Leveraging Student Voices to Explore Career Interest in STEM PhD Programs

Authors:

Jennifer Claydon, PhD
Yale University

Meghan Bathgate, PhD
Yale University

ABSTRACT

As career landscapes within and outside of academia shift, higher education STEM programs increasingly must navigate assessing student experience and career goals with an eye towards actionable improvements in career preparation for myriad roles. In this study, we aimed to better identify and respond to career interests across four years of graduate students (N=364) as they considered their post-graduation plans at different points in their training. These results revealed students are most interested in pharmaceuticals/biotechnology careers, postdoctoral positions, research-heavy faculty positions, and non-faculty academic roles, though the most notable results are the reductions in degree of career interest between the first and last year of PhD training. Specifically, first year students express significantly higher levels of interest (depth) across more career areas (breadth) compared to graduating students. This work highlights the changing pattern of career interests alongside how a collaborative assessment approach can inform choices in how to best support students.

Correspondence E-mail: Jennifer.Claydon@yale.edu
Keywords: Assessment, STEM education, graduate school, career development

Many students enter graduate education with an eye towards securing a position in a tenured faculty role and the traditional apprenticeship model of training these students follows that desire (Anderson, et al., 2011; Walker, et al., 2008). Unfortunately, the availability of those highly sought after tenure track roles has been in decline over the past decade (National Academies of Sciences, Engineering, and Medicine, 2018). In 2008, 25.9% of STEM graduates had secured a tenure track faculty position within 5 years of graduating, and only 17.7% percent of STEM Ph.D.'s secured these positions by 2015 (NSB, 2018). Studies by Larson and colleagues explored whether there was a dearth in positions, or a burst of additional PhD graduates that contributed to this trend (Larson et al., 2014; Xue & Larson, 2015). They found that although the overall number of STEM PhDs had been climbing steadily, the number of tenure track positions remained nearly constant in most fields.

The lack of new tenured positions for graduates has shifted the landscape towards non-traditional roles in fields such as biotechnology, consulting, and finance (Garrison, 2024) with a majority of doctoral graduates pursuing positions outside of academia (Larson et al., 2014). As data collection and data accessibility have grown, administrators are seeking ways to assess the student experience that align with actionable ways to apply findings (Montenegro & Jankowski, 2020; Cubarrubia, 2019). Implementing improvements in higher education training first requires institutions to understand the successes and challenges of their graduate student population, making the path to best support new scholars both a disciplinary and assessment challenge. Despite evaluation of the graduate student experience in STEM PhD programs being a way to better identify and remedy potential gaps in career development during training, these assessments have been poorly documented at a national level (Reeves et al., 2022).

The challenges to designing and sharing common models of how student experience is assessed are varied, including where accreditation requirements are standardized. Even when students share their experiences, the follow-through to reviewing and responding to this feedback is often incomplete (Blaich & Wise, 2011; Banta & Blaich, 2010; Baghramian & Roberts, 2023). The gaps in knowledge create missed opportunities for departments to highlight strengths and allow higher education to remake the same mistakes cohort after cohort (Alberts et al., 2014).

The Current Study

Our work here describes how an interdisciplinary program in the biomedical and biological sciences used collaborative assessment to reflect on and apply student perspectives to the training graduate students received. Specifically, our research questions are:

- R1: What career areas are graduate students in the Biological and Biomedical Sciences Umbrella Program (BBS) interested in, and do those interests shift over the course of graduate training?
- R2: How can using collaborative assessment contribute to designing measures that collect and use data to center student experiences in STEM PhD programs?

Funding agencies for graduate training have been shifting their language to support approaches that modify graduate training to align with job market demands (Blume-Kohout, 2007; Denecke et al., 2017; Fuhrmann et al., 2011). Finding viable and efficient avenues for graduate programs to implement career preparedness across various fields has proven challenging (Subramanian et al.2022; Bixenmann et al., 2020). Anecdotally, our program knew students were consistently exploring non-traditional career options outside of mainstream tenure-track faculty positions but had not consistently examined student experiences about career interests. Ganapati and Ritchie explored student perceptions of how their graduate programs prepared them for positions outside of the traditional academic pathways and found that students consistently requested tailored professional development for various career trajectories (2021). As we explored ways to assess student experience, and subsequently how to initiate evidence-based decisions in PhD career development, we found variability in how students had been engaged in the assessment process and how training programs addressed career preparation (Gibbs & Griffin, 2013). Golde and Dore discussed the concerns that PhD graduates "often struggle to make the transition out of the academy and into the workforce," perhaps because of a lack of specific career preparedness programming for a variety of career trajectories (2011). In order to best understand our population of student needs and interests, we aimed to design an assessment survey built on input from our student population. Towards this end, we embedded collaborative assessment techniques into the entire process of designing questions, collecting and analyzing data. The details of these procedures are outlined in the Methods. Additionally, once data were collected and analyzed, we partnered with students and departmental leadership to instigate action at the programmatic level.

Context of Collecting Program-Specific Data in Higher Education

There has been an increasing demand for assessment expertise within educational departments, in part driven by evaluation criteria for research and training grants. Despite a recognition of the importance of assessment, there are challenges in using assessment data. First, as assessment professionals, those collecting the data in higher education tend to have a lack of direct authority to implement any of the changes that might be warranted or recommended. This includes institutional research offices, teaching centers, student affair offices, and the like. These hubs of data are often well-informed, though removed from the direct training of students. Second, once an assessment report has been created and sent along with recommendations, it is not uncommon for there to be minimal follow-up from stakeholders. At times, our colleagues have informally described feeling as if their reports "float into the ether." A variety of explanations might exist for why administrators struggle to navigate the connection between data on student experience and how to shift or improve programming to influence that data in future assessments. At the crux of these explanations, communication among all involved individuals plays the largest role in supporting stakeholders as they digest data and balance administrative pressures within programs.

Furthermore, understanding how data are actively used can often be muddied by the data themselves. Sometimes in higher education, assessments can be scaled too large, with stakeholders attempting to collect too many variables at one time. As survey fatigue continues to climb, low response rates can call into question what to do with the data that are collected (Fass-Holmes, 2022). Additional research has demonstrated that it is atypical within higher education to use survey feedback in decision-making to improve educational programs (Jonson et al., 2014). Finally, poor communication of the findings to key stakeholders—including to the participants themselves—can dampen enthusiasm for future participation and reduce the value placed on providing feedback for educational programs.

In order to use student feedback in actionable ways, the design of any assessment tool needs to incorporate deep consideration of the participant experience coupled with collaborative stakeholder engagement. The relationships built during the entire assessment process are the foundation for effective evaluation (Chouinard & Cousins, 2009); Wilson, 2008). A primary goal of our assessment team is understanding how to engage students, faculty, and administrators in the discussion, purpose, and use of evaluation. In designing surveys of the graduate student experience in the BBS program, we employed the Collaborative Assessment Model (CAM), first presented by Bathgate and Claydon in 2021. CAM advocates that effective and successful assessment requires four broad principles to guide the work and elevate interpersonal relationships throughout the assessment cycle. Specifically, program assessment must be aligned to program goals, actionable when data are collected, sustainable for programs to maintain over time, and contextual in their conception, design, collection, analysis, and reporting (see Figure 1).

Figure 1. *The Four Principles of the Collaborative Assessment Model.*

Before reviewing our specific methods for this study, we first outline ways in which we applied CAM to this work. First, the authors met to articulate where our assessment activities would align with program goals, which were largely shaped by the program's objectives for meeting PhD milestones and by the grant-specific objectives towards training highly skilled scientists. These discussions included meeting with faculty Principal Investigators on training grants (NIH T32s) to ask them about how they assess whether students are meeting their department specific goals. Throughout the survey development, we met with these individuals a couple of times, and traded drafted language via email, to ensure our questions for students aligned with the goals of the program. Questions were also discussed twice with the Yale BBS Development & Involvement Community (YBDIC) student group of more than 20 individuals to ensure they were interpreting the questions the way we were intending, a technique known as cognitive interviewing (Beatty & Willis, 2007). Cognitive interviewing has emerged as a prominent way to create ideal question formats and language that is understood by the target participants.

In making the findings as actionable as possible, we engaged stakeholders (students, faculty) in the BBS program in the roles of Directors of Graduate Studies (DGSs), student program leaders, specifically in the YBDIC, early and frequently, including attending departmental meetings across the BBS program, and articulating the goals behind the assessment work. We met with each department twice: once before the survey launched, and once to discuss the findings after everything was collected and analyzed. We worked collaboratively with faculty and students to show them why we were asking specific questions, how the answers to those questions could inform programmatic changes at the departmental level, and how those changes would benefit the student experience specifically with career preparedness. We also presented findings once to the larger BBS group of DGSs and departmental registrars to encourage them to review the findings and seek out ways to implement changes to improve the graduate student experience.

Sustainability of the assessment was a focus from initial discussions with faculty program leaders, as we recognized that longitudinal data from students and their mentors needed to be nimble enough to fit within existing structures with changing staff roles and robust enough to meaningfully inform the program. In this light, we decided not to survey all graduate students in the program, but targeted our surveys to the end of the first year when students are choosing a PhD lab and department, and at the end of their academic career in the BBS program when they are about to graduate, to obtain perspective on career interest at different parts of the program. We also used program alignment and student feedback to maintain a shorter survey so that students did not feel overly taxed with the time required to share their experiences.

Finally, we recognized that the context in which the assessment took place inherently shapes the framing of the data. For example, who we included to engage for feedback, the language we used in communications, and the timing, method, and tone in which data were shared back, all influence this work. As such, we reflected as a team and with program leaders on the selection of our methods and measures to best encompass and represent the perspectives of all students and discussed how to iteratively share results to allow for broad faculty access to these findings.

In this study, we share assessment findings describing patterns in career interest among four cohorts of first year and graduating students who complete their STEM PhD training in our interdisciplinary umbrella program. We also provide examples of how positioning, implementing, and reflecting on assessments within STEM PhD programs can promote responsiveness to student feedback. Throughout, we share our assessment approach and how it allowed us to engage departmental programs at different strategic points. Researchers interested in STEM persistence may be most drawn to the findings of this work, while assessment professionals may be more interested in the process of gathering, reflecting, and acting on these data. With either lens, the context of the data collection and content of the findings reflect each other in ways that further spur conversations in the higher education assessment community.

Method

In line with the principles outlined in CAM, we walk through the specifics of our methodological decisions here. We prioritized equity-centered practices as we designed measures exploring multiple areas of the graduate student experience (Henning & Lundquist, 2022). A single survey, even if excellently designed, cannot fully capture the broad range of students' experiences nor fully represent the nuance for any single student. The complexity in the context and pressures of graduate school vary in ways that are challenging to capture. To help represent and respect these differences, we engaged a few strategies that allow for students to meaningfully shape and guide our approach and methods. Namely, we integrated data from multiple sources so as not to rely on a single timepoint or item type (Hohensinn & Kubinger, 2011), engaged students and program leaders in co-creating assessment measures, collaborated with students to verify our interpretations of the data reflected their experiences, used a series of norming conversations to reduce bias when coding qualitative data, and collected mixed-method data to better represent the nature and variety among students' perspectives and voices. We also met with faculty and graduate students to discuss and receive their reflections on the analyses, and subsequently sought multiple avenues for disseminating our findings to share back the findings with the community (Oliveri et al., 2019).

As we designed our measures, we started with a literature review of current assessment methods in graduate education and incorporated several existing measures (Anderson et al., 2016; Sinche et al., 2017). Additionally, we designed our own question of career interest across thirteen common sectors. These thirteen sectors were previously identified using BBS alumni data housed in the Institutional Training Grant hub (ITG hub) database of which career areas our graduates have been working over the past 25 years. We also included an "other" category where students could write in a topic or career area they did not see listed among the options.

Our quantitative career interests items asked students to rate the following sentence, "I am interested in pursuing a career in this field" for each of thirteen career areas (see Table 1) on a Likert scale of "1-strongly disagree", "2-moderately disagree", "3-disagree a little", "4-agree a little", "5-moderately agree", to "6-strongly agree." Demographic questions were also collected such as department tract, year of study, and gender. We also asked students the open-ended question, "Do you have any comments or suggestions for the BBS program regarding your graduate student experience?"

The surveys were finalized by working collaboratively with graduate student groups, such as the YBDIC, with Directors of Graduate Studies (DGSs) and training program directors, sharing our final survey drafts before distributing the survey to the target population. The current study is part of the larger programmatic assessment of the BBS department and its tracks, complementing its training grant funding, and institutional goals. There were other measures in the broader survey that included questions about satisfaction with specific training activities and confidence across skill sets, for example. For our current research questions, we focus on career interests measures.

Table 1. The thirteen career areas students were asked to rate their interest in pursuing.

1. Postdoctoral Training	2. Finance or Law
3. Faculty in academia at research intensive institution	4. Government or Non-profit
5. Faculty in academia at teaching intensive institution	6. Business/Entrepreneurship
7. Academic, other job type	8. Publishing/Communications
9. Pharmaceuticals or Biotechnology	10. K-12 Education
11. Healthcare or Clinical	12. Library Science
13. Consulting	Other (please specify)

Procedure

To explore whether and how graduate student career interests may change over their course of study, career interest was measured at the end of the first year of graduate training when students are joining their PhD labs and again at the end of their training as they defend their dissertations and graduate (see Figure 2). Surveys were sent to students' emails via Qualtrics software in May of 2021, and have been administered annually in May since then (2022, 2023, and 2024). Students were identified using the ITG hub database to generate a list of all first-year students, and a list of all students who were graduating the respective year. Data were collected confidentially, but not anonymously. Being able to link student data over time would eventually allow us to match within subjects from the end of their first year to the year they graduated (another few years of data will be needed before within subjects' comparisons can be explored due to the years of study necessary for students to receive their degrees). Data were de-identified after exporting from Qualtrics before conducting any analyses. This study was approved by the Yale University Institutional Review Board (# 2000024769).

Analysis

Quantitative and Likert scale questions were processed and compared using SPSS software (version 24.0 for Mac). All eight surveys (two per year from 2021-2024, inclusive) were combined into one large dataset to explore all BBS student career interests and delineated by whether each response reflected first year students or graduating students. The open-ended question "Do you have any comments or suggestions for the BBS program regarding your graduate student experience?" was thematically coded according to the 6-

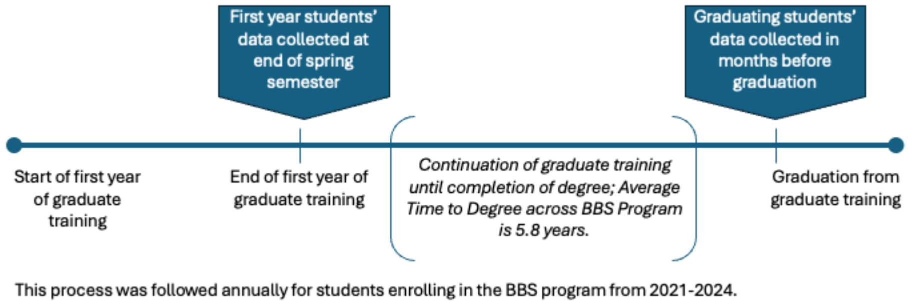

Figure 2. *Data collection process for surveying first year and graduating students.*

step process detailed by Braun and Clarke, using NVIVO qualitative analysis software by the authors (QSR International, 1999; Braun & Clarke, 2006 & 2013). Responses relating to career interest, career development, career self-efficacy, or professional development were identified and further coded. Two norming and discussion sessions were held between the authors to develop a shared coding structure and familiarize ourselves with the data, which used grounded theory to enable initial codes to emerge. Open coding resulted in several themes that were then refined further with axial coding to review potential themes in the responses. The authors then defined and named the themes in the responses and defined the themed results presented here. The sample size for the open-ended coding was smaller, relative to the overall sample, and codes, counts, and percentages are included in the results section to complement themes found in our quantitative analyses.

Results

Over the four years of survey data collection, a total of 364 students participated in the survey, representing a 47% response rate from the overall potential population (55% from first years and 39% from graduating students, on average). There was a relatively stable response rate of about 40-50 people per cohort (first year students, graduating students) per year (2021-24). Sample sizes across first year students and graduating students are included in Table 2, with about 60% of the sample being female.

Table 2. Sample of BBS participants across 8 surveys.

	Total Students	**Percent**
All Students	364	100%
1st Years	224	62%
Graduates	140	38%

Overall Interest

Students' interests varied across career categories, as Figure 3 shows.[a] On average, students were most strongly interested in a pharma/biotechnology career (M=4.53, SD=1.50), pursuing a postdoctoral position (M=4.10; SD=1.87), or becoming a faculty member at a research-intensive institution (M=3.89; SD=1.89). Average interest levels varied across the remaining careers, with lower average interest towards careers in finance or law (M=2.20; 1.45), K-12 education (M=2.06; SD=1.37), and library science (M=1.71; SD=1.08).

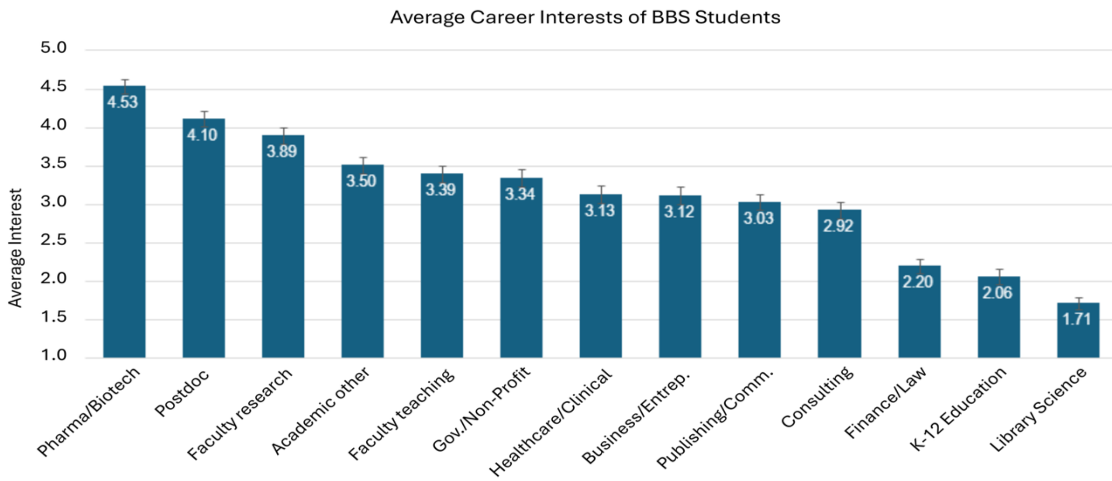

Figure 3. *Average Career Interest of BBS students from 2021-2024. For additional descriptive statistics for whole sample's average interest in disciplines, please see Appendix A.*

Interest Differences Between First Year and Graduating Students

To explore whether career interest differed between first-year students and graduating students, we ran a repeated measures ANOVA including cohort as a between-subjects variable and career category as the within-subject variable. Students' interest varied significantly by career category, which reflects the spread of means in Figure 3 ($F(1,6.17)=94.70$, $p<.001$, partial $eta^2=.22$)[b].

[a]While there are statistical differences across some categories, we do not report every pairwise comparison across categories, both for theoretical and statistical limitations (e.g., compounding error across more dozens of comparisons within the same sample). Additionally, a handful of students opted to write in a career choice in the open-text box, though there was little consistency in these areas and they are not included in these analyses. These write-in areas included: administrative positions, project management, science policy, data science, scientific art production, biotechnology, research at non-academic institutions, translational research, medical school, sustainability, artificial intelligence, psychology, community college professor, culinary arts, and further education.

[b]Greenhouse-Geisser correction applied, given Mauchly's Test for Sphericity was significant ($W=.029$, $p<.001$)

Further, we found a significant effect of cohort (F (1,6.17)=40.63, p<.001, partial eta^2 =.11) and a significant interaction between cohort and career categories (F (1,6.17)=7.70, p<.001, partial eta^2=.02). This means first year students' interest varies from graduating students, and that interest varies by career category for both first year students and graduating students, respectively.

While this overall difference is important to note, additional analyses are needed to explore specific contrasts between first year and graduating students interests in careers. To examine pair-wise differences, we conduced t-tests comparing first year students' average interest to graduating students' average interest across each career option. Bonferroni corrections were applied to establish a more rigorous significance threshold that better accounts for repeated comparisons (α=0.0038). There were five significant differences emerging with three additional differences that were significant at the p<.05 level but did not meet the more stringent Bonferroni corrected alpha. Figure 4 and Table 3 give details across each comparison. The largest differences were all within the academic industry: postdoctoral position, faculty research, faculty teaching, or other academic position. Graduating students' interests in each of these four areas were significantly lower than first year's interests. Also notable is that these are four of the top five career interests of first year students. Publishing/communication also showed lower interest for graduating students. The consulting, healthcare/clinical, and library science showed trending differences with lower graduating student interest compared to first years, though library science showed the lowest interest overall. These results show us that while there are trends of career interests within the sample, the overall average obscures notable variations in the depth and type of career interests from early to late graduate school.

In addition to the disciplinary differences in interest between cohorts, we also see a difference in the breadth of interest, as measured by the number of topics students selected they were at least "a little" interested in ($\geq$4 on the six-point scale). Specifically, students in the 1st year selected an average of 6.7 areas of interest (i.e., selecting that they are at least "a little" interested in a given career), with an average of 48% of students reporting interest in more than half the career areas. Graduating students selected an average of 5.2 areas of interest, with an average of 23% of students reporting interest in more than half the career areas. Taken together, we see a narrowing and deepening of career interest in graduating students compared to a broader interest in first year students.

The open-ended question about improving the BBS program had a total of 103 participants respond, from the 364 who took the survey (28% response rate to the open-ended question). These 103 responses were reviewed by both authors and 11 responses (11%) were selected for further coding for the current study as they mentioned a career-related improvement to the BBS program (Cohen's Kappa, k = 1.0). The other responses were unrelated to career interest and either focused on various other aspects of graduate training, such as stipend, length of lab rotations, and administrative suggestions, or were made up of 'no', 'N/A', or praise for the overall program. Upon initial coding, the first author determined five main themes out of the 11 responses which were discussed with the second author. Given the low number of total responses for this sample, the authors agreed 100% on the five themes below. None of the five themes had more than five responses total. The purpose of coding this question was to consider whether additional nuance or depth about students' career interests and preparation could be offered, recognizing that most comments were unrelated to the current research questions.

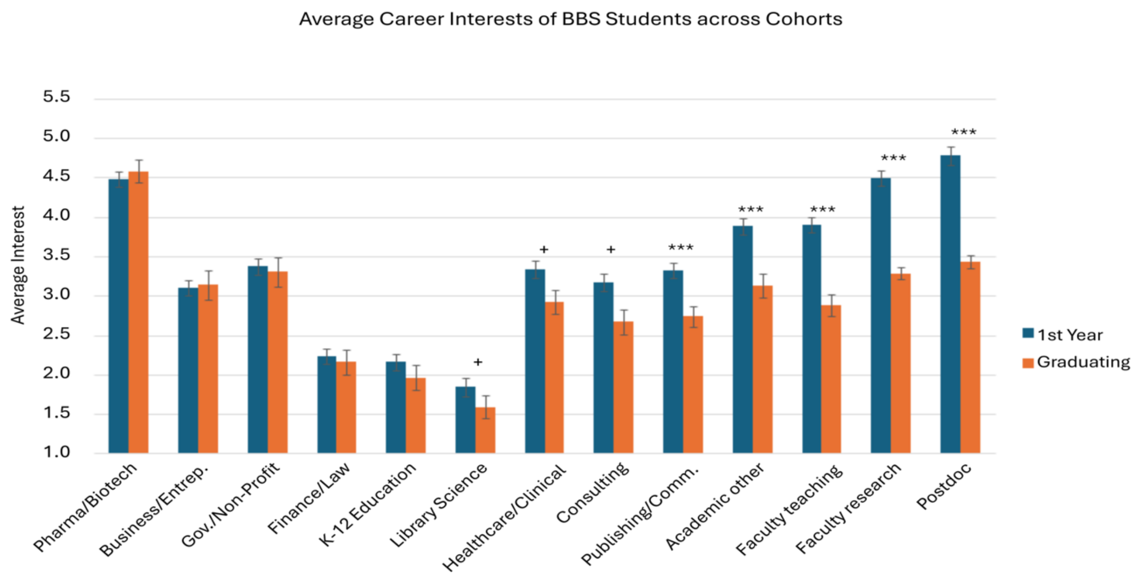

Figure 4. *Average Career Interest separated by first year and graduating BBS students from 2021-2024.*

Table 3. *Pairwise t-test comparisons of differences in career interest between first year and graduating students.*

	t	df	sig.	d
Postdoc	6.30	201.45	***	0.77
Faculty Research	5.67	220.05	***	0.67
Faculty Teaching	5.45	253.12	***	0.62
Academic Other	3.98	235.58	***	0.46
Publishing/Communications	3.58	339	***	0.40
Consulting	2.79	255.64	+	0.32
Healthcare/Clinical	2.21	338	+	0.25
Library Science	2.20	309.17	+	0.24
K-12 Education	1.30	339	n.s.	0.14
Finance/Law	0.47	337	n.s.	0.05
Gov/Non-Prof	0.38	339	n.s	0.04
Business/Entrep	-0.21	340	n.s	-0.02
Pharma/Biotech	-0.57	250.28	n.s.	-0.07

Significance is indicated by *** when the t-value exceeded the Bonferroni corrected alpha (α=.00384) and + when t-value exceeded alpha threshold of (α<.05). Cohen's d effect size is also included. Corrected degrees of freedom were used in cases where tests for homogeneity of variance were significant.

The 11 responses were coded into five themes, including the need for additional statistics courses (n = 5), better support for career exploration (n = 4), support for finding funding sources (n = 2), additional time for career planning (n = 1) and prioritizing teaching (n = 1). Selected deidentified representative quotes are presented below.

> "Also, I would appreciate if the program were more accepting and supportive of first years pursuing internships. The BBS advertises internships/extracurricular activities in the newsletter, but I received somewhat negative feedback from my program director about how the summer internship would set me back even though I am pursuing the internship to learn a skill and even though some of my colleagues and peers are still rotating over." [Time for Career Planning]

> "My only other suggestion would be to perhaps prioritize teaching a bit more, or at least have avenues for that. While we require TF semesters, most of the time the courses available do not require any independent teaching (at least that's been the experience I've observed). That's fine for some, but for others who want to teach, I think it poses a challenge." [Prioritize Teaching]

> "Data analysis courses could be offered in 1st year from BBS, and that would be extremely helpful for many BBS students." [Additional Statistics Classes]

> "I also don't feel that the program provided enough resources or support for people trying to enter fields other than academia or industry. Often there wasn't even acknowledgement that other options exist for people with science PhDs." [Support for Career Exploration]

> "Need more career support and scholarship support" [Finding Funding & Support for Career Exploration]

Disseminating Findings and Curricular Responses

We emphasized actionable and sustainable elements of the collaborative assessment model by sharing results not only with participants, but all possible stakeholders to help decision makers design future workshops, webinars, or courses that align with student needs based on equitably designed assessment measures. In our dissemination of results, we presented data in multiple ways and across multiple audiences. This included presentations emphasizing findings (e.g., PowerPoint slides of graphs and tables), written and verbal executive summaries of changes to consider, and communication strategies for how to share these findings within departments. Results were shared with current BBS students through summary reports in the program newsletter and to key student groups to share within graduate student networks. Students were encouraged to have discussions with their labs to bolster awareness of student career interests and support further career exploration throughout their PhD training. Formal presentations and slides were also given and shared with the entire 50-person faculty and registrars within the BBS Executive Committee who were then encouraged to share broadly within their home departments. Presentations included not only the results from the survey, but also recommendations and possible action steps for departments and tracks to consider as they reviewed the student experience data on career interest. Our hope in sharing summary data was to develop a collaborative process to address the needs students were highlighting and to acknowledge the broader calls to revolutionize training programs based on evidence and student experience (Gammie & Gibbs, 2017).

Curricular & Programmatic Responses

Similar to O'Meara et al., (2014) who revealed departmental attitudes and support for non-traditional academic career paths can support graduate student awareness and interest in a variety of career trajectories, the BBS program made actionable shifts in curriculum and programs offered to the graduate student population based on these data and the subsequent discussions of the results. Below, please find several examples of how BBS programs have implemented changes based on the graduate student feedback from these surveys.

- Interdepartmental Neuroscience Program: incorporated student voice by adding students to their Executive Committee and making significant curricular revisions to focus on diverse skills development that prepare students for a variety of career sectors.
- Computational Molecular Quantitative Biology: added a required statistics course for all trainees to develop deeper knowledge of scientific research avenues and added events with diverse guest speakers to raise awareness of additional career avenues outside the traditional academic routes.
- Genetics Department: revamped their orientation programming to offer student-led "bootcamps" in various coding, statistics and data analysis skill sets.
- YBDIC, a group independently run by graduate students across all PhD programs in the BBS, hosted a day long panel in the spring of 2025 on diverse careers.

Discussion

Our exploration into career interests of STEM graduate students was conducted to explore firstly what career areas our students expressed interest in, and secondly how we could use collaborative assessment principles to design measures that collect and use data to center student experiences in STEM PhD programs. Results showed differing interests between first year and graduating students. Specifically, first year students showed greater depth of interest in many careers (measured by their average interest) and greater breadth of interest in careers (measured by nominal interest across careers). These findings suggest that students narrow their career interests during their course of study. To some extent, this is expected, given that students gain disciplinary expertise during their training, learn the ins and outs of their fields, and begin to more practically consider their next career step as they approach graduation. Yet, the strength of these differences and the overall attenuation of interest to lower averages across many disciplines was notable, particularly in academic careers. There is an increasing pattern of graduate students considering careers outside of academic track faculty, whether by choice or by a dearth in these positions (Bird & Rhoton, 2021; Cidlinska et al., 2023; Roache & Sauermann, 2017; Sinche, 2018). Our current work adds to this conversation by showing that students, at least in this sample and program, start out with academic positions (e.g., postdoc, research faculty position) among their highest interests.

Similar to Sinche (2018), who found that "only 14% of PhD graduates in science occupy tenure-track positions five years after completing their degree," we noted elevated student interest for non-academic career trajectories. This finding was first noted on a smaller dataset exploring how career interests can change over the course of a semester in graduate school (Claydon et al., 2021). These researchers found that a semester long course, with each week focusing on different career avenues, was enough to shift student knowledge of and interest for various career trajectories. Building on that knowledge, our recent survey data demonstrates clear avenues to support student exploration of career interest across a variety of career sectors.

While differences between first year and graduating students are themselves notable, the dissemination of these results and the accompanying programmatic response is a major contribution to why this work matters and is worthy to share. To cultivate program-level impacts required to maintain a focus on actionable assessment, we intentionally shared back results with key stakeholders to build better awareness, transparency, and responsiveness to student experience. Meeting with departments to reflect on patterns of students' career interests provided an opportunity to bring data into curricular action, with four curricular and programmatic shifts made directly in response to these discussions within a year of their review. Without coordinating discussions to bring these findings to department and program meeting agendas, they would not have as readily been integrated into a strategic plan and the students may not have seen the impact of their feedback.

Our research demonstrates how assessment processes can be used to build community within and across programs, with the goal to best prepare trainees for future success across myriad career trajectories. How data are used can visibly shift the perspectives of the participants providing that data, and if students can see changes being implemented in their programs, this can inspire trust in the stewardship of their feedback and create an excitement to provide additional data in future endeavors.

Collaborations have been blossoming nationally to support these initiatives, such as the workshops on "Enhancing Dissemination of Evidence-Based Models for PhD Career Development" (Bixenmann et al., 2020). Raising awareness among more faculty to both understand the current market landscape for graduates, in addition to understanding the career interests of the students in their programs, can support broader training and skills development that would seamlessly integrate into a variety of positions. Our embedded assessment efforts built momentum for students to share their data and for faculty to receive the results in a way that allowed for actionable programmatic changes.

For other institutions, their student populations may be looking for avenues to share their career interests in the current career landscape for STEM PhDs. Understanding student perspectives can provide faculty with the information needed to examine their career development offerings and to ascertain whether changes need to be made to best prepare their future scientists. The collaborative evaluation approach presented here can be used as a framework by other institutions to help them conduct evaluations of their own programs, starting with identifying what assessment support exists at their institutions. If there is an Office of Career Strategy, or a place where graduates can go to learn about varied career avenues, faculty could partner with these individuals to design survey questions (or adopt other methods, such as focus groups or a town hall), to first gather student perspectives on career development and career interest. Communicating with students about the purpose of a career interest assessment will help generate student excitement to share their perspectives, while communicating with training program leaders can support new initiatives to use collected data to adjust career development offerings. If a goal of STEM PhD education is to prepare the next generation of scholars adept at integrating across myriad career trajectories, then building supports to prepare students for those trajectories can be accomplished by engaging students, faculty, and staff to assess career interests and subsequently develop relevant content.

Limitations and Future Directions

Our work can be expanded on and bolstered given the boundaries of what can be concluded using our data. One limitation of the current work are the middling response rates, especially for graduating students, revealing the need for streamlined processes to capture when students are defending their dissertations, communicate expectations for and demonstrated use of students' feedback, and to potentially offer motivational incentives (monetary or not) for completing surveys within an expected timeline. We are navigating various administrative infrastructures to coordinate across a dozen departmental registrars such as building a simple but centralized database to capture key information that will drive timing of assessment collection methods. Future work with this project also includes assessing the impact of the program and departmental changes that were made in response to these data.

Additionally, we recognize that while the breadth of the BBS tracks encompasses a range of STEM disciplines, our sample draws students who may be seeking a particular trajectory based on the faculty areas of study or the university's association with medical school access, for example. The extent to which we can verify our current students' views represent the career interests of students across higher education is limited. As we build our dataset over time, share our work with colleagues exploring related questions, and look within and across the disciplines represented in our institution, we can speak to more robust patterns.

Our current analyses also do not explore patterns related to race, gender, or international status, though we acknowledge there are notable challenges of access and equity in graduate STEM education associated with such categories (Posselt et al., 2021). We opted not to include these variables in our analyses for a few key reasons. First, the completion rates paired with the limited percentage of members within given categories (whether self-described or gathered from admissions), particularly when intersectionality is considered, limits our ability to make patterned claims based on such demographic categories. Given this sample size, analyzing people based on such categories also limits our ability to adhere to confidentiality and lends towards overinterpreting the influence of one demographic factor over another. For example, there are a small set of people who are first year, female, Black, international students who have enrolled in the past few years. If we parse people along multiple categories, we risk pointing towards identifying members who contributed to this work and are likely overestimating which part of one's multi-dimensional identity may be associated with any pattern in the data. We recognize that people's individual and cultural identities are a factor in how they interact with the world around them, and want to respect the need that without much larger samples that allow us to understand individual and contextual factors, we may be misattributing effects with limited data to help us explain such differences.

Similarly, membership within given labs may influence people's career interest over time, assuming that skill sets and career examples may be more central to some disciplinary tracks and lab staffing than others. For similar reasons related to confidentiality and limited identifiable contextual factors (mentorship, perception of principle mentor encouragement, resource support, teaching experience), we do not examine lab-by-lab effects in our current sample. We look across the averages of the sample to give us a broader direction of patterns in career interest across years of study. In relation to the open-ended data presented here, we recognize that a specific question related to career interest and preparedness would provide better results than the broad question used on these surveys. In future iterations, we would like to expand the section for open-ended feedback on graduate student experiences with career interest and development during graduate school.

Future directions for this research involve alumni research to explore how recent graduates navigate the job market, and to what degree their expressed interests while in graduate school translate to their post-graduation job positions. Additionally, given the timeline of our data collection and students' time to degree, we are in the first years of exploring within-sample data that follows the same set of students from enrollment through graduation, paired with career choices of alumni. A repeated measures approach will allow us to finetune our analyses and look at individual patterns or sets of patterns over time. The current dataset takes a between-sample approach using cross-sectional cohorts of students, which may be more sensitive to individual differences. We aim that the year over year analyses of this work will allow us and our colleagues to continuously improve the BBS program and best prepare the next generation of scientists.

Appendices:

Appendix A: Descriptive Statistics for Whole Sample's Average Interest in Disciplines

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