advantage they had over their peers was the freedom that being funded outside a department or lab provided them ("The money is really great because it allowed me to change research focus and the freedom to find what field I really like"). This allowed participants to seek what interested them by doing lab rotations or through experimentation and personal reflection and to even change disciplines ("still want a PhD, but in a different field"). Students could "focus on studies rather than worries about funding" and having to join an existing team to secure financial support.

Specific Areas of Career Preparation

As the codebook indicates (see above), BTD participants recognized contributions toward their career preparation in seven areas: (1) advanced qualifications and the presentation of them (coded as CV/resume), (2)

funding source information and assistance, (3) job seeking guidance, (4) career planning, (5) publication assistance, (6) developing a better understanding of why a PhD is necessary, and (7) understanding the value of a graduate degree.

Advancing Credentials and Seeking Fellowships or Grants

Students felt BTD participation elevated their credentials ("BTD has boosted my CV so that I can get even more opportunities. It is opening doors for me") and they saw value in the training they received regarding CV/resume preparation ("creating a resume;" "ways to approach the job market and make myself more marketable"). This is a powerful combination which students said "made me more well-rounded and more professional" and "made me more prepared for what I will do after I finish my PhD. It has helped me prepare for the next steps."

A topic related to advancing credentials is leveraging these to secure a funded post as a PhD candidate, current pursuit of external funding, and preparing to seek grants and fellowships in the future. Students were pleased to have learned about "employment and fellowship opportunities" which let them understand "what is involved in academia and in getting a PhD, about different funding sources, and about developing a grant proposal and how much time it will take." This included instruction in workshops, experiential learning during construction of fellowship applications (all TAMUS LSAMP BTD participants are required to apply to two or more fellowships), and mentoring provided by faculty and staff familiar with the funding agencies and programs to which BTD participants were applying.

Career Planning and Job Seeking

Both presentation of information and application in practical processes proved valuable to BTD participants as they considered their career trajectory. "The opportunity to hear from researchers about their experiences was very valuable. This helped me to focus on career development and to see all the different paths both before and after the PhD." This included "hearing people giving their own experiences and how they made it in grad school. Those have really informed me as to how to proceed. What they did has helped me make decisions." The seminars "have been quite helpful to me." They "really help you think about things and plan for the future." "I have gained a lot of insight." Participants felt "Departments may have orientations to graduate school, but those are nothing like BTD who gives good orientation not just to graduate school but to our future and careers."

BTD students noted elements of the programming they found valuable in establishing a career orientation and having a "plan for the future." "The goal setting was especially helpful because it helped me see that you are aiming for 20 years from now and 30 years from now." "Learning about what it will take and the process has been very helpful." "It has definitely made me start planning better" including "thinking to the end and knowing what I want my life to be like." Having learned "different options that I have for what to do in life" proved valuable. The process of considering current and future options "helped me to know if I am on track and what I need to be doing to prepare for my future." There was "guidance that has helped me about deciding between" career fields and that "showed me a different way to use my [earlier] degree and how to channel it in a way to get a PhD related to my interests."

The BTD processes, informational seminars, mentoring, and guided identification of and application to fellowships, "provided information so that I can make a better decision about my career than before." Students felt this helped "solidify what I really want to do." For some that meant "broaden[ing] my perspective about career options" and "open[ing] my eyes" to other possibilities while for others it "reinforced my career goals."

Participants learned that in academia "you really get to discover new things and new knowledge" and that this makes it possible to contribute to the welfare of society ("doing research because they want to do it and improve the world"), to give back to one's community of origin ("BTD opened up the idea of giving back to the community"), to provide instruction ("BTD has opened my eyes to giving back through teaching"), and focus on aiding specific segments of the population ("work with minority students"). They also learned how this can be possible through publication and that, in many cases, this is required for advancement ("evidenced with publishing papers;" "publications before I graduate which I know is a plus in becoming a professor"). Overall, "BTD has broadened my outlook about possible careers. It has raised my self-expectations. When you see successful individuals, you want to be like them. So I now have higher goals."

Publication Assistance

As noted by a BTD participant, "Publishing is important and you need to start right now." Another stated "It was really valuable to hear from someone what to do with respect to writing and making publications." This emphasis and the guidance provided made BTD participants feel they were ahead of their departmental peers ("My peers just have not had that kind of support"). In fact, one felt that "if you look at what I am doing now, I am way ahead of the other first year students in my department. I'm finishing up a publication while a lot of other grad students are still rotating in labs and haven't really even got started with their research. Being in BTD has already saved me a year."

Reasons to Complete a PhD

BTD participants also expressed that understanding the need for and value in obtaining a PhD was an area in which they had grown. Their basic orientation was a desire to be "where you really get to discover new things and new knowledge" coupled with an understanding that "I needed a PhD so that I could make the decisions about what to do in the research." For some this meant pursuing big picture goals like "improve the world." For others, it was related to interest in a specific topic ("animal science"). For all it involved realizing a broader and more nuanced perspective of opportunities available to persons holding a PhD based on "better information about what I could do with a PhD and why I would need a PhD to do those things." This came their way as part of their BTD experience yielding a more formalized "perspective about what I could do with a PhD."

Barriers BTD Participants Perceive in Continuing on to a PhD

Coding of the comments from the 147 interviews conducted with TAMUS LSAMP BTD participants resulted in a list of 19 suggested barriers to minorities continuing to PhD study in STEM fields. One notable response was that there were no perceived barriers, a comment made by several students. While this is an admirable sentiment, it can be considered as a rare case or even an outlier sentiment as the response was received four times in 147 interviews across nine years and contrasts with the number and diversity of possible barriers listed by the other participants and those that have been reported in the literature.

Table 2. Perceived Barriers to Completing a PhD

Barrier	Illustrative Quote(s)
None	- "Nothing really comes to mind as being a big barrier to my getting a PhD."
Assumed knowledge or skill	- "Sometimes my professor assumes that I already know things." - "I have learned things you don't hear from your professors." - "…not sure that what I have learned from BTD is taught in any graduate program."
Confidence	- "It is really about yourself being a barrier. Sometimes people just stop themselves." - "…maybe my biggest issue is about confidence." - "…having trouble with the confidence…" - "I thought I would be behind other candidates and have a lot of catching up to do."
Continued funding	- "The biggest factor about pursuing a PhD is the funding." - "…the one issue that could be most immediate is to secure more long-term financial support." - "…funding was the biggest concern."
Finding a location or sponsor	- "I know what I would like to focus on so I have to find a place to work on that." - "…finding professors to work with…"
Gender	- "I think being a woman in a White, male field is a barrier to completing my PhD."
Graduate Advisor	- "I have had good experiences with some mentors and my thesis advisor who has encouraged me to go on for a PhD." - "Maybe with a different PI I would feel differently about getting the PhD." - "My PI reacts strongly to things, and it is very hard to not take things personally."

Table 2. Perceived Barriers to Completing a PhD

Life balance	- "…it would be difficult to balance school, work, and research." - "…balancing work and life as a possible barrier."
Missing role models	- "I don't have any role models…I have always looked around and found someone like me who had made it through a similar situation. I guess it is the 'if they can do it, then I can do it' mindset."
Motivation	- "Now I must be self-motivated and have the passion for completing." - "I think the motivation to continue is the most difficult thing I face. It is harder than finding the funding." - "…how I find motivation to stick with things."
Needed skills	- "I…thought I wanted a PhD, but in looking at the skills I still need, it may be that I need to work two or three years before pursuing it."
Personal sacrifice	- "The biggest barrier is the time it requires and the time it takes away from other things like friends and family." - "The question that I will have to answer is: Is the cost to personal life worth getting the PhD?" - "I want to be a mom and have family involvement so how all that fits with getting a PhD is a big question for me."
Publication	- "Several things…for my PhD: publishing..." - "The biggest barrier I anticipate is publishing in a timely manner."
Qualifying exam(s)	- "I am concerned that passing the qualifying exams may be hard." - "…my cumulative exams were very stressful."
Relationships/Family	- "There might be some issues with my family that would keep me from getting my PhD." - "I hope family issues don't create any barriers." - "Several things may put things on hold for my PhD: publishing, classes, and personal relationships."
Research and results	- "Whether or not the research works and you have results can be a struggle. You can't control the research." - "…having the necessary research results..."
Rigor	- "…the difficulty of the material…" - "…been much harder than I expected…"
Stress	- "…it will be important for me to balance out all the commitments and the stress." - "It is really helpful to have seminars on anxiety and stress management."
Time to complete	- "The time to get my PhD may be a barrier." - "Questions about the research and the time it takes to get the PhD might be barriers since I went straight into it from my undergraduate years…"
Time management	- "The seminars have been really good, especially those that focused on stress management and on time management." - "…time management as a possible barrier…"

As none of the BTD students provided extensive lists of barriers or touched on each subject listed, not all of the above were applicable to every informant. Yet, the table contains the testimony of a group of graduate students active across a nine-year period, the vast majority of whom identified as minorities. Addressing each of the topics listed in a meaningful way with a departmental, interest- or affinity-based group of graduate students, would open some of the hidden curriculum of higher education, provide insight for graduate students in many areas of practical concern, and, likely, cast light in spheres that can act as inhibitors of further study.

The authors believe this list of perceived barriers is worth investigating. Each might not be present at every institution and they may not all be fully accurate, as, for example, a negative research finding can be a valuable research outcome, family members may prove to be supportive and willing to make sacrifices to enable graduate study, and there are White males in the sciences who welcome and encourage female minority graduate students. But perceptions can be powerful motivators. Even if they are speculative, incomplete or incorrect understandings, they may still prove to be a barrier. Talking about and seeking to understand them is a first step in mitigating their influence.

Conclusion and Recommendations

As the following comments from URM STEM graduate students, "BTD has broadened my outlook about possible careers….It has raised my self-expectations," "I might have quit without BTD and the tools they have equipped me with….I felt alone but realized that I really wasn't," and "Minorities have a place" in academia, represent outcomes being sought by federal agencies, private corporations, and institutions of higher education, the programming that elicited them appears worthy of further study and replication in other settings.

The TAMUS LSAMP BTD seminars and support services, as they have been refined across the nine years of programming under consideration, are valued by participants and provide clear information that opens new vistas of thought for students. Yet, they are also eminently replicable. They were developed in-house by project personnel and representatives of student support programs at the institution. In the nine years they have included 31 seminars with nine topics repeated in each year. It should be noted that this pattern occurred based on a continuous improvement orientation and that the responsiveness of the TAMUS LSAMP BTD team in this area was recognized by participants. Several responded to a question asking for suggestions for improvement by stating that the project personnel had accepted and already acted on suggestions made the year before and, as a result, they had no suggestions to make.

There were 11 activities repeated with each cohort in the nine years under consideration. Nine of these were seminars and two were attendance at conferences. The seminars were, using summary titles provided by the BTD project team: (1) orientation, (2) time management, (3) financial management, (4) stress management, (5) the library as a research tool, (6) success in graduate school, (7) fellowship personal statements, (8) fellowship application packages, and (9) what I wish I knew (i.e., retrospective consideration by former graduate students). The TAMUS LSAMP BTD cohorts identified the areas of learning they felt were most important from these (see above). Combined these form an outline for an intervention as the informants, 80 STEM master's and doctoral degree seeking students, the vast majority of whom were URMs, stated seminars regarding practical concerns for graduate students had positive impacts on them. Seminars in the nine topic areas above, which parallel the eight areas of learning noted by the TAMUS LSAMP BTD participants, appear to be worthy of consideration as a support system for minority graduate students in STEM fields based on the testimony of the informants in this study.

As noted in TAMUS LSAMP BTD documents, there are few graduate programs in the sciences and engineering that incorporate the development of leadership skills that doctoral graduates will need to ascend to and succeed in positions of leadership in the professions that they choose. Furthermore, there are few purposely designed and implemented efforts for providing insight into careers in higher education for minority students. Emphasis on the importance of scholarship at the master's and doctoral level, understanding the promotion and tenure process, developing a research agenda, and developing and maintaining a healthy balance between professional demands and personal responsibilities is not included in most graduate programs. This appears, based on the evidence provided by TAMUS LSAMP BTD participants, to be a significant oversight on the part of institutions of higher education.

The barriers to continuing study toward a STEM PhD suggested by the TAMUS LSAMP BTD cohorts can inform a training and support structure for minority graduate students. Communicating clear expectations, openly discussing fears or possible challenges and ways others have addressed challenges in these areas, providing guidance related to practical and life balance concerns, and suggesting strategies in multiple areas that address both task and emotive realms has been successful for the BTD program according to the participants. "The BTD program provides a rich, supportive network that can be incredibly valuable to graduate students." "I think it's a program that goes far beyond just offering student financing. It also provides seminars to develop as professionals and academics in different areas…. providing support and motivation during such an important stage…graduate school."

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References

Alfred, M. V., Ray, S. M. & Johnson, M. A. (2018). Advancing women of color in STEM: An imperative for U.S. global competitiveness. *Advances in Developing Human Resources*, 21(1), 114-132.

Bayer Corporation. (2012). Bayer facts of science education XV: a view from the gatekeepers – STEM department chairs at Americas top 200 research universities on female and underrepresented minority undergraduate STEM students. *Journal of Science Education and Technology, 21,* 317-324.

Beard, K. & Julion, W. (2016). Does race still matter in nursing? The narratives of African-American nursing faculty members. *Nurs. Outlook, 64*(6), 583-596.

Bilimoria, D. & Buch, K. K. (2010). The search is on: engendering faculty diversity through more effective search and recruitment. *Change*, 27-32.

Charleston, L., Adserias, R., Lang, N. & Jackson, J. (2014). Intersectionality and STEM: the role of race and gender in the academic pursuits of African American women in STEM. *Journal of Pharmaceutical Policy and Practice, 2*(3), 273–293.

The Chronicle of Higher Education. (September 10, 2019). Full-time instructional faculty members, by gender, rank, and race or ethnicity, fall 2017. Web. Retrieved from https://www.chronicle.com/article/Gender-RaceEthnicity-of/246695?cid=cp260

Clewell, B. C., Cosentino de Cohen, C., Tsui, L., and Deterding, N. (2006). *Revitalizing the Nation's Talent Pool in STEM*. Urban Institute: Washington, DC.

Collins, K.H. (2018). Confronting color-blind STEM talent development: Toward a Contextual model for Black student STEM identity. *Journal of Advanced Academics, 29*(2), 143–168. DOI: 10.1177/1932202X18757958.

Garcia, G. A., & Johnston-Guerrero, M. P. (2016). Challenging the utility of a racial microaggressions framework through a systematic review of racially biased incidents on campus. *Journal of Critical Scholarship on Higher Education and Student Affairs*, *2*, 50–66.

Ghose, T., Ali, S. & Keo-Meier, B. (2018). Diversity in social work doctoral programs: mapping the road ahead. *Research on Social Work Practice, 28*(3), 265-271. DOI: 10.1177/1049731517710725

Gonzales, L. D., Murakami, E. & Nunez, A. M. (2013). Latina faculty in the labyrinth: Constructing and contesting legitimacy in Hispanic Serving Institutions. *Educational Foundations, 27,* 65-89.

Good, C., Aronson, J. & Harder, J. A. (2008). Problems in the pipeline: stereotype threat and women's achievement in high-level math courses. *Journal of Applied Developmental Psychology, 29*(1), 17–28. https://doi.org/10.1016/j.appdev.2007.10.004

Good, C., Rattan, A. & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102*(4), 700–717. https://doi.org/10.1037/a0026659

Grapin, S. L., Bocanegra, J. O., Green, T. D., Lee, E. T. & Jaafar, D. (2016). Increasing diversity in school psychology: uniting the efforts of institutions, faculty, students, and practitioners. *Journal of Contemporary Psychology, 20,* 345-355. DOI 10.1007/s40688-016-0092-z

Greene, J., Lewis, P. A., Richmond, G. L. & Stockard, J. (2011). Changing the chairs: Impact of workshop activities in assisting chemistry department chairs in achieving racial and ethnic diversity. *Journal of Chemical Education, 88*(6), 721-725.

Hadinger, M. A. (2017). Underrepresented minorities in medical school admissions: a qualitative study. *Teaching and Learning in Medicine, 29*(1), 31-41, DOI: 10.1080/10401334.2016.1220861

Haizlip, B. N. (2012). Addressing the Underrepresentation of African-Americans in Counseling and Psychology Programs. *College Student Journal*, 46(1), 214-222.

Infoplease. (n.d.). U.S. population by race. Retrieved August 9, 2018 from: https://www.infoplease.com/us/population/us-population-race

Johnson, E. (2017). Micro-barriers loom large for first-generation students. In *How to help first generation students succeed. Chronicle of Higher Education* (February, 2017), 15-16.

Knight, W. B. (2010). Sink or swim: Navigating the perilous waters of promotion and tenure--what's diversity got to do with it? *Studies in Art Education: A Journal of Issues and Research in Art Education, 52*(1), 84-87.

Kolb, S. M. (2012). Grounded theory and the Constant Comparative Method: valid research strategies for educators. *Journal of Emerging Trends in Educational Research and Policy Studies, 3*(1), 83-86.

Lechuga, V. E. (2012). Latino faculty in STEM disciplines: Motivation to engage in research activities. *Journal of Latinos and Education, 11*(2), 107-123.

Lee, E. M. (2017). Elite colleges and the language of class. In *How to help first generation students succeed. Chronicle of Higher Education* (February, 2017), 30-31.

Lewis, C. & Olshansky, E. (2016). Relational-Cultural Theory as a framework for mentoring in academia: Toward diversity and growth-fostering collaborative scholarly relationships. *Mentoring & Tutoring: Partnership in Learning, 24*(5), 383-398.

Linley, J. L. & George-Jackson, C. E. (2013). Addressing underrepresentation in STEM fields through undergraduate interventions. *New Directions for Student Services, 144*, 97-102.

Liu, C. C. & Chen, I. J. (2010). Evolution of Constructivism. *Contemporary Issues in Educational Research, 3*(4), 13-16.

Longwell-Grice, R., Adsitt, N., Mullins, K. &Serrata, W. (2016). The first ones: three studies on first-generation college students. *NACADA Journal, 36*(2), 34-46.

Meyer, M. & Warren-Gordon, K. (2013). Marginal mentoring in the contact space: diversified mentoring relationships at a midsized Midwestern state university (MMSU). *The Qualitative Report, 18*(19), 1-18.

Mowatt, R. A., Johnson, C. W., Roberts, N. S. & Kivel, B. D. (2016). "Embarrassingly White": Faculty racial Disparities in American recreation, park, and tourism programs. *Schole: A Journal of Leisure Studies and Recreation Education, 31*(1).

Murakami, E. & Nunez, A. M. (2014). Latina faculty transcending barriers: Peer mentoring in a Hispanic-Serving Institution. *Mentoring & Tutoring: Partnership in Learning, 22*(4), 384-301.

Marrun, N. A. (2015). *Gente estudiada: Latina/o students confronting and engaging home/community knowledge within/outside institutions of higher education*. [Doctoral dissertation, University of Illinois at Urbana-Champaign]. Retrieved from ProQuest. (UMI Number: 3737898)

National Aeronautics and Space Administration. (2018). NASA STEM engagement: about MUREP. Retrieved from: https://www.nasa.gov/offices/education/programs/national/murep/about/index.html

National Science Foundation. (n.d.). Louis Stokes Alliances for Minority Participation (LSAMP). Retrieved from: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13646

National Science Foundation. (October 30, 2017). Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science. Retrieved from: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505289.

National Science Foundation. (February, 2018). Building the future: investing in discovery and innovation. Retrieved from: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf18045

National Science Foundation. (March, 2018). 2016 doctorate recipients from US universities. Retrieved from: https://www.nsf.gov/statistics/2018/nsf18304/static/report/nsf18304-report.pdf

Nguyen, H. H. & Ryan, A. M. (2008). Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. *Journal of Applied Psychology, 93*(6), 1314. https://doi.org/10.1037/a0012702

Patton, S. (2017). Here's Smarty-Pants home for the holidays. In *How to help first generation students succeed. Chronicle of Higher Education* (February, 2017), 17-19.

Peguero, A.A. (2018). Reflections of a Latino Associate Professor. *Hispanic Journal of Behavioral Science, 40*(1), 73-80.

Perez II, D., Garcia-Louis, C., Ballysingh, T. A. & Martinez Jr., E. (2018). Advancing an anti-deficit achievement framework for Latinx/a/o college students. In E. B. Batista, S. M. Collado & D. Perez II. *Lationx/a/os in higher education: exploring identity, pathways, and success.* National Association of Student Personnel Administrators, 117-136.

Pertuz, S. B. (2018). Exploring Latinx/a/o identity, cultural values, and success in higher education. In E. B. Batista, S. M. Collado & D. Perez II. *Lationx/a/os in higher education: exploring identity, pathways, and success.* National Association of Student Personnel Administrators, 117-136.

Poloma, A. W. (2014). Why teaching faculty diversity (still) matters. *Peabody Journal of Education, 89*(3), 336-346.

Sharkawy, A. (2015). Envisioning a career in science, technology, engineering and mathematics: Some challenges and possibilities. *Cultural Studies of Science Education*, *10*(3), 657-664.

Solórzano, D., Ceja, M. & Yosso, T. (2000). Critical race theory, racial microaggressions, and campus racial climate: the experiences of African American college students. *Journal of Negro Education, 69*, 60–73.

Sue, D. W., Capodilupo, M., Torino, G., Bucceri, A., Holder, M., Nadal, K., & Esquilin, M. (2007). Racial microaggressions in everyday life: Implications for clinical practice. *American Psychologist, 62*, 271–286.

Texas A&M University. (July 12, 2017). Texas A&M University System Louis Stokes Alliance for Minority Participation (TAMUS LSAMP) Bridge to the Doctorate (BTD) XII Cohort Program (2016-2018) 2017 Annual Report.

Texas A&M University. (October 16, 2017). Texas A&M University System Louis Stokes Alliance for Minority Participation (TAMUS LSAMP) Bridge to the Doctorate (BTD) IX Cohort Program (2013-2015) Final Report.

Texas A&M University. (February 18, 2018). Texas A&M University System Louis Stokes Alliance for Minority Participation (TAMUS LSAMP) Bridge to the Doctorate (BTD) X Cohort Program (2014-2016) Final Report.

Texas A&M University. (May 28, 2018). Texas A&M University System Louis Stokes Alliance for Minority Participation (TAMUS LSAMP) Bridge to the Doctorate (BTD) XI Cohort Program (2015-2017) Final Report.

US Census Bureau. (August 6, 2012). Profile America: facts for features. Retrieved from: https://www.census.gov/newsroom/releases/archives/facts_for_features_special_editions/cb12-ff19.html .

US Census Bureau. (2018). QuickFacts: United States. Retrieved August 9, 2018 from: https://www.census.gov/quickfacts/fact/table/US/PST045217 .

US Census Bureau. (2019). QuickFacts: United States. Retrieved April 28, 2020 from: https://www.census.gov/quickfacts/fact/table/US/PST045219 .

US Department of Education. (March 4, 2016). Applications for new awards: Hispanic-Serving Institutions STEM and articulation program. *Federal Register*, 81(43), 11532-11539. Retrieved from: https://www2.ed.gov/programs/hsistem/applicant.html .

US Department of Education. (2019). Hispanic-Serving Institutions – Science, Technology, Engineering or Mathematics and Articulation programs. Retrieved from: https://www2.ed.gov/programs/hsistem/index.html

Weng, S. S. & Gray, L. A. (2017). Advancement in social work education: fostering a supportive environment for students of non-dominant racial and ethnic backgrounds. *Social Work Education, 36*(6), 662-677.

Wolfe, B. L. & Dilworth, P. P. (2015). Transitioning normalcy: Organizational culture, African American administrators, and diversity leadership in higher education. *Review of Educational Research, 85*(4), 667-697.

Zambrana, R. E., Ray, R., Espino, M. M., Castro, C., Douthirt-Cohen, B. & Eliason, J. (2015). "Don't leave us behind": The importance of mentoring for underrepresented minority faculty. *American Educational Research Journal, 52*(1), 40-72.

Zamudio-Suarez, F. (2016). I fit in neither place. In *How to help first generation students succeed. Chronicle of Higher Education* (February, 2017), 12-14.

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