JOURNAL OF CHEMICAL EDUCATION

Article

pubs.acs.org/jchemeduc

An Intensive Training Program for Effective Teaching Assistants in Chemistry

Vera Dragisich,* Valerie Keller, and Meishan Zhao

Department of Chemistry, The University of Chicago, 5735 South Ellis Avenue, Chicago, Illinois 60637, United States

Supporting Information

ABSTRACT: We report an intensive graduate teaching assistant (GTA) training program developed at The University of Chicago. The program has been assessed and has been successful in preparing GTAs for effective discussion and laboratory teaching for both general and organic chemistry. We believe that this training program can provide insightful information to benefit other similar GTA training programs in the future.

KEYWORDS: *Graduate Education/Research, Collaborative/Cooperative Learning, Curriculum, Safety/Hazards, Inquiry-Based/Discovery Learning, Testing/Assessment, Ethics, Professional Development, TA Training/Orientation*

INTRODUCTION

Graduate teaching assistants (GTAs) play an essential role for undergraduate college education at many research universities in the United States. In many cases, the quality of GTA teaching ingrains a crucial and lifelong signature in undergraduate students that affects career choices and development. This is especially true due to the fact that a large majority of GTAs in chemistry teach freshman and sophomore year undergraduate students. Therefore, the quality of GTA teaching has a long but foreseeable impact on the future scientific community and for our society at large.

Not only are GTAs a vital component in teaching chemistry to undergraduates, but the training that they themselves receive impacts their own development. In *An Overview of the Changes in the 2015 ACS Guidelines for Bachelor's Degree Programs*, the ACS Committee on Professional Training stated explicitly that "the committee recognizes that many chemistry programs employ undergraduate and graduate students as teaching assistants and that these are positive educational experiences for these students. The 2015 Guidelines indicate that programs must properly train and supervise teaching assistants."[1]

Recognizing the importance that GTAs play in American education, the chemistry education community has been striving to design and develop the most effective GTA training programs, so as to ensure that undergraduate students have a smooth and positive learning experience. Earlier developments of GTA programs and teaching techniques have been fruitful.[2−11] Advances in pedagogical approaches for effective teaching have won widespread recognition,[12−20] e.g., scientific inquiry-based instruction in teaching laboratories,[18] feedback and evaluation on case studies,[19] and the impact of GTA self-image on teaching performance.[20] Academic lab-safety culture was examined and discussed in *Science* by Benderly after the UCLA lab accident.[21] A few comprehensive training courses for GTAs and advice for new science faculty have also been developed, but these are designed to train teachers at a much later point in their careers.[22−26] While these are all important programs, they do not address our need to have comprehensive and holistic training prior to the first day of class. We add to this portfolio of training programs with our own successful program that brings all incoming GTAs up to the same quality of teaching.

In this paper, we report an intensive two-week GTA training program developed in the Department of Chemistry at The University of Chicago. The challenge that we face every year is to bring all of our entering graduate students, many with no teaching experience, up to the same level of proficiency in order to stand in front of their own classes on day one. This program focuses specifically on the most relevant and imminently pressing categories: introducing the teaching role through policy orientation; training to be an ethical and authoritative figure in the classroom through pedagogical learning and self-examination; building a positive self-image by way of peer-review and peer-led discussions; preparing to establish and reinforce safety culture by drawing on lessons from lab accidents at several higher educational institutions; and establishing an open and supportive scholastic teaching and learning environment through a variety of community social activities. Due to the current GTA demographics, an appreciable percentage of teaching assistants are international GTAs. We also embrace the challenge of addressing the issues of diversity in GTA training, including language and cultural barriers. All these objectives are necessary given our demographic of undergraduate students and their high level of engagement in classes.

Our GTAs consist primarily (>90%) of first year graduate students, approximately 40 per year. They are required to teach at least one full year of either General or Organic Chemistry, which includes a 50 min discussion section of 14−20 students and a linked 4 h lab period. We process approximately 500 General Chemistry and 280 Organic Chemistry students per quarter. This training is a required part of our graduate program because of the emphasis that the University of Chicago puts on teaching as part of a broader education. We strive to embody

Received: July 16, 2015
Revised: December 30, 2015

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX

the phrase "Teacher of Teachers". The effectiveness of the program was assessed using assessment protocols. The findings from the program provided us insightful information and experience for improvement of the program going forward. We also hope that by reporting this program it will benefit other similar GTA training programs in the future.

GTA TRAINING PROGRAM

Program Structure

Upon entering the graduate program in chemistry, all incoming GTAs are provided with two sets of training and orientation at the University of Chicago. Prior to the start of the academic year, the two essential programs are a university-wide graduate student orientation and a pedagogical training program in the Department of Chemistry. International GTAs are also required to attend an additional training for English as a second language and cultural awareness.

The departmental pedagogical training is a required and intensively scheduled two-week training program (see Table 1), ensuring a smooth transition for GTAs from being undergraduate students to graduate student teachers. Graduate students attend training sessions from 9 AM to 5 PM every day for 2 weeks. This gives a total of 80 h of contact time prior to the start of class, which is unique among our peer institutions[27] (see Supporting Information for training schedule). The training provides GTAs with various activities to achieve the fundamental goals of effective teaching, particularly in the development of GTA positive self-image, confidence in teaching, professional behavior, and pedagogy building on the product−process mechanism.[6] Through case studies and assessments from the various activities, GTAs are trained to determine what pedagogical tools are most effective for their own teaching style.

Table 1. GTA Training Activities

Activity Title	Activity Description
Departmental Orientation and Policies	Departmental orientation and policies
	Basic exams—physical, inorganic, organic
	Graduate student requirements and policies
	Specific GTA policies and responsibilities
	Advice from PSD Dean of Students
Ethics and Authority in the Classroom	Ethics and authority in the classroom: senior GTA panel discussion
	Ensuring equity in the classroom
	Workplace harassment awareness
	Workshop on teaching in the college
Self-Image, Confidence, and Pedagogies in Teaching	Cooperative Learning in Chemistry (CLiC)
	Introduction to leading a discussion
	Advice for international GTAs
	Practice discussions
	Practice lab experiments
Laboratory Safety	Lab safety training—protocols
	Lab safety training—hands-on in lab
	Lab safety training—case studies
Social Activities	University graduate student social
	University student services
	PSD student services and stress management
	Department social activities
	Paired graduate student mentor activities
	Community social activities
Other Activities	Science library services
	University police and campus safety
	Departmental individual consultation

While training GTAs on the operational logistics of teaching, the training program also pays special attention to several aspects related to GTA physical and mental health which is a base for career network development, e.g., community building and social activities. These segments have been added in the past few years after both interest from outgoing GTAs and observations over the years. Our TA training started in 1985 after graduate student initiative and faculty support at a time when there was no university-wide support for GTA training. While our program has been around for some time, the inclusion of these aspects that focus on a holistic approach to teaching necessitates publication at this time. Many programs concentrate on the logistics of teaching, whereas we touch on many more aspects of the GTA experience. Following the training, an assessment of the activities is performed based on the feedback provided by the participating GTAs. As discussed later, this assessment was positive. Departmental support and assistance remain throughout the duration of their teaching duties by way of weekly meetings led by the teaching faculty and in conjunction with *An Advanced Training Course for Teachers and Researchers in Chemistry*.[22] This Advanced Training Course is a recent addition to our GTA training program that grew out of the Intensive Program to help create a continuing mechanism for GTAs to foster their teaching skills.

Beyond the actual program assessment, GTAs are assessed by their undergraduate students and by teaching faculty. Continued overall good evaluations by undergraduates along with the winning of GTA teaching awards have indicated that the program has provided a positive impact on the undergraduate students taking chemistry.

Departmental Orientation and Policies

The training program starts at the entry point for GTAs into their career in graduate school and introduces them to their position in the department, the division, and the university. This is critical in establishing a realistic expectation of their duties as students and as teachers.[28] As noted earlier, GTAs in the Department of Chemistry are responsible for both laboratory and discussion teaching as a part of their requirements.

The orientation includes a welcome message from the department, global and course-specific GTA policies, graduate student requirements, and early career development guidance. Various campus programs involving the role of GTAs are integrated into the orientation to provide an ongoing and supportive network. The full schedule of events is available in the Supporting Information.

Ethics and Authority in the Classroom

To ensure the academic integrity of the university community, ethics and professional development training is crucial for all GTAs to become effective and professional teachers. The training is comprehensive, including equity in the classroom, workplace harassment awareness, and a senior GTA panel discussion to share experiences on professional conduct.

Training on ethics in the classroom introduces the GTAs to situations where different groups of students could be treated differently, either intentionally or unintentionally. This training is to ensure that, as teachers, GTAs are sensitized to equity in the classroom. A representative from the Provost's Office is

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX

invited to deliver wider ranging training on workplace harassment to include Title IX issues. Since GTAs can experience harassment issues both as students and as teachers, this training is especially important and has been well received. Also discussed is the importance of academic freedom and open discourse within the current climate.

A particularly common struggle of GTAs is managing an effective transition from being a student to being an authority within the classroom. The GTAs attend a panel discussion that addresses how the first year teachers can establish themselves as an authority on the first day of class. The panel is composed of experienced GTAs who share their own techniques for effective teaching and creating a professional environment. Because the guidance comes from fellow GTAs, this panel also helps to foster community building and provides positive mentors for incoming GTAs.

Positive Self-Image and Confidence Building

GTA positive self-image sets the tone in a classroom. In this program, GTAs are trained to build a positive self-image through reflection and an understanding of their teaching role and its associated responsibilities.

Pedagogical activities and teaching practice in the form of mock discussion sessions and practice laboratories are provided as part of the self-image and confidence building training. These components provide GTAs with broad, first-hand training in engaging with students, e.g., teaching in the style of open forum discussions, student-led problem solving, and small group work. Each GTA mock discussion is evaluated in a low-risk environment through evaluations filled out by fellow GTAs and direct supervisors. These evaluations and the ensuing conversations, both during and after the mock discussion, help give the GTAs real-time feedback on their skills and effectiveness as teachers. This practice also provides GTAs examples of other teaching styles since they watch approximately 20 different mock discussions over the course of the training.

The Collaborative Learning in Chemistry Program (CLiC) is used as an initial introduction to pedagogies and philosophy. CLiC is a supplemental program for undergraduates that facilitates small group problem solving sessions to build skills that students can directly use in their General and Organic Chemistry courses. These collaborative teaching techniques are demonstrated to the GTAs in a classroom setting to show rather than tell about the different ways to integrate group work into a discussion section.

A separate panel led by experienced international GTAs focuses on the unique challenges that non-native English speakers face while in the classroom.

Laboratory Safety

One of the key elements in effective instruction is hands-on laboratory experience that is helpful for both teaching and learning. Meanwhile, a critical concern of working in a lab is the safety of students and GTAs during lab experiments. To ensure the safety of everyone, safety officers from the Environmental Health and Safety (EHS) office are invited to provide comprehensive training on the chemical hygiene plan and laboratory safety protocols.

The training is 2-fold: (1) providing policies and knowledge on safe handling practices for chemicals and evacuation; (2) hands-on training involving eyewash stations, chemical spill control, and fire extinguisher training. The training provided by EHS is supplemented with case studies and discussions of chemistry laboratory accidents in recent years at higher educational institutions. Along with the main goal of ensuring safety for undergraduate students, the discussion also aims to expose GTAs to situations that they may find themselves experiencing as researchers and the potential consequences that come with poor decisions and lack of preparation.

This safety training serves as a foundation for effective teachers in a chemistry laboratory and prepares GTAs to handle the responsibilities of becoming an authority in teaching and research settings.[21,29]

Social Activities

To support positive learning in a scholarly environment, our training program schedules multiple social activities to reduce potential stress during the training period. These activities include university graduate student social services, departmental and other community social activities, and Physical Sciences Division (PSD) student services and stress management tools which specifically promote self-care practices, positive thinking styles, time management techniques, and social connections.

Meanwhile, GTAs are paired with older graduate students for a series of casual meetings and social activities in order to establish a personal connection with someone who has had first-hand experience with the types of situations and challenges the GTAs will face in their first year—creating organic pathways of mentorship. These meetings incorporate GTAs into the scholastic culture of the Department of Chemistry and establish a sense of community within the entry class of students.

International Teaching Assistants

For the program to be effective, it is important to consider the diversity in cultural and educational backgrounds of GTAs. Special attention is given to international GTAs in the form of a separate panel led by senior experienced international GTAs. This portion of the training focuses on unique challenges that non-native English speakers face while teaching their classes. It is interesting to note that advice from international GTAs becomes universal since leading a class is a foreign experience to the majority of the first year GTAs.

Additional Support and Resources

The Graduate Student Affairs office provides support for GTAs in their academic careers as well as social and personal needs on a university-wide level. The Chicago Center for Teaching provides additional support for GTAs in the form of pedagogy training and orientation to the University through an annual "Workshop on Teaching in the College".

■ PROGRAM ASSESSMENT

We have internally developed assessment protocols to gauge the effectiveness of the program and provide specific feedback to the GTAs regarding their teaching performance. There are three means by which the effectiveness of this program is measured. At the same time, we are evaluating the individual GTA's development as a teacher. The first is a real-time evaluation during the Intensive Training Program of individual GTA mock discussions by each of the graduate students and supervising teaching faculty. Each GTA gets both peer and supervisor evaluations to help give a broader picture of the training. The evaluation form is shown in Box 1 along with the points of focus and serves to give the GTA feedback on their skills in front of the class as well as information to the teaching faculty on how well the training is going. These points are all

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX

Box 1: Peer GTA Discussion Evaluation Form

TA Name_____

Chemistry TA Discussion Evaluation

The following are areas that you have either mastered or need to improve on in your discussion. These topics come directly from the TA guide, and more information can be found there.

1. How well prepared was the TA? Were topics presented thoroughly?
2. How was the TA's time management? Did topics proceed too quickly or too slowly?
3. Was the TA enthusiastic about the material? Did he/she criticize the course materials?
4. Were the students treated in a respectful manner? Was the TA professional in attitude and appearance?
5. Did the TA speak clearly and loudly? How well did the TA communicate with students? Did the audience have difficulty understanding the TA's diction or accent?
6. How well did the TA use the chalkboard?
7. Did the TA lecture to the students or was the presentation a class discussion with student participation?
8. How well did the TA answer questions? Was the TA open and honest if he/she didn't know the answer? Were directions given clearly?
9. What were other strengths of the class?
10. How can the TA improve his/her discussion?

introduced in either the Orientation and Policies sections or the Pedagogies sections of the Intensive Training Program.

Question: *How well prepared was the GTA? Were topics presented thoroughly?*
Focus on: (i) organization of topics and structures, (ii) flexibility in tailoring the direction of the content to the audience's needs, (iii) balance between thoroughness and conciseness, and (iv) ability to fully utilize the time without either grasping for topics or excluding material.
Question: *How was the GTA's time management? Did topics proceed too quickly?*
Focus on: (i) adequate time given to lab, lecture, and problem solving portions and (ii) ability to manage the class if students are asking too many or not enough questions.
Question: *Was the GTA enthusiastic about the material? Did he/she criticize the course?*
Focus on: (i) GTA demonstrates enthusiasm for teaching the material, (ii) application of material to real life, (iii) respect for the importance of the material being taught, and (iv) understanding that teaching is a team effort and direction is set by the lecturing faculty member.
Question: *Were the students treated in a respectful manner? Was the GTA professional?*
Focus on: (i) GTA listens to students' questions and concerns and (ii) GTA dresses properly to reflect positively on both him/herself and the department.
Question: *Did the GTA speak clearly and loudly? Was there trouble understanding the GTA?*
Focus on: (i) GTA faces students in class instead of the board, (ii) level of student interaction and willingness to ask questions, (iii) after answering questions, does the GTA check if the students understand, and (iv) GTA puts forth effort to overcome strong accent.
Question: *How well did the GTA use the chalkboard?*
Focus on: (i) clear and effective use of the board to highlight major points, (ii) proper size of diagrams and structures on the board, and (iii) materials not erased right after they are written.
Question: *Did the GTA lecture or was the presentation a class discussion?*
Focus on: (i) the GTA actively engages the students and (ii) enough material is covered.
Question: *How well did the GTA answer questions? Were directions given clearly?*
Focus on: (i) honesty if an answer unknown, (ii) the GTA follows up unanswered questions with the correct answer, (iii) professional language without too much jargon, and (iv) proper verbal instructions and key points written down on the board.

Following each mock discussion 5 min is devoted to a group discussion with respect to the aforementioned questions, where each GTA may self-reflect on the following points:

a. Was the discussion effective?
b. Has the GTA met the threshold of responsibility?
c. Has the GTA learned from the peer observation?
d. What was the strength and weakness of this discussion?

By the end of the Intensive Training Program, a summative class evaluation is performed through a comprehensive assessment form and is the second level of evaluation on the training. This evaluation form is available in the Supporting Information. For each activity, the assessment is emphasized on its strong points, weak points, effectiveness of the teaching style, usefulness of course material, and career development helpfulness. The areas where pedagogical activities still needed improvement were identified in order to be optimized more successfully in the future.

Each category of the training was assessed such as professional ethics, effectiveness of teaching and learning, lab safety for students and GTAs, and social activates to foster GTA community building and promote a healthy learning environment. These categories were evaluated on a scale from 1 to 10, with 8−10 characterized as "favorable", 4−7 as "neutral", and 1−3 as "poor". Meanwhile, the level of GTA confidence and the overall rating of the program were also evaluated. The results of the assessment are summarized in Figure 1.

The third and final level of the assessment of the Intensive Training Program is evaluation of the GTAs both during and at the end of the first quarter of teaching. Each GTA's discussion is observed by the supervising teaching faculty, and the same evaluation form (Box 1) is used to emphasize any improvement or areas of need as compared to the evaluation given during the training program. This gives the GTAs ongoing real-time feedback on their teaching. Lastly, each GTA is evaluated by their undergraduate students and supervising teaching faculty at the end of each quarter. These forms are available in the Supporting Information. The teaching faculty and GTA have a one-on-one meeting to discuss the progress made in teaching over the past quarter. The undergraduate comments are constantly monitored and provide unvarnished feedback on the quality of teachers produced by our training program. The majority of the comments are positive and, in an anecdotal way, support our assertion that the training was successful. For example: "He is incredibly supportive & always ready to help.

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX

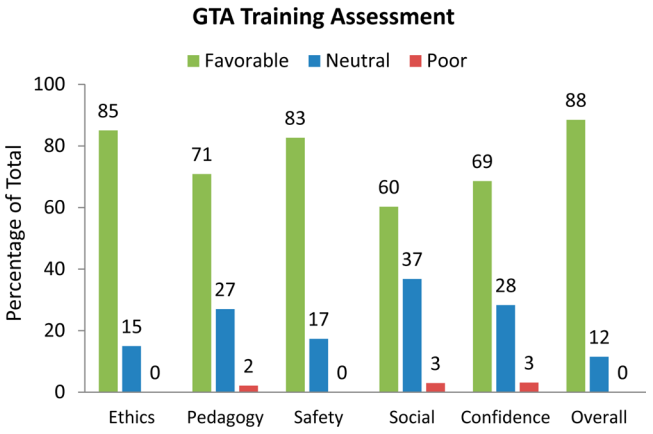

Figure 1. Intensive Training Program assessment for Autumn 2014: 38 participants.

He is always prepared & beyond with materials & other resources for extra help", and "[he] really wanted us to do well—his review powerpoints, lab flowcharts, and approachability really made organic chemistry a lot more bearable. He always responds to emails promptly and is super helpful, both in discussion and lab."

Another mark of our success is that our GTAs have won many university-wide teaching prizes over the years. The first is "The Physical Sciences Collegiate Division Teaching Prize" and is given to three GTAs that have been the most effectual in their teaching for a given year. This prize encompasses the seven divisions (Astronomy and Astrophysics, Chemistry, Computer Science, Geophysical Sciences, Mathematics, Physics, and Statistics), and at least one chemistry GTA has received the prize each year. The second is the "Wayne C. Booth Graduate Student Prize for Excellence in Teaching". This prize is university-wide and on average every 2−3 years a chemistry GTA has won it. Since both prizes are judged based on undergraduate nomination letters, these are a testament to the level of teaching our GTAs achieve as compared to the whole university.

CONCLUDING REMARKS

With this training program, we have for several years produced effective GTAs for our undergraduate classes, both in small classroom discussions and in chemistry laboratory instruction. The program evaluations provided favorable feedback (see Figure 1). Within the six major training categories evaluated, three categories had no negative evaluations. The other three groups provided 97% favorable or neutral evaluations, with a maximum of 3% for poor evaluations. Surpassing our initial expectations, the results of these evaluations support our conclusion that we have achieved the goals of the training program.

It is satisfying to note that, in evaluating the Intensive Training Program, the most highly rated categories by GTAs reside in the program overall, with 88% positive, 22% neutral, and no negative evaluations. This may be a reflection of confidence and empowerment by applying the pedagogical tools, as well as positive self-image and mental attitude within GTAs. Figure 1 also shows that, practically, every training category was favored by the training participants. Judging from the positive assessments, we again conclude that the training program has been successful.

Alongside the pedagogical tools, it is worth noting a psychological development through this training program, i.e., confidence in teaching and a sense of preparedness. Confidence is one of the key elements GTAs need in order to be successful going forward in their classroom teaching and in their future careers. Figure 2 shows the confidence levels of the GTAs after

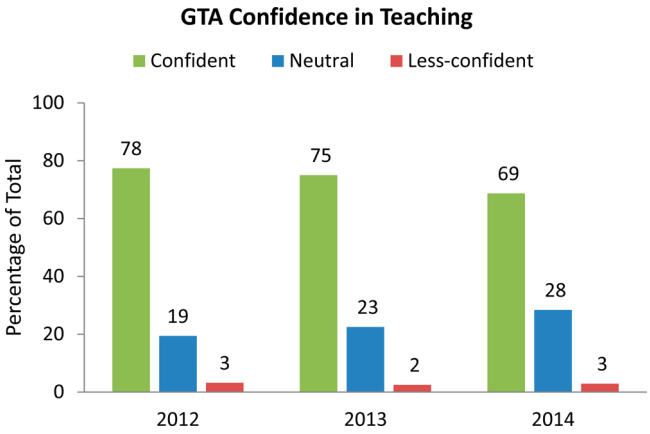

Figure 2. Three-year data on GTA teaching confidence following the training program: 35 participants in 2012, 43 participants in 2013, and 38 participants in 2014.

the training for the three years of 2012−2014, and is an aggregate of that portion of the Intensive Training evaluation, available in the Supporting Information. On a scale from 1 to 10, we characterized 8−10 as "confident", 4−7 as "neutral", and 1−3 as "less-confident". For the assessment data from these three years as shown in Figure 2, it showed successful training in terms of building confidence in teaching. We also wanted to measure how the GTAs felt the Intensive Training Program prepared them for teaching. After one quarter of teaching experience, the GTAs were asked to rate how well they were prepared to teach their own course, and their responses are shown in Figure 3. This retrospective is important because many GTAs do not know what difficulties they may face before they actually stand in front of a class. On a scale from 1 to 10, we characterized 8−10 as "favorable", 4−7 as "neutral", and 1−3 as "poor". For each of the different categories, policy and safety training, lab and discussion practice, and overall program,

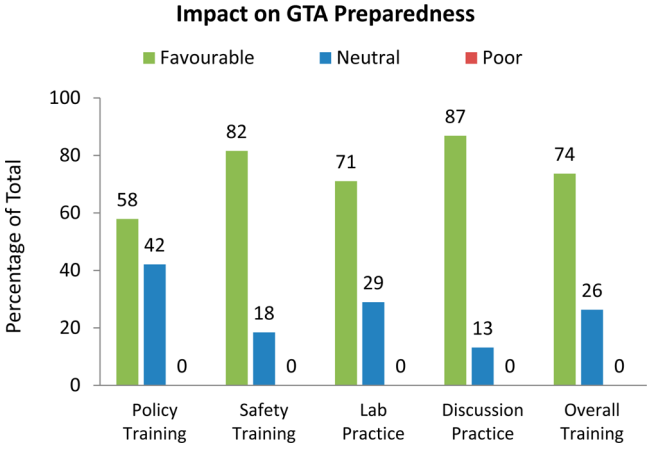

Figure 3. Impact the Intensive Training Program had on preparedness following one quarter of teaching experience in 2014: 38 participants.

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX

an overwhelming majority of GTAs responded that the program had a favorable or neutral impact on their day-one preparedness. This is perhaps a better assessment of our program than measuring confidence, since confidence can be gained through experience in addition to training. When looking back on the previous quarter, the GTAs responded that they were given the tools with which to handle the situations that they encountered. This is a reassuring result and supports our assessment that the program was successful. The preparedness evaluation form is available in the Supporting Information.

Although the community and social activities were by no means rated poorly, they received the lowest ranking of all categories, with 60% positive, 37% neutral, and 3% negative. This provided us insight into needed improvements going forward in the training program as well as the realistic thoughts of the incoming GTAs. Clearly, we need strategies to stimulate GTA enthusiasm in this specific component of the training. Several possible factors may have contributed to this relatively imperfect rating. One of the reasons may be that, when entering as new graduate students to a premier research institution, many incoming GTAs are mentally pre-research-oriented. If GTAs do not see an immediate benefit to their teaching roles, the preexisting biases may lead to a skewed rating. Another reason, which is related to the first, might be that many GTAs have limited exposure to practical work when they first arrive, so they do not feel high pressure nor do they find urgency to engage in social and stress management activities.

Statistically, a nonignorable percentage of graduate students seek professional assistance due to stress during their graduate student tenure,[30] which reflects an indispensable need for adequate GTA training in earlier years. Indeed, one of the modules of our social skills training includes stress management, such as self-care practices, thinking styles, time management, and social connections. From the assessment, it is clear that some GTAs did not recognize the significance of this training module. Now, going forward, we must make a personal connection with this training module.

On the receiving end of the classroom teaching, comments from undergraduate students on their GTAs were also encouraging. Example undergraduate student remarks regarding their GTAs: "Super knowledgeable, good at gauging the strength & weakness with respect to the materials, always really prepared." "Very nice and accessible, a very good teacher, and cares about us as people and us understanding the material." One undergraduate student commented that "My GTA is so encouraging and optimistic that he inspires us to believe in ourselves in order to succeed."

Over the years, our GTAs have been successful university-wide prize winners of the prestigious "Wayne C. Booth Graduate Student Prize for Excellence in Teaching", "The Physical Sciences Collegiate Division Teaching Prize" winners, and departmental winners of the "Nathan Sugarman Teaching Award in General Chemistry" and the "Gerhard Closs Teaching Award in Organic Chemistry". In addition, three former GTA participants from our training program moved on to work as teaching fellows in the Chicago Center for Teaching at The University of Chicago: two teaching consultants and one senior teaching consultant.

With the success of the current program, we plan to continue improving with respect to issues that may arise from our current practices, such as the issue discussed above regarding social activity training and stress management. We also hope that the experiences gained from this training program will provide some insightful information for other similar GTA training programs at other institutions.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00577.

Evaluation forms and example of training module: Safety Case Studies (PDF)

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: v-dragisich@uchicago.edu.

Notes

The authors declare no competing financial interest.

Drs. Vera Dragisich, Valerie Keller, and Meishan Zhao are Senior Lecturers and have the academic hybrid titles of, respectively, the Chemistry Department Executive Officer, Chairman of Graduate Admissions, and Associate Director of Graduate and Undergraduate Studies; the Organic Chemistry Laboratory Director; and the General Chemistry Laboratory Director and Senior Scientist.

■ ACKNOWLEDGMENTS

We thank the Department of Chemistry and the Physical Sciences Division at The University of Chicago for financial support for this program. We thank the U.S. Department of Education GAANN program. We would also like to thank Rebecca Black, Chad Heaps, Judith Kamm, Frank Olechnowicz, Jonathan Raybin, and Michael Rombola, the Chemistry GAANN Fellows, and many other graduate students, including Sara Chamberlin and Nicole James, for their invaluable contribution. Financial support for the GAANN program came from the U.S. Department of Education (P200A120093). Additionally we thank the many guest speakers who participated. We thank Melinda Moore for administrative assistance in contribution to the program.

■ REFERENCES

(1) Wenzel, T. J.; McCoy, A. B.; Landis, C. R. An Overview of the Changes in the 2015 ACS Guidelines for Bachelor's Degree Programs. *J. Chem. Educ.* **2015**, *92*, 965−968.

(2) Anderson, R. C. Reorientation for training chemists as teachers. *J. Chem. Educ.* **1952**, *29* (11), 562−565.

(3) Lippincott, W. T. Training teaching assistants for general chemistry. *J. Chem. Educ.* **1959**, *36* (2), 84−85.

(4) Pickering, M.; Kolks, G. Can teaching assistants grade lab technique? *J. Chem. Educ.* **1976**, *53* (5), 313−355.

(5) Brooks, D. W.; Lewis, J. D.; Lewis, K.; McCurdy, D. W. The teaching coach. A means of enhancing student-teaching assistant interactions during recitations. *J. Chem. Educ.* **1976**, *53* (3), 186−187.

(6) Pickering, M. Teaching assistant predictions of student performance in general chemistry. *J. Chem. Educ.* **1980**, *57* (5), 354−355.

(7) Renfrew, M. M.; Moeller, T. Training of teaching assistants in chemistry - A survey. *J. Chem. Educ.* **1978**, *55* (6), 386−388.

(8) Barrus, J. L.; Armstrong, T. R.; Renfrew, M. M.; Garrard, V. G. Preparing Teaching Assistants. *J. Coll. Sci. Teach.* **1974**, *3*, 350−352.

(9) Carroll, J. G. Effects of Training Programs for University Teaching Assistants: A Review of Empirical Research. *J. Higher Educ.* **1980**, *51*, 167−183.

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX

(10) Clark, D. J.; McLean, K. Teacher Training for Teaching Assistants. *Am. Biol. Teach.* **1979**, *41*, 140−144.
(11) Druger, M. Preparing the Next Generation of College Science Teachers. *J. Coll. Sci. Teach.* **1997**, *26*, 424−427.
(12) McComas, W. F.; Cox-Petersen, A. M. Enhancing Undergraduate Science Instruction: The G-STEP Approach. *J. Coll. Sci. Teaching.* **1999**, *29*, 120−125.
(13) Olson, J. K.; Cox-Petersen, A. M.; McComas, W. F. The Inclusion of Informal Environments in Teacher Preparation. *J. Sci. Teacher Educ* **2001**, *12* (3), 155−173.
(14) Herrington, D. G.; Nakhleh, M. B. What Defines Effective Chemistry Laboratory Instruction? Teaching Assistant and Student Perspectives. *J. Chem. Educ.* **2003**, *80* (10), 1197−1205.
(15) Wenzel, T. J. Evaluation Tools to Guide Students' Peer-Assessment and Self-Assessment in Group Activities for the Lab and Classroom. *J. Chem. Educ.* **2007**, *84* (1), 182−186.
(16) Pienta, N. J. Understanding Our Students in General Chemistry. *J. Chem. Educ.* **2015**, *92*, 963−964.
(17) Lasry, N.; Mazur, E.; Watkins, J. Peer instruction: from Harvard to the two-year college. *Am. J. Phys.* **2008**, *76* (11), 1066−1069.
(18) Kurdziel, J. P.; Turner, J. A.; Luft, J. A.; Roehrig, G. H. Graduate Teaching Assistants and Inquiry-Based Instruction: Implications for Graduate Teaching Assistant Training. *J. Chem. Educ.* **2003**, *80* (10), 1206−1210.
(19) Van Der Sluys, W. G.; Koch, J. Distributed Access Teaching Assistant (DATA). *J. Chem. Educ.* **2001**, *78* (12), 1696−1698.
(20) Sandi-Urena, S.; Gatlin, T. Factors Contributing to the Development of Graduate Teaching Assistant Self-Image. *J. Chem. Educ.* **2013**, *90*, 1303−1309.
(21) Benderly, B. L. Study to Examine Academic Lab-Safety Culture. *Science* **2013** (June 05), http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2013_06_05/caredit.a1300120; DOI:10.1126/science.caredit.a1300120.
(22) Dragisich, V.; Keller, V.; Zhao, M. Development of an Advanced Training Course for Teachers and Researchers in Chemistry. *J. Chem. Educ.* **2016**, DOI: 10.1021/acs.jchemed.5b00578
(23) Gerdeman, R. D.; Russell, A. A.; Eikey, R. A. A Course to Prepare Future Faculty in Chemistry: Perspectives from Former Participants. *J. Chem. Educ.* **2007**, *84* (2), 285−291.
(24) Keller, S. L.; Smith, A. L. Advice for New Faculty Teaching Undergraduate Science. *J. Chem. Educ.* **2006**, *83* (3), 401−406.
(25) Marbach-Ad, G.; Schaefer, K. L.; Kumi, B. C.; Friedman, L. A.; Thompson, K. V.; Doyle, M. P. Development and Evaluation of a Prep Course for Chemistry Graduate Teaching Assistants at a Research University. *J. Chem. Educ.* **2012**, *89*, 865−872.
(26) Bond-Robinson, J.; Rodriques, R. A. B. Laboratory Teaching through Design Research. *J. Chem. Educ.* **2006**, *83*, 313−323.
(27) Luft, J.; Kurdziel, J.; Roehrig, G.; Turner, J. Growing a Garden without Water: Graduate Teaching Assistants in Introductory Science Laboratories at a Doctoral/Research University. *J. Res. Sci. Teach.* **2004**, *41*, 211−233.
(28) Dragisich, V.; Keller, V.; Zhao, M. *Guide for Teaching Assistants*, 2nd ed.; Department of Chemistry, The University of Chicago: 2012; https://chemistry.uchicago.edu/content/uploads/filesTAguide.pdf.
(29) Schröder, I.; Huang, D. Y. Q.; Ellis, O.; Gibson, J. H.; Wayne, N. L. Laboratory safety attitudes and practices: A comparison of academic, government, and industry researchers. *J. Chem. Health Saf.* **2015**, DOI: 10.1016/j.jchas.2015.03.001.
(30) Fogg, P. Grad-School Blues: Students fighting depression and anxiety are not alone. *Chron. Higher Educ.* **2009**, http://chronicle.com/article/Grad-School-Blues/29566.

DOI: 10.1021/acs.jchemed.5b00577
J. Chem. Educ. XXXX, XXX, XXX−XXX