The BioTAP Professional Development Model: Expanding Empirical Research on Graduate Student Teaching Professional Development

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Abstract

The Biology Teaching Assistant Project (BioTAP) provides a year-long mentoring program for practitioners and researchers of Biology Graduate Teaching Assistant Teaching Professional Development (GTA TPD). The program participants, known as BioTAP Scholars, are guided through the process of implementing a research project on GTA TPD. The rationale for the program is that GTAs are critical to the instruction of STEM majors and therefore need TPD to build instructional skills known to support students’ academic performance. However, there is a paucity of empirical data documenting effective GTA TPD practices. Here we describe the BioTAP Scholars program that sought to increase this literature base. In this essay, we detail program activities, Scholar feedback about the program, and changes in Scholars’ confidence in conducting research over the length of the program. As a result of the program, BioTAP Scholars have contributed to and expanded the GTA TPD literature base. With this growing base of empirical data, STEM departments can make evidence-based decisions related to their GTA TPD programs. The BioTAP Scholars program provides a model that could be adapted to increase capacity for research in other aspects of STEM education.


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THE BIOLOGY TEACHING ASSISTANT PROJECT

“…I think one of the best things is just the amount of feedback, I always knew that feedback was important, but you really got feedback here from different people from multiple institutions, with different background and experiences and it really helped [shape my research idea to something that was] stronger and I think better overall, so I’m really excited to get back to my institution and actually put this feedback into play.”

End of Research Development Session interview with Cohort 1 Scholar

This essay introduces a professional development model developed as part of BioTAP (Biology Teaching Assistant Project) that provides mentoring to GTA TPD (Graduate Teaching Assistant Teaching Professional Development) community members (e.g., faculty, staff, and graduate students) on how to conduct research on GTA TPD programs. This model, called the BioTAP Scholars program, is designed to increase the research base regarding GTA TPD so that GTAs have empirically-driven teaching preparation that supports STEM student learning and retention. Herein we describe how BioTAP was born and the steps involved in the development of the Scholars program.

There are many factors that influence attrition in undergraduate STEM majors including inadequate preparation and a lack of STEM identity in students (1). However, poor STEM instruction is cited by students as one of the most common factors to their leaving the field. Simultaneously, there is a need to prepare increased numbers of undergraduate students for post-graduate studies and STEM careers. Since the 1970s, instructional burdens, particularly in introductory science courses, have increasingly fallen on graduate teaching assistants (GTAs) (2, 3). Research indicates that 94.9% of all STEM GTAs teach undergraduates at some point during their degree program (4), and that 91% of introductory Biology labs at research universities are taught by graduate students (5). However, these GTAs are typically given
little to no pedagogical training (6, 7). If graduate students are shoudering such a critical teaching responsibility, then they need to be adequately prepared to use empirically based teaching practices to best prepare and retain undergraduate students.

It was this concern that brought us, the PIs of BioTAP, together. We were all engaged with GTA TPD programs and/or research at our respective institutions when we met. A review of empirical studies on GTA TPD and discussions with colleagues indicated that our worries were well-founded (8, 9, 10). Many higher education institutions have little or no GTA TPD, and there is not an adequate literature base to inform evidence based TPD practices. In fact, the number of empirical studies on GTA TPD effectiveness is so small that it would be difficult to recommend “best practices” for GTA TPD. So, although GTA TPD offerings have increased over time (11, 7), they remain exceptionally variable in approach and quality.

To address these concerns, we applied for and received funding from the National Science Foundation via the Research Coordination Network Undergraduate Biology Education (RCN-UBE) program (NSF#1539903) for BioTAP. The overarching goal of BioTAP was to increase the literature base on assessment of GTA TPD practices by mentoring members of the TPD community to conduct educational research related to GTA TPD programming. We proposed to develop and implement a year-long mentored experience called the BioTAP Scholars Program to achieve this outcome (Figure 1). Many GTA TPD community members have been historically isolated in their professional positions (e.g., Lab Coordinators), and the Scholars program brings these practitioners together to foster new collaborations to enhance research in the field. After five years of investment in this program, we share here our research mentoring model. Even though the BioTAP Scholars Program focuses on Biology GTA TPD, we believe the program’s approach can be a useful model to empower any education community seeking to enhance its GTA TPD research.

BIOTAP SCHOLARS PROGRAM DEVELOPMENT AND DESIGN

The PIs took a deliberate, time-intensive, and iterative approach to design the BioTAP Scholars program. In the program, BioTAP Scholars undertake independent research projects, and while some had experience conducting education research, many did not. Therefore, we needed to provide support at every stage of the research development process. We started by identifying program learning outcomes (Figure 2). Then, we created a one-year program consisting of six Virtual Learning meetings (VLCasts) and a 1.5-day face-to-face workshop (Research Development Session, or RDS). Both were designed to build educational research design skills through collaboration. Using these components, the PIs and program peers mentored BioTAP Scholars through their GTA TPD research projects. We vetted our program plans with our steering committee (16 GTA TPD experts), and they helped us shape the first delivery of the Scholars program. As we implemented each Cohort of Scholars, we continued to revise the program elements based on Scholar and Evaluator feedback.

Figure 1. Interactions among BioTAP scholars program stakeholders and outcomes.

Figure 2. BioTAP Learning Outcomes.

To describe the BioTAP Scholars Program, we have divided it into three phases: Application, Early Program, and Late Program (Figure 3). Our discussion of the Application includes the recruitment information and the items on the application. The Early Program phase involves the first two VLCasts and the RDS. The Late Program phase includes the final four VLCasts and Scholar submission of the final research abstracts. The BioTAP Virtual Conference was not an original part of the Scholars program; however, we added it during Cohort 1 as a venue for the Scholars to share their work with the larger BioTAP network. Therefore, we include it in our timeline and program description. Below we elaborate on each of the three phases and provide evaluation data from Cohorts 1 (N=16) and 2 (N=18).

Application

The application process began with an email invitation to apply to the BioTAP Scholars Program. We sent this email through listservs of professional science education practitioners and research groups (e.g., Association for Biology Laboratory Education, ABLE). We hoped to attract individuals who had a variety of professional positions (e.g., faculty, lab staff, teaching and learning centers staff), were interested in GTA TPD research, and were motivated to succeed in the program. The application (S1. BioTAP Professional Development Model – BioTAP Scholars Application) helped us identify prospective Scholars with the following characteristics: (a) interest in conducting research on GTA TPD (as compared to developing...
Once the Scholars were confirmed, we compiled their demographic data (Table 1). We then administered a survey to collect baseline data on their levels of confidence in multiple aspects of the education research process. Scholars in Cohorts 1 and 2 entered the program with confidence levels above 3.5 out of a scale of 7 (range from 1=not at all to 7=to a great extent) for all the research skills posed. This indicated that the Scholars were at least somewhat confident of their research abilities coming into the Program (Figures 4A and 4B and Table 2). The data collection methods and analysis are described in the figure legends and in the note associated with Table 2.
Early Program

We designed the Early Program to increase the BioTAP Scholars’ sense of community and develop research skills related to research justification, creating research questions, identifying participants, and delineating methods. The Early Program consisted of the first two VLCasts and the RDS (Figure 3). The first VLCast was a synchronous Zoom video conferencing meeting that gave Scholars a chance to meet the PIs and other Scholars in their Cohort. Scholars and PIs shared a single PowerPoint slide with information about their institution, interests in GTA TPD, goals for the BioTAP Scholars Program, and a picture of a pair of their shoes to “break the ice” (Figure 5).

In VLCast 2, Scholars viewed a PI-created video overview of education research approaches and methods (e.g., data collection methods, quantitative and qualitative approaches). VLCast 2 also included pre-RDS homework about how the context of a study could influence the collection of outcomes variable data (S2. BioTAP Professional Development Model – VLCast Homework, VLCast 1 Outcomes and Context Worksheet). They then identified two research questions related to their outcome variables and reviewed two research articles relevant to their research questions (S3. BioTAP Professional Development Model - VLCast Homework – Research Questions). In addition, they reflected on what they learned in the VLCast 2 video (S4. BioTAP Professional Development Model – VLCast Homework – Reflection Questions). Finally, the Scholars reviewed relevant resources to develop their research skills including Dietz-Uhler & Bishop-Clark’s guide to the Scholarship of Teaching and Learning (SOTL) (13), AAAS’s report on measuring undergraduate STEM teaching practices (14), and Connolly et al.’s research which can serve as a model for investigations on GTA professional development programs (15). The Scholars had approximately one-two weeks to complete post-VLCast 2 homework in preparation for the RDS.

After this preparatory work, Scholars attended the face-to-face RDS, an intensive 1.5-day meeting during which they used Dietz-Uhler & Bishop-Clark (13) to refine their research questions and made plans for data collection. During the RDS (S5. BioTAP Professional Development Model - RDS Agenda – Participant Version), Scholars worked both individually and in small groups to share ideas and get feedback on their developing research plans. Each Scholar used a template (S6. BioTAP Professional Development Model – RDS Presentation Template) to present their research plans to the rest of the Cohort for feedback at the end of the RDS. Our goal was for Scholars to have vetted many of the details they would need for their IRB application. Based on Cohort 1 feedback, we added another round of PI review of research plans after the RDS for future cohorts.

We re-administered the research confidence survey at the end of the RDS. Results indicated that after the Early Program completion, both Cohort 1 and 2 Scholars had statistically significant higher levels of confidence in 9 of the 14 research skills on the survey (see Figures 4A and 4B and Table 2).

The Scholars also completed the Project Activity Benefit Survey to evaluate the usefulness of the Early Program components (see Figure 6). These data are reported on a scale of 1 = Not beneficial, 2 = Slightly beneficial, 3 = Somewhat beneficial, and 4 = Very Beneficial. The mean for each

![Image](https://via.placeholder.com/150)

Figure 5. Sample of introduction slide that Scholars used in VLCast 1.

![Image](https://via.placeholder.com/150)

Figure 6. Findings from the Project Activity Benefit Survey for Cohorts 1 and 2. These items assessed how beneficial Scholars found each of the program components. \( p < .05 \) the likelihood of cohorts and stating program components were beneficial was compared with a series mann-whitney u tests mean reported benefit for each component within cohort always greater than slightly most being rds both cohorts. demonstrated statistically significant differences all vlcast feedback on final project abstracts perceiving more positive benefits these aspects.>
Cohort for each component was always greater than Slightly Beneficial, with the most beneficial program component being the RDS (3.8 for Cohort 1 and 4 for Cohort 2). Cohort 2 indicated a statistically significant higher benefit than Cohort 1 for VLCasts 1 and 2, likely due to iterative program changes (e.g., from Cohort 1 to Cohort 2, we cut a session devoted to IRBs because Scholars were more knowledgeable about this process than we expected, we added a discussion of barriers to implementing GTA TPD research experienced by prior Scholars, and we added an additional social event). In the open-ended portions of the survey, many Scholars described three aspects as beneficial: the combination of large and small group meetings, assignments to focus their thinking, and a practical final product (research plan). These components propelled them into the next phase of their research projects.

Late Program

We designed the Late Program to support the Scholars as they collected and analyzed their data and prepared their work for dissemination. It consisted of VLCast Meetings 3-6, abstract development and submission, and the BioTAP Virtual Conference. VLCasts 3-6 occurred in small groups (3-5 Scholars), with one or two PIs joining each meeting. These groups were formed at the end of the RDS and were loosely based on similarity of research projects. The groups were referred to as “pods” and each group gave themselves unique names (e.g., Self-efficacy Pod, Write Pod). Pods retained the same group members for the remainder of the Program. For each of the pod meetings, Scholars used a simple PowerPoint template (S7. BioTAP Professional Development Model – VLCast Pod Presentation Template – PowerPoint Slide) which ensured that every Scholar reported on the same topics. This included information such as a reminder of their research questions, progress to date, specific feedback requests, and next steps. The template also enabled Scholars to receive advice on sticking points, or barriers, they faced during their research process. We spent considerable time with Cohort 1 Scholars discussing barriers and were able to use our knowledge of typical sticking points to confront and address similar issues at the RDS for future Cohorts (S8. BioTAP Professional Development Model – Research Process Barriers).

Throughout the Late Program, the Scholars understood that it was expected and acceptable for them to progress at different rates. The Scholars stated that having these meetings helped them reach their milestones and kept them accountable to one another. For example, a Cohort 1 Scholar stated,

“All of the VLCasts were very motivating. Knowing a VLCast was coming up pushed me to keep working on the project. After a VLCast I was pumped up to continue with the next steps of my project. I needed this encouragement.”

VLCast 6, provided a more unstructured meeting format for the Scholars to tie up loose ends and prepare for writing their final abstracts. BioTAP Scholars submitted a one-page “extended” abstract that summarized the findings from their projects as the culmination of the program. For later cohorts, we provided a template for this abstract as well as an example, so they knew the level of detail we expected (S9. BioTAP Professional Development Model – Final Abstract Template). In the Abstract, the Scholars reported their research question, research methods, and any results they had completed. Following Cohort 1, we understood that not all Scholars would be able to fully complete their projects within the year of the program. We decided that Scholars should submit abstracts at the same time regardless of their progress so we could capture how much they accomplished within the year. This abstract, in addition to a reflection about what they learned from the program, was the final product of the BioTAP Scholars Program.

At the end of the program, we administered the confidence in research survey items again as well as items about what they learned from the program. We found that Scholars in Cohort 1 continued to have statistically significant gain in confidence in six skills through the end of the Program, while Scholars in Cohort 2 continued to have statistically significant gain in confidence in only two skills through the end of the Program (see Figures 4A and 4B and Table 2). The difference may be that Cohort 2 attained maximum confidence in seven skills earlier in the program, while Cohort 1 only attained maximum confidence in two skills at that time. This suggests that through iterative reflection and redesign, we improved Early Stages of the Program for Cohort 2.

The Scholars’ responses to the Project Activity Benefit Survey indicated that they judged all Late Program components to be at least Somewhat Beneficial, with Cohort 2 indicating statistically significant greater benefits from the Late Program components than Cohort 1 (Figure 6). Many mentioned that these aspects were essential to helping them move their projects toward completion. For example, a Cohort 2 Scholar commented,

“The POD check-ins for me were spaced at the exact right intervals. Far enough apart that you could have actually gotten something done, but close enough together that you didn’t lose momentum.”

Virtual Conference

In the fall of 2018, we launched the BioTAP Virtual Conference to provide a venue for the BioTAP Scholars and BioTAP community to share their research regarding GTA TPD. The annual 4-hour, synchronous conference includes 1-2 keynote presentations with the remainder of the time divided among short (15 minute) and lighting (7 minute) presentations. The online nature of the conference gives us an efficient, low-cost way to share research and connect with others in the community.

Critical Components and Challenges

As we reflect on the efficacy of our research mentoring model designed to empower change in an education community, we conclude that three program aspects are critical for Scholars to enact their research projects and overcome inevitable barriers inherent to conducting research. First, ongoing and extensive feedback is needed from the PIs, beginning with the homework, continuing through the RDS and the VLCasts, and culminating in the final abstracts. Second, peer support from other Scholars is crucial because it provides a space to commiserate and share ideas with one another while working through the program. Third, intermittent deadlines of scheduled pod meetings provide motivation for Scholars to continue making progress on their research as they know they
must provide updates on their work to receive constructive feedback to continue moving forward.

Running this program has not been without challenges. Many Scholars are interested in improving GTA TPD broadly, so discussions about research can quickly turn into discussions about TPD program development, particularly during the RDS. Although we encourage sharing of programming ideas, we are careful to redirect discussions in order to keep Scholars focused on GTA TPD research and not practice. Also, for Scholars not experienced in education research, helping them find local resources to support their work can sometimes be challenging. However, the PIs and the Scholars spending a short time together investigating departments and programs on the Scholars’ home campus that typically utilize education research in their disciplines (e.g., Department of Education, Department of Educational Psychology, Center for Teaching and Learning) often provides fruitful starting points.

Many Scholars choose projects with qualitative components and have no background in this technique, which can be daunting. Similar to efforts to locate local resources, it is important to have a ready library of resources that Scholars can access (e.g., instructional videos, research design and methods textbooks). A shareable and easy-to-search location, such as Google Docs, for program documents for both PIs and Scholars, is a must. Finally, facilitating working groups can be time-consuming. Busy schedules and different time zones make it tough to find common times for pod meetings, and email communications need to be explicit about what is required and when it is due. Similar to the suggestions made by Jensen-Ryan et al., 2020 (16), we encourage those considering the adoption of this PD model to consider means to alleviate logistical planning pressures, including course-release for one of the PD leaders or hiring additional administrative assistance to provide support for scheduling and communication to all involved in the project.

Moreover, some complications simply cannot be predicted. COVID-19 made our work more challenging in 2020. Even though we conducted many aspects of the program online pre-COVID-19, we had to move the PI meeting and Cohort 4 RDS to online sessions during the pandemic. Unfortunately, we felt that the essential community connection that comes from sharing meals and physical space was missing. Lastly, despite all efforts to help all Scholars successfully complete the program, unexpected circumstances always arise that prevent a few Scholars from completing their work. The reasons for this varied widely, but most often occurred because of limited time to conduct research on GTAs by lab staff members, which may be one of the main reasons why the literature in this area has always been limited.

CONCLUSION AND RECOMMENDATIONS

Evidence supports our perception that the professional development model employed by the BioTAP Scholars program is useful. First, to date, Scholar research outcomes have included 23 presentations and three publications (17, 18, 19) increasing the scholarly literature about GTA TPD. Scholars are also collaborating with others in their own Cohort, in other Cohorts, and within the BioTAP network (unpublished data). By making these connections within the GTA TPD community, Scholars are strengthening their research and professional network and expanding the systematic examination of GTA TPD. Finally, Scholars have applied the model in other contexts, which indicates the model is broadly useful. For example, one Cohort member used the BioTAP VLCast model in her new position working with elementary and middle school teachers:

“I repurposed our format for BioTAP Pod-check ins for… Teacher-Leader Check-ins—short and sweet template slides for each teacher to 1) gather their thoughts before the meeting and 2) have a focused discussion during the check-ins. The format has been super efficient and has provided guide-rails/mile posts for where they should be in the process—mirroring my experience as a BioTAP Scholar.”

For those who want to adopt the BioTAP Scholar Model in other education improvement contexts, we have several key recommendations:

- Provide participants with iterative opportunities to develop their education research skills.
- Provide opportunities for ongoing deadlines and mentoring, individually and in peer groups, to encourage new research and collaborations.
- Create an environment that encourages community, participant trust, and motivation.

There are many ideas to improve education that lack a strong research base. If we want to encourage the adoption of research-based improvements, we need to broaden the community of researchers focused on those improvements. The BioTAP Scholars program is a professional development model that can be used to help build that education research community and ultimately lead to improved undergraduate education.

SUPPORTING MATERIALS

- S1. BioTAP Professional Development Model – BioTAP Scholars Application
- S2. BioTAP Professional Development Model – VLCast Homework, VLCast 1 Outcomes and Context Worksheet

ACKNOWLEDGMENTS

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REFERENCES


Table 1. Characteristics of BioTAP Scholars in Cohorts 1 and 2 in Terms of Institution and Position Type. *Note: Many Scholars listed more than one position type, so the number of positions is greater than the total number of Scholars (n=29).

<table>
<thead>
<tr>
<th>Scholar Characteristics</th>
<th>N</th>
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<tr>
<td><strong>Institution Type</strong></td>
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<td>Doctoral Research-Intensive Universities</td>
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<td>Masters Colleges and Universities</td>
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<td>Baccalaureate/ Associate’s Colleges</td>
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<td>Tribal Colleges</td>
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<td>HBI/HBCU</td>
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<td>Introductory or Undergraduate program director</td>
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<td>Graduate Student</td>
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<td>Other</td>
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Table 2. Cohorts 1 and 2 Significant Changes in Research Skills Confidence – Explanation of Hierarchical Linear Model Results. Hierarchical linear modeling was used to determine the statistical significance of changes in BioTAP Scholars’ confidence regarding education research skills over time. A parabolic model (blue cells) indicated Scholars’ perceived confidence for some skills grew more during the Early Program and flattened in gains, signifying that growth did not significantly continue throughout the Late Program. A linear model (gold cells) indicated that Scholars perceived confidence for these skills continued to grow throughout the entire program; *=significance level at p < .05, **= significance level at p < .01, ***= significance level at p < .001; blank cells indicate no significant growth in those skills over time. Note: This table does not include three skills that were included on the surveys but for which the HLM did not indicate significant growth.

<table>
<thead>
<tr>
<th>Research Skill</th>
<th>Significant Increase in Confidence</th>
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<tr>
<td></td>
<td>Cohort 1</td>
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<td>Early Program</td>
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<tr>
<td>Identify variables to measure the effectiveness of your GTA TPD program</td>
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<td>Write a GTA TPD research question</td>
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<tr>
<td>Locate peer-reviewed literature relevant to a particular GTA TPD research question</td>
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<tr>
<td>Choose appropriate research instruments (e.g., surveys, interview protocols) to measure your GTA TPD outcome variables</td>
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<tr>
<td>Choose a research design that could help you answer your GTA TPD research question</td>
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<tr>
<td>Specify an appropriate participant sample to address a given GTA TPD research question</td>
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<tr>
<td>Implement a study to address a GTA TPD research question</td>
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<td>Analyze your GTA TPD research data</td>
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<td>Collaborate with others to conduct GTA TPD research</td>
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<td>Present your GTA TPD research to other researchers at conferences</td>
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