

Development of an Advanced Training Course for Teachers and Researchers 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

S Supporting Information

ABSTRACT: Based on our long-standing Intensive Training Program for Effective Teaching Assistants in Chemistry, we have developed an Advanced Training Course for Teachers and Researchers in Chemistry at The University of Chicago. The topics in this course are designed to train graduate teaching assistants (GTAs) to become effective teachers and well-rounded PhD candidates. The goals of the course are to build ethics, critical thinking, and a positive self-image as a teacher through the use of a variety of pedagogical tools. Concurrently, the GTAs are transitioned into independent researchers with the skills to prepare written reports and oral presentations. The goals of this course were achieved based on the results of participant feedback. The experience gained and issues identified from the course may be used to guide future training courses.

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

INTRODUCTION

Training graduate teaching assistants (GTAs) to be effective teachers in chemistry while also providing a smooth transition for them to advance their careers in teaching and research has always been challenging. Nevertheless, it is critically important to thoroughly train the next generation of chemistry teachers and researchers. As addressed in the Graduate Education Commission Report published by the ACS, integrating career development skills into graduate education is critical to producing exceptional and employable PhD scientists.¹ Proper training and guidance at an early stage in their graduate career provides effective tools with which to advance their career in teaching and research. Creating a healthy level of enthusiasm for teaching is also essential from the beginning of graduate school. These, coupled with high expectations and the tools to succeed, is a comprehensive way to train effective teachers and researchers.

Beyond providing the basic skills and tools needed for career advancement, the goals of GTA training have been to engender empowerment while stressing collaborative learning and community building. Perhaps the biggest challenge in training has been to help establish an authoritative classroom presence and build a unique teaching style. This can be achieved by training GTAs to master a variety of pedagogies for their given group of students. Prior to introduction of this training course, it was hard for GTAs to continue working on their teaching skills after the end of the Intensive Training Program since their focus shifted from teaching to their own classes and research. Meanwhile, a smooth transition from teaching to research is without a doubt another key element for broader career success.

The chemistry educational community has long strived to achieve effective methods in GTA training. Various types of research and surveys have been reported.^{2–11} Advances in pedagogical approaches for effective teaching have been wide ranging. For example, scientific inquiry-based instruction has

been suggested and applied in teaching undergraduate chemistry laboratories.^{12–14} Feedback and evaluations have been developed extensively, and case studies were assessed by Koch and Van Der Sluys.¹⁵ Most recently, the significance of GTA self-image in relation to teaching performance has been discussed by Santi-Urena and Gatlin.¹⁶ Additionally, some comprehensive pedagogy has been developed and discussed by the Chicago Center for Teaching at The University of Chicago.¹⁷

While these important pedagogical tools have been developed, none of the aforementioned methods addressed our need for a comprehensive and systematic GTA training course. Although there have been a few developments for such a program, we feel our course goes beyond these programs developed so far. For example, using their departmental seminars as a model base, Gerdeman, Russell, and Eikay developed a GTA training course at University of California, Los Angeles,¹⁸ while Marbach-Ad et al. developed a GTA precourse at a research university.¹⁹ Based on the feedback from their former training participants, these programs were reported as successful. Alternatively, Keller and Smith provided some useful advice for new faculty in teaching undergraduate science classes.²⁰ In the Department of Chemistry at The University of Chicago, we have specifically designed and developed an advanced GTA training course to facilitate effective teaching and career development that is more comprehensive and holistic than those described above.

Building on the Intensive Training Program that we provide at The University of Chicago, our Advanced Training Course extends this preliminary GTA training into a yearlong course.²¹ While the Intensive Training Program produces GTAs who are well-trained to stand in front of their own class on the first day,

Received: July 16, 2015

Revised: December 17, 2015

Table 1. Topics in Advanced Training for Teachers and Researchers in Chemistry

Module No.	Module Title and Description
1	Ensuring Equity in the Classroom: GTAs are trained to look for bias in their teaching style and how to take steps to ensure that all students are treated fairly.
2	Dealing with Problem Students: Several scenarios involving common problems are acted out by groups of GTAs, and proper ways to handle them are discussed.
3	Plagiarism and Internal Case Studies: Plagiarism is defined, and GTAs are given several real-life examples of plagiarism that they may encounter either as students or as teachers.
4	Peer Discussion Observation: GTAs are trained to observe fellow GTA discussions and how to give constructive feedback on successes or improvements.
5	How People Learn: Different pedagogical tools are discussed and compared for their effectiveness in the broader context of building and maintaining knowledge.
6	Diversity Hiring and Recruiting: A faculty member presents his/her work on a committee for recruiting and hiring faculty members and how that impacts the greater University community.
7	Compressed Gas Safety: This is a training session on the safe use and transport of compressed gas cylinders and cryogenic liquids.
8	Presentation Skills: Several strategies are shared on how GTAs can prepare and present research data in an oral presentation.
9	Public Speaking: In order to demonstrate effective aspects of speaking, participants spoke spontaneously on a topic of their choice and received feedback.
10	Scientific Writing: The instructor used many examples and tips for how to effectively put data into words and find a scientific voice.
11	Phasing Teaching into Research: This was an open discussion about the details of candidacy exams and what challenges lie ahead in research, graduate school, and beyond within the context of open discourse in the academic community.

we found that interest and focus on teaching ebbed over the course of the year and had the potential to end in weaker-performing teachers. In addition, the transition from student and teacher to researcher could be bumpy with a lack of guidance and support. These trends precipitated our development of this course with the goal of not only maintaining a strong teaching performance but also building upon it to nurture well-rounded PhD candidates. The development process also gave us the challenge to actively address the skills highlighted in the Graduate Education Commission Report.¹ Our goal is to present and nurture the ideas of critical thinking, problem solving, building a pedagogical tool portfolio, transiting into independent research, and strengthening professional and scientific skills. These are built into a framework that focuses on both immediate and future applications, and fits within the environment of the broader University as the “Teacher of Teachers”.

To evaluate the course’s level of success, the course was assessed upon completion by the GTAs. The teaching faculty continually assess the course, both in real time and retrospectively, based on the GTA evaluations, discussions within the different modules, and personal observations. Positive experiences and prospective improvements for the future are discussed and will be incorporated into future courses.

COURSE STRUCTURE

Upon entering graduate school at The University of Chicago, all new GTAs are required to attend the Intensive Training Program before the start of the academic year. This Intensive Training Program is described in a companion publication,²¹ and was the basis for developing this yearlong program where teaching pedagogies can be reinforced. The Advanced Training Course described in this publication stretches throughout the first year of graduate studies and meets in the first, third, and seventh weeks of each academic quarter. The course schedule is designed so as to not interfere with any graduate courses and is chosen to have minimum interference with normal GTA teaching duties. Each meeting takes the form of a course module, focusing on a particular aspect of GTA training, and is prefaced by a clear purpose and how it can be applied toward professional growth.

Due to the full list of responsibilities that first year GTAs have, each module ends with a list of recommended readings and the homework is to integrate the ideas and pedagogies presented in the course into their current teaching and research duties. This incorporation involves critical thinking and problem solving, two of our goals for the course. The homework structure and a pass/fail grade system was a stipulation by faculty in order to gain their support for implementing the course and balances the limited time of the GTAs with the need to present and discuss these important topics. We continue to have support from the Department of Chemistry as well as the GTAs for this course.

This publication describes the new Advanced Training Course (CHEM 500) that supplements and enhances our traditional GTA training. These two training portions are distinct because GTAs need to have some fundamental skills prior to teaching both a discussion and laboratory class at the start of the academic year. GTAs in the Department of Chemistry at The University of Chicago are required to spend their first year of graduate school teaching one discussion and one laboratory class each quarter for either General Chemistry or Organic Chemistry. There are about 40 GTAs with an average of 14–20 students in their section each year. Throughout their first year of teaching, GTAs are given the skills in the Advanced Training Course that build on the teaching and professional training that is provided before the start of the academic year in the Intensive Training Program. While extremely important to producing well-rounded PhD candidates, these skills are not crucial for a GTA to be successful in the classroom on day one, whereas the Intensive Training Program topics are crucial for day one preparedness. The training course also helps foster a continuing platform for discussing and honing teaching skills.

COURSE MATERIAL AND TOPICS

While our Intensive Training Program²¹ is crucial in producing well-prepared GTAs, it includes a large amount of material that is given to GTAs in a relatively short period of time. Due to this limitation, some of the policies and pedagogical skills tend to be forgotten once GTAs become immersed in their own graduate classes and the rigors and stresses of graduate research. Our goal is to maintain a formal structure of support for GTAs as

well as to introduce them to topics that directly impact their career development.

The development of course topics is focused on transforming GTAs from students to effective teachers and professional researchers. This is done by progressively building up GTA confidence as a teacher and providing exposure to pedagogical practices in chemistry with each course meeting. Based on social and scientific development and in consultation with relevant experts, the course covers a series of advanced training modules, as listed in [Table 1](#).

Confidence building and developing an authoritative class presence are constantly emphasized throughout the training course. Skillful application of pedagogical tools requires continual assessment and reflection, in terms of both GTA self-assessments and course evaluations. The assessments take the form of midquarter evaluations of discussion classes by the teaching faculty, quarterly evaluations by both the undergraduate students and teaching faculty, and a peer-review module that is part of this course.

There is no required textbook. Class notes, references, and recommended readings are provided during each meeting period and in the follow-up sessions, covering topics on ethics, self-image, evidence-based pedagogies, case studies and tools, psychology, class and lab safety, and more. While most modules are taught by members of the Department of Chemistry, some external experts are invited to both enhance and provide support for the Chemistry community.

The topics covered in this class are chosen to support the goals of developing ethics, critical thinking, and GTA self-confidence, as well as career development. This first goal of developing an ethical groundwork starts with “Ensuring Equity in the Classroom”. While part of this Advanced Training Course, it is presented during the Intensive Training Program that GTAs receive prior to teaching their first class and is discussed in our companion publication.²¹ This topic dovetails well with the other pedagogical tools introduced that build confidence in teaching and train GTAs to be authorities in their own classroom. It also serves as a bridge between the two programs. “Plagiarism and Internal Case Studies” involves a presentation of recent and relevant plagiarism incidents with open discussions of each. The diverse background of GTAs, to include international students, gives each incoming class differing opinions on the threshold for plagiarism. It can no longer be taken for granted that all students know what plagiarism is, let alone understand the ramifications of submitting plagiarized work, especially in this era of readily available Internet information.

Confidence and comfort level building occurs through several different exercises and tools that are incorporated into this Advanced Training Course, and two topics deal specifically with this issue. First, the topic “Dealing with Problem Students” is an interactive exercise that introduces GTAs to common situations that they may encounter when teaching their own classes. This meeting occurs very early in the academic year in order to prepare the GTAs for what they may expect to encounter at the start of teaching. GTAs are split into groups and given mock scenarios that they act out. The scenarios are open ended, so the groups develop their own solutions. At the end of each situation, there is a class discussion to correct any errors in policy or to add alternate solutions to a given problem. This topic is designed to give GTAs a boost in their self-image by helping them walk through common issues while in their first weeks of teaching. The presentation that accompanied this

module is included as an example of the course materials in the [Supporting Information](#). The second topic to address confidence, along with classroom management, is “Peer Discussion Observation”. The structure of this module is for a discussion to be observed by a fellow GTA along with an experienced mentor graduate student. The module presents scenarios that the observers may encounter and a discussion of how the teacher can improve. GTAs are encouraged to record observations of both the students and teacher in order to create a supportive and nonjudgmental environment. Prior to the discussion observation, the GTA communicates to both observing graduate students, peer and mentor, what areas he or she feels need the most improvement. This self-reflection helps to focus both the observer and observed on a common goal. After the discussion is assessed, all three participants have a meeting to talk about the observations and recommendations for improvement. One of the benefits of this type of peer review is that all teachers, both experienced and novice, can apply techniques that they observed in their own class. This presentation is also included in the [Supporting Information](#).

Critical thinking is key to developing exceptional teachers and researchers, therefore the topic “How People Learn” introduces the pedagogy of learning in a way that can be used by GTAs in their dual role as teachers and students. For example, constructivist teaching methods were presented and examples given on how to incorporate them.²² Understanding how learning occurs can open up the channels to self-teaching that are fundamental for graduate students in their independent research. In addition, teachers must reflect on how their students comprehend, analyze, and finally learn material in order to understand how best to teach.

The remaining topics fulfill the goal of career development, whether of a researcher or teacher. Since safety is a major concern for everyone in the chemistry community, a class on “Compressed Gas Safety” is given. All researchers, regardless of discipline, need to know how to safely recognize and handle compressed gases due to the central location of liquid nitrogen dispensing stations and storage of gas cylinders. Other topics addressed in this course were three essential skills for successful scientists: presenting research and data, effectively speaking in public, and writing well in both publications and grant proposals. The topic “Diversity Hiring and Recruiting” introduces GTAs to a real issue that they will face, whether in an academic or research career. Additionally this module provides GTAs the understanding that a faculty position involves not only research and teaching but also service in the form of committee work. And finally, “Phasing Teaching into Research” is an open discussion that helps GTAs reflect on their first year as graduate students and teachers and what to expect in their next phase of graduate school: information on candidacy examination, ethical issues, professional demeanor, to include the importance of open discourse in an academic setting, and support services.

■ COURSE ASSESSMENT

For this course, we have internally developed assessment protocols to gauge the effectiveness of the curricula for future improvement. Each class activity was assessed either by an open discussion or by an evaluation assessment form, such as a minute paper.²³ By the end of the course, a summative class evaluation was performed through a comprehensive assessment form, which included assessment of each activity on its strong points, weak points, effectiveness of the teaching style,

Course Module Evaluation

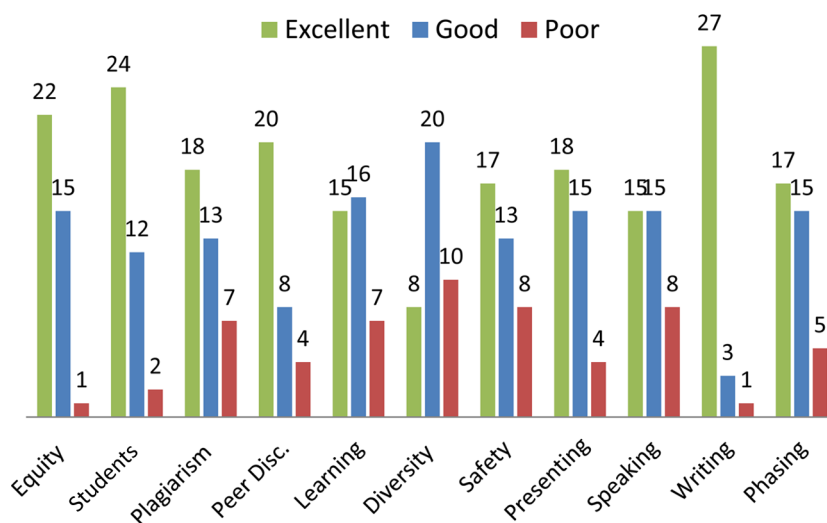


Figure 1. Course module assessments for 2014/2015.

usefulness of course material, career development helpfulness, and more. This evaluation is available in the [Supporting Information](#). Invoking the product–process mechanism,²⁴ the areas where pedagogical activities still needed improvement were identified in order to more successfully apply teaching strategies in the future.

The summative assessment emphasized the helpfulness of the course and its impact on GTA teaching duties as well as their career development. Both the course modules and the instructors were assessed to gauge the effectiveness of both aspects of the course.

Specifically, we wanted to know if the course modules were important and interesting, if students had improved teaching skills after the training, if students felt more prepared to go on to research after this course, and if students could apply what they learned from the course toward their future careers. The assessment results are summarized in [Figure 1](#), with each course module evaluated and characterized as “Excellent”, “Good”, or “Poor”.

The overall ratings of the course material were also assessed as either “Excellent”, “Good”, or “Poor”, interpreted from agree, neutral, and disagree for each topic as presented in [Table 1](#). With respect to the overall instructor ratings, we paid special attention to the effectiveness of the instructor, including factors such as classroom engagement, respectfulness of different viewpoints, encouragement of students to think critically, and effectiveness in responding to questions. The instructors were rated as “Excellent”, “Good”, or “Poor”, and the summarized evaluation is given in [Figure 2](#).

CONCLUSIONS

The main goal of the course is to train GTAs to become effective teachers, and from there to become successful graduate researchers. This is achieved by developing GTA confidence and providing a variety of pedagogical and professional tools in chemistry. To what degree have we achieved the goals of the course?

GTA summary evaluations of the course provided favorable feedback (see [Figures 1 and 2](#)). We feel that the key impact that this course had on GTAs was due to the diversity in the topics

Content and Instructor Evaluation

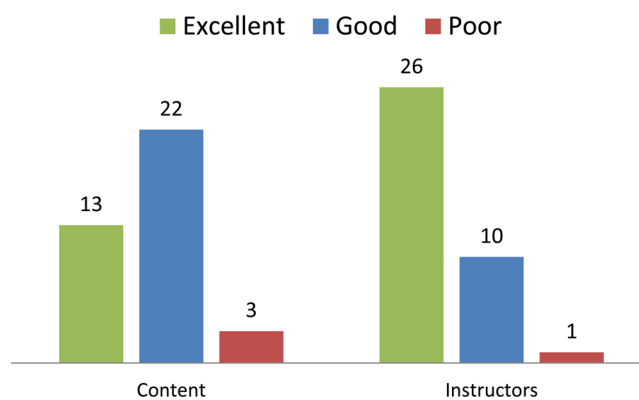


Figure 2. Overall course evaluation on content and instructors for 2014/2015.

presented and the amount GTAs learned on the topics of confidence building, teaching strategies, and professionalism. The results of the course evaluations support that we have achieved the goals of the course.

Most of the highly rated modules were those of ethical and pedagogical tools, e.g., “Equity in the Classroom”, “Dealing with Problem Students”, and “Peer Discussion Observation” (see [Figure 1](#)). These modules immediately benefited GTA teaching at the time of the training course, so this may be the reason for their popularity. The modules on career development were also highly rated, such as those on plagiarism, presentation skills, public speaking, scientific writing, and introduction to research. The overall course performance and effectiveness was assessed using both the module and instructor ratings. Out of the 38 GTAs in the course, 35 rated the course contents as either good or excellent. The teaching performance from the instructors in this course was distinguished with 37 out of 38 GTAs rating the instructor as either good or excellent (see [Figure 2](#)). Judging from the course assessments, we can conclude that this Advanced Training Course has been successful.

The evaluations also revealed challenging issues that could offer us an improved understanding on GTA training going forward. The module on “Diversity Hiring and Recruiting” was given the lowest rating; only 21% of GTAs rated it as excellent, but more than 26% rated it as poor. Even though the module is important for future young faculty, i.e., teachers and researchers, this rating may indicate that the topic is slightly far-reaching with respect to immediate concerns of the GTAs. This provides us an intellectual challenge: we need to select the most valuable modules for the course, but we also need to enlighten GTAs with insights and perspectives beyond the graduate level in a way that has immediate implications.

Comments from the GTAs were also informative. It is always encouraging to know how much they have learned from the course for their practical use and how the class has influenced their perspective on teachers and researchers. For example, some GTAs commented: “I am grateful for this course. I feel it as an investment in myself”, “...modules were useful and engaging”, and “very helpful”. These comments reflect the importance of a GTA training course of this nature during their graduate education.

Building on the experience from this course, we are encouraged to create more effective training modules with high impact factors for GTA life and career development. We also hope that the experiences from this training course will provide other GTA training programs helpful insight, so as to prepare seasoned teachers and researchers in chemistry for the future.

■ ASSOCIATED CONTENT

📄 Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: [10.1021/acs.jchemed.5b00578](https://doi.org/10.1021/acs.jchemed.5b00578).

Course syllabus, reading list, “Dealing With Problem Students” and “Peer Discussion Observation” presentations, and course evaluation form (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 the course. We thank Rebecca Black, Chad Heaps, Judith Kamm, Frank Olechnowicz, Jonathan Raybin, and Michael Rombola, the Chemistry GAANN Fellows. Financial support for the GAANN program came from the U.S. Department of Education (P200A120093). Contributions from our guest lecturers and pedagogy demonstrators are also appreciated. We thank Melinda Moore for administrative assistance in contribution to the program.

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