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A Critical Review of the Literature on Biology Graduate Teaching Assistant Professional Development

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Abstract: Graduate Teaching Assistants (GTAs) are critical yet under-appreciated instructors in the movement to reform undergraduate science instruction. In biology specifically, GTAs teach a large proportion of undergraduate "gateway" courses shown to be critical for success and retention of biology students. Yet GTA Teaching Professional Development (TPD) continues to be limited or nonexistent nationwide. To inform the state of the field for both research and practice, this study is a critical review of the GTA professional development literature. We focus on a sub-sample of n = 23 studies of biology GTAs in the larger sample of n = 117 reviewed manuscripts. Findings are aligned with a evaluation framework (Reeves et al., 2016) and highlight the types of TPD being published in the literature and the types of outcomes variables being measured including: GTA cognitive outcome variables, GTA teaching practice variables, and undergraduate student learning outcomes. We discuss implications for research and practice in this field.

Keywords: Biology, Graduate Teaching Assistants, Professional Development, Literature Synthesis

Introduction

Undergraduate biology educational reform initiatives are supported by an ever-growing body of evidence that promotes active engagement of students in the learning process in order to develop deep conceptual understanding of disciplinary content (AAAS, 2011; NRC, 2012). Effective implementation of these strategies demonstrates increases in biology student achievement and retention (Freeman et al., 2011). Outcomes are also disproportionately positive for student groups commonly underrepresented in STEM fields (Eddy & Hogan, 2014). Despite the evidence for the effectiveness of evidence-based strategies there remains a research-to-practice gap; they are not broadly implemented or sustained by various undergraduate instructors at a national scale (Gess-Newsome et al., 2003).

Undergraduate STEM instructors, including tenure and non-tenure track faculty, part-time instructional faculty, and graduate and undergraduate teaching assistants, represent the front lines of educational reform in higher education. This particular work focuses specifically on biology Graduate Teaching Assistants (GTAs) as instructors because increases in undergraduate STEM student retention have been closely linked to student engagement and positive interactions with GTAs, even more so than with faculty (Rushin et al., 1997; Seymour et al., 2005; Nicklow et al., 2007; O'Neal et al., 2007). Biology GTAs impact on undergraduate education is important to consider, as they can be responsible for teaching over 91% of freshman labs and other important "gateway" introductory courses linked to poor student retention (Sundberg et al., 2005).

Despite GTAs' impact on undergraduate education, teaching professional development (TPD) programs remain largely inadequate nationwide (Prieto & Scheel, 2008; Gardner & Jones, 2011; Schussler et al., 2015). GTAs TPD opportunities vary widely across institutions, are limited in the scope of topics taught, and over half of them require only approximately 10 hours of contact per year (Schussler et al., 2015). This does not meet the recommendations for PD best practices (Darling-Hammond & Richardson, 2009). Universities that continue to provide only "one shot" teaching supplements in the form of a pre-semester orientation (Schussler et al., 2015) without regard for measuring the effectiveness of the program on GTA instruction can unduly influence the quality of undergraduate education.

One way to increase the quantity and quality of effective biology GTA TPD programs is to increase the literature base that empirically examines best practices in the field. These findings can then be generalized and adopted for various contexts to promote effective pedagogical training of GTAs. To promote more research into biology GTA TPD, the Biology Teaching Assistant Project (BioTAP) is a NSF-sponsored Research Coordination Network - Undergraduate Biology Education (RCN-UBE) designed to support and synthesize research in the field. A component of this project is bringing together researchers to network, design and develop research projects in GTA TPD. In order to provide participants with an appropriate grounding in the literature, the research team conducted a comprehensive literature review of the field of GTA TPD the results of which are reported here.

Methods

The BioTAP team conducted a comprehensive and systematic review of the literature on GTA TPD using scholarly databases that included Google Scholar, Web of Science, and PsychInfo. Search terms included "professional development", "graduate", "graduate student", and "graduate teaching assistant". Data sources included peer-reviewed journal articles, dissertations, and formal research papers published by scholarly organizations. Each author also further mined their own personal bibliographic databases to determine appropriate articles for review in order to be as comprehensive and exhaustive as possible.

Information regarding research design and methodologies, research questions, data collection instruments, type of data collected, study sample characteristics, and study context from each manuscript were recorded on a shared database. To code the outcome variables in each study, an analytic framework on GTA TPD was used (Reeves et al., 2016; Figure 1). Three categories of GTA TPD outcome variables are identified in this framework and the codes used for this study are shown after each: 1) *GTA cognition variables* consist of cognitive outcomes on GTAs such as knowledge of pedagogy (C.1), attitudes toward teaching (C.2), or beliefs about teaching and learning (C.3); 2) *GTA practice variables* consist of graduate student behaviors in planning for (P.1), implementing (P.2) and assessing instruction (P.3); 3) *Undergraduate student variables* consist of outcomes from students of GTAs such as student content knowledge (U.1), student retention (U.2), or student interest in biology (U.3).

The researchers also coded for the type of GTA TPD reported in the manuscript using a framework by Schussler et al. (2015; see Figure 4). These TPD types ranged from pre-semester institutional, departmental or course orientations, in-semester institutional PD, in-semester institutional or departmental PD, the presence of a teaching certificate program, PD during lab preparatory meetings, peer mentoring, teaching observation, and review of teaching evaluations. Inter-rater reliability of codes was conducted by all authors on each of the manuscripts in the sample.

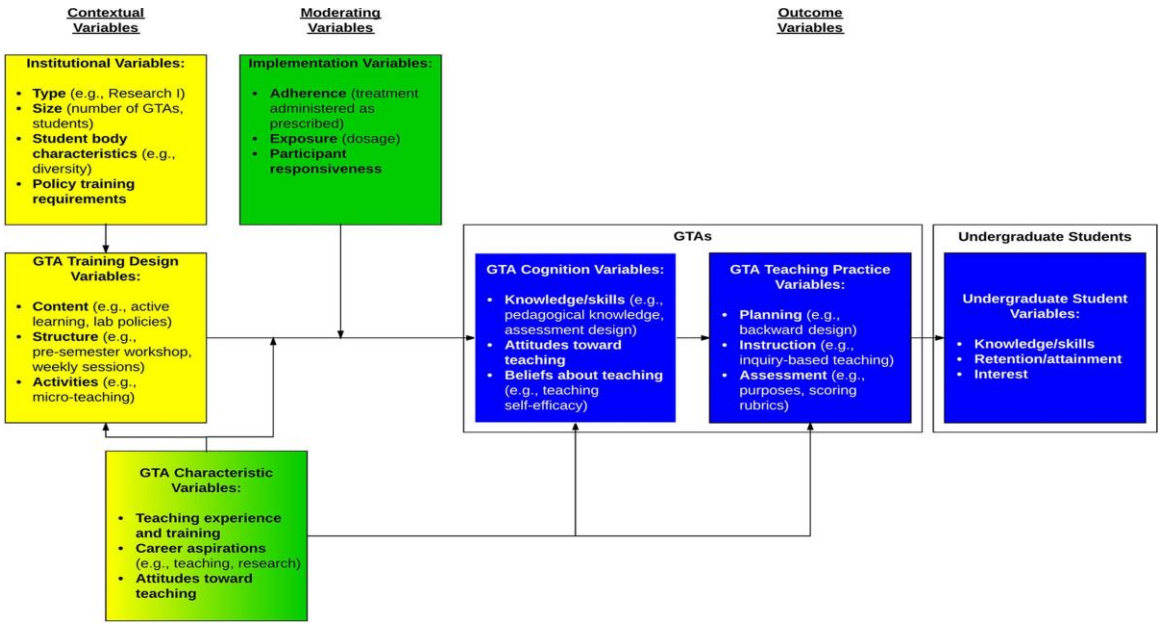

Figure 1: Analytic framework showing contextual variables (Institutional context, GTA training design) in yellow. Moderating variables (Implementation, GTA characteristics) are shown in green. Outcome variables of GTA TPD studies (GTA cognition, GTA teaching practice, Undergraduate outcomes) are shown in blue.

Analysis and Results

We identified n = 117 articles written since 1989 that addressed some form of GTA TPD. Of these n = 73 (59.82%) sampled GTAs in a Science, Technology, Engineering, or Mathematics (STEM) fields, publishing either descriptions of programs or research/evaluation articles. For the purpose of this analysis n = 11 (15.07%) of these 73 articles were coded as *descriptive* in that they did not provide any data at all evaluating or assessing aspects of the TPD program. The remaining studies (n = 62; 84.93%) provided some form of data and were coded as *research/evaluation* manuscripts (note these were only for STEM fields in the sample).

The STEM fields represented in these GTA TPD research studies included n = 23 (37.10%) in biology, n = 14 (22.58%) in general science, n = 11 (17.74%) in chemistry, n = 5 (8.06%) in physics, n = 3 (4.84%) in geology, and only n = 1 (1.61%), respectively, in engineering, mathematics and computer science. For the purpose of the audience for this talk (the National Association of Biology Teachers) we limited this in-depth analysis to a subsample (n = 23) of the STEM research article that were in a biology context (Figure 2).

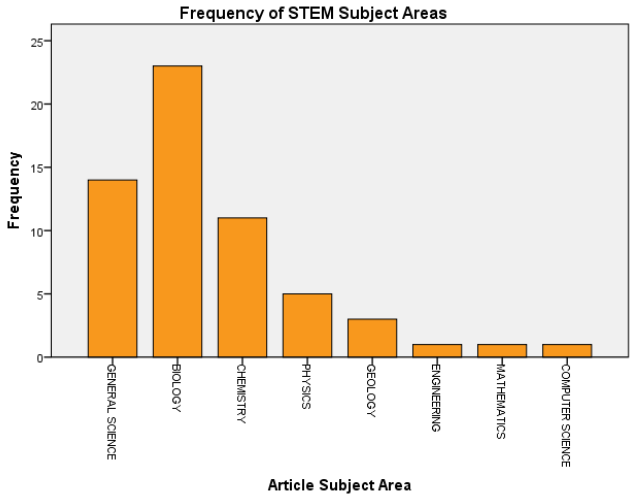

Figure 2: Numerical frequency of identified studies (n = 62) that were conducted in various STEM disciplines.

Overall, our analysis revealed that the most common outcome measured in these studies was GTA cognition variables at 65.22% of the biology sample, followed by GTA practice variables at 39.13% of the biology sample, and undergraduate student variables at 26.09% of the biology sample. Note that the unit of analysis here is outcome variables and not individual studies as some studies measured multiple GTA or undergraduate student outcomes and these were analyzed independently (Figure 3).

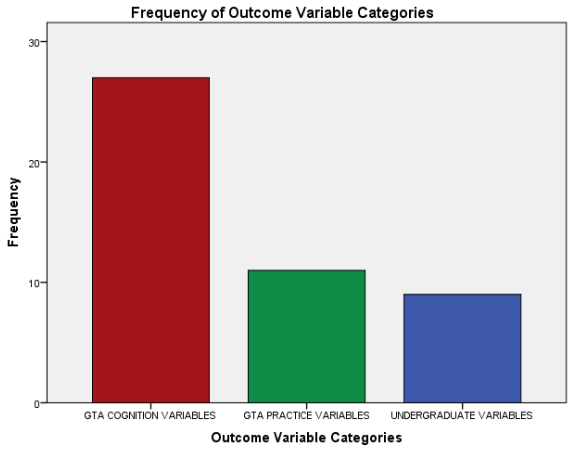

Figure 3: Numerical frequency of identified studies in biology (n = 23) that measured a particular category of outcome variable as defined by Reeves et al. (2016).

Within each of these broad outcome variable categories we conducted a more fine-grain analysis of outcomes using the Reeves et al. (2016) framework as shown in Table 1. The top four outcome variables measured were GTA knowledge of pedagogy (47.83%), GTA beliefs about teaching and learning (43.48%), GTA implementation of instruction (39.13%), and GTA attitudes toward teaching and learning (26.09%).

Table 1: Relative frequency of outcome variables within each outcome category.

Variable Codes	Frequency	Relative Frequency (%)
C.1 GTA Knowledge/Skills	11	47.83
C.2 GTA Attitudes	6	26.09
C.3 GTA Beliefs	10	43.48
P.1 GTA Planning	1	4.35
P.2 GTA Instruction	9	39.13
P.3 GTA Assessment	1	4.35
U.1 Student Knowledge/Skills	5	21.74
U.2 Student Retention	1	4.35
U.3 Student Knowledge	3	13.04

We also conducted an analysis of the types of TPD programs studied in each manuscript. In-semester departmental pedagogical seminar (30.43% of the sample) and PD during lab preparatory meetings (52.17% of the sample) were the most common types of GTA TPD (Figure 4). Our analysis also revealed the paucity of studies that reported impact on GTAs for the following types of GTA PD: pre-semester institutional orientation, pre-semester departmental orientation, in-semester institutional PD, teaching certificate program, peer mentoring, teaching observation, and review of teaching evaluations.

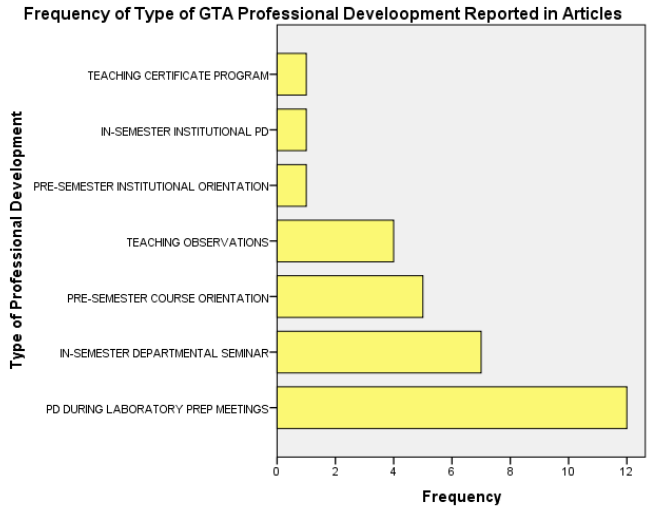

Figure 4: Numerical frequency of identified studies in biology (n = 23) that described a particular type of teaching professional development intervention.

Discussion

This study highlights an existing, yet widely ignored body of literature, which has the potential to benefit practitioners, researchers, and TPD specialists in implementing GTA TPD and conducting research on GTA TPD. We identified just over 100 articles, only 62 of which examine STEM GTA TPD and a subsample of n = 23 articles that focused specifically on biology GTAs. It is important to note that the rigor of these studies is also of varying quality but we did not attempt to evaluate that here. We note that this is a limitation of this particular analysis in that we are indicating *what* data exists related to biology GTA TPD and not the *quality* of that data or the research design from which it was collected. This work synthesizes the established literature, thereby, expanding the GTA TPD knowledge base. Findings from this study illuminate gaps in the current standing of the field of biology GTA TPD; thereby, highlighting next steps for scholarship in the field.

The data collected from this study illuminates the gaps in the biology GTA TPD literature. Specifically, most research in this field examines the state of or changes in what GTAs know (GTA cognition) about teaching and learning but very few examine how this cognition translates to instructional practice or the impacts that these practices have on undergraduate

student learning. This highlights the comparatively little research in GTA TPD in general and few studies that focus on GTA practice outcomes (i.e., assessment and planning) and undergraduate student learning outcomes (i.e., retention) specifically. In addition, through a fine-grained analysis of this data, it was determined that the preponderance of the data being collected is on undergraduate student knowledge and skills (within undergraduate student variables), GTA instructional practice (within GTA teaching practice variables), and GTA knowledge and skills (within GTA cognition variables).

This work builds on the current literature base by describing the current state of GTA TPD programs being offered at post-secondary institutions. Schussler et al. (2015) reported data collected from an international (U.S. and Canada) survey on the types of TPD offered to GTAs. The current study surveyed the biology GTA literature base and cataloged the types of GTA TPD reported in research manuscripts. Together, these two studies (Schussler et al., 2015 and the current study) helps paint a more holistic picture of biology GTA TPD and the research being conducted to assess the efficacy of these TPD programs. In particular, although many institutions reported offering a teaching certificate program (30%), pre-semester institutional orientation (70%), and in-semester institutional orientation program (70%; Schussler et al., 2015), only one article was found to report any data on these types of PD models for biology GTAs. Therefore, there is currently an exigent need for more research into the efficacy and effectiveness of these types of GTA TPD models.

This project should be of interest to both biology education research scholars as well as professional development practitioners in both undergraduate and K-12 settings. Utilizing our analytical framework on biology GTA TPD research identified gaps in the scholarly literature that might be targeted for further analysis and future research design. These results will also inform best practices in biology GTA TPD that could be used for iterative designs of GTA TPD programs at universities.

References

American Association for the Advancement of Science (AAAS). (2011). Vision and change in undergraduate biology education: A call to action. Final report of a national conference organized by AAAS with support from NSF. Washington, DC.

Chen, X. (2014). STEM attrition: College students' paths into and out of STEM fields. Retrieved from the National Center for Education Statistics website: http://nces.ed.gov/pubs2014/2014001rev.pdf

Darling-Hammond, L., & Richardson, N. (2009). Research review/teacher learning: What matters. *Educational leadership*, *66*(5), 46-53.

Eddy, S. L., & Hogan, K. A. (2014). Getting under the hood: How and for whom does increasing course structure work? *CBE-Life Sciences Education*, *13*, 453-468.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroator, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science,

engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*, 8410-8415.

Gardner, G. E. & Jones, M. G. (2011). Pedagogical preparation of the science graduate teaching assistant: Challenges and implications. *The Science Educator*, 20(2), 31-41.

Gess-Newsome, J., Southerland, S. A., Johnston, A., & Woodbury, S. (2003). Educational reform, personal practical theories, and dissatisfaction: The anatomy of change in college science teaching. *American Educational Research Journal*, *40*, 731-767.

Gormally, C., Subiño Sullivan, C., & Szeinbaum, N. (2016). Uncovering barriers to teaching assistants (TAs) implementing inquiry teaching: Inconsistent facilitation techniques, student resistance, and reluctance to share control over learning with students. *Journal of Microbiology & Biology Education*, *17*, 215-224.

National Research Council (NRC). (2012). Discipline-based education research: Understanding and improving learning in undergraduate science and engineering. National Academies Press. Washington, D. C.

Nicklow, J. W., Marikunte, S. S., & Chevalier, L. R. (2007). Balancing pedagogical and professional practice skills in the training of graduate teaching assistants. *Journal of Professional Issues in Engineering Education and Practice*, *133*, 89–93.

O'Neal, C., Wright, M., Cook, C., Perorazio, T., & Purkiss, J. (2007). The impact of teaching assistants on student retention in the sciences: Lessons for TA training. *Journal of College Science Teaching, 36(5), 24–29.*

Prieto, L. R., & Scheel, K. R. (2008). Teaching assistant training in counseling psychology. *Counselling Psychology Quarterly*, *21*, 49-59.

Reeves, T. D., Marbach-Ad, G., Miller, K., Ridgway, J., Gardner, G. E., Schussler, E. E., & Wischusen, E. W. (2016). A conceptual framework for graduate teaching assistant professional development evaluation and research. *CBE-Life Sciences Education*, 15(2), Essay 2.

Rushin, J. W., De Saix, J., Lumsden, A., Streubel, D. P., Summers, G., & Bernson, C. (1997). Graduate teaching assistant training: A basis for improvement of college biology teaching & faculty development? *The American Biology Teacher*, *59*, 86–90.

Schussler, E. E., Read, Q., Marbach-Ad, G., Miller, K., & Ferzli, M. (2015). Preparing biology graduate teaching assistants for their roles as instructors: An assessment of institutional approaches. *CBE-Life Sciences Education*, 14(3), Article 31.

Sundberg, M. D., Armstrong, J. E., & Wischusen, E. W. (2005). A reappraisal of the status of introductory biology laboratory education in US colleges & universities. *The American Biology Teacher*, *67*, 525-529.