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Implementing and Assessing the Use of a New Strategy for Training Chemistry Graduate Teaching Assistants

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IMPLEMENTING AND ASSESSING THE USE OF A NEW STRATEGY FOR TRAINING CHEMISTRY GRADUATE TEACHING ASSISTANTS

BY

AMANDA HYETT

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DISSERTATION ACCEPTANCE PAGE

Amanda Hyett

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Matthew Miller
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This dissertation is dedicated to all aspiring female scientists: go for it even when people tell you that you can't. And to all educators, thank you!

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CONTENTS

ABBREVIATIONS

GORP	Generalized Observation and Reflection Protocol
GTA	Graduate Teaching Assistant
HLC	Higher Learning Commission
LOPUS	Laboratory Observation Protocol for Undergraduate STEM
PCK	Pedagogical content knowledge
POGIL	Process Oriented Guided Inquiry Learning
TAIA	Teaching Assistant Intervention Activity
ZPD	Zone of proximal development

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ABSTRACT

IMPLEMENTING AND ASSESSING THE USE OF A NEW STRATEGY FOR TRAINING CHEMISTRY GRADUATE TEACHING ASSISTANTS

AMANDA HYETT

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Graduate teaching assistants (GTAs) largely contribute to undergraduate education but are often underprepared for their role as educators. Most graduate students attend graduate school to perform research and are then asked to teach for the first time without sufficient pedagogy training. To assist in increasing the GTAs pedagogical knowledge, a scenario-based activity series was developed and implemented for first- and second-year GTAs. Developing scenario-based scenarios from actual laboratory events provided GTAs with the opportunity to practice prior to engaging in the laboratory classroom. The Teaching Assistant Intervention Activities (TAIAs) included topics such as interpersonal skills and behaviors, group process, working with students of different abilities, and higher-order thinking skills. Methods of data collection included observations of undergraduate laboratories and individual interviews with sample GTAs, and end of semester student surveys. The Laboratory Observation Protocol for Undergraduate STEM (LOPUS) procedure from the Generalized Observation and Reflection Protocol (GORP) platform from the University of California Davis was utilized for data collection. Observation data included times of every occurrence within the laboratory sessions. Subtle changes in GTA teaching behavior were determined after one year of implementation for Cohort 1 and one semester for Cohort 2. One particular topic of GTA growth occurred after discussion about analysis, laboratory techniques, and

assessment. GTAs were interested in learning more about their teaching including: “student-centered” versus “instructor-centered” classrooms, strategies to increase student participation, and asking students questions with the questions being at an appropriate level. Student survey responses indicate generally positive, yet mixed, interpretations of the GTAs teaching methods.

CHAPTER 1—INTRODUCTION

Motivation of the Study

Chemistry was not my first choice of an academic discipline due to prior lack of discipline exposure and a lack of engagement from my laboratory teaching assistants during experiments. As a student, I didn't see a connection between the information presented in lecture by my professors and the concepts being taught (or lack thereof) during the laboratory experience. My lecture experiences were positive, but I dreaded my time in the laboratory.

When I began my own pedagogical training at my undergraduate institution, I began to see where, as an instructor, my laboratory teaching assistants were deficient in knowledge of pedagogy and I began to consider how they could be helped in their teaching careers. I wanted more meaningful engagement with my instructors as well as instruction founded in research-based ideas. My teaching assistants lacked the skills to teach the content, instead of telling the students information about the topic of the day. There was little direction from the instructor other than, "start the experiment." I wanted more and I wanted better for my students.

As a teacher, my goal is to do my best for my students and to help them prosper in their academic journey. The question we might want to keep in mind is are laboratory instructors also so inclined to do the best for their students? Graduate students assigned as laboratory assistants are paid to be instructors, yet this pay is their support structure for their main goal, research. Therefore, it is likely that the graduate student is not focused on the well-being of their students.

Teaching high school continued to invigorate my desire to help other teachers, since many were so helpful in my transition from student to teacher. This feeling only continued as I began graduate school and experienced my own graduate teaching assistant (GTA) assignments. While I had pedagogical training, many of my peers had not—neither formal nor informal training. How do these graduate students provide engaging experiences in the lab for undergraduates when they have had no training? How do we provide the necessary support for graduate students as they learn about the impact and influence they have on undergraduate students in the undergraduate laboratory?

Importance of the Study

Undergraduate education requires quality instructors willing to provide excellent instruction to their students. In the sciences, quality instruction enables students to work and think like a scientist. Scientists possess and exhibit a unique type of thinking we want our students to observe, practice, and emulate: scientific thinking and inquiry. The ultimate goal of an instructor should be to facilitate this type of thinking. Yet the facilitation of this type of thinking is not effectively accomplished through the use of directing learning. When an instructor directs learning using an explicit path of learning, students are not as likely to gain as thorough of an understanding of a topic.[1]

There has been a significant directive for instructors at the university level to adopt student-centered learning, which generally refers to less lecturing and more student-to-student and student-to-instructor interactions. Unfortunately,c Stains et al. found that up to 80% of instructional time is didactic, or lecturing, and 55% of the

instructors observed in the study primarily taught in this style.[2] Instructors and college faculty, who were trained in graduate research, tend to find teaching with a learner-centered teaching model challenging.[3] These instructors and faculty tend to fall back to lecturing for several reasons. First, this is the method they likely experienced as students and this method requires the least amount of preparation for faculty. The problem is that this pedagogical approach promotes passive learning by students which does not help students to engage in learning. Yet, how do we expect instructors and faculty to teach in a way they have likely had little training in during the preparatory stages of their career? We learn from experiencing, and the pedagogical techniques used when instructors and faculty were taught are likely to be the default method of least resistance for them. If it has been found that instructors and faculty are struggling to create student-centered environments, what does this mean for GTAs in their newly found teaching positions?

For institutions hiring graduate instructors, 15 to 30 percent of all student contact for that institution were with these instructors.[4] For our institution in Fall of 2016, I calculated that 88% of instruction for all students in the first semester general chemistry course was led by GTAs (when including all laboratory session time). Weekly, each chemistry student spent 43% of their combined lecture and laboratory instructional time in direct contact with their laboratory GTA. From an administrative point of view, a large portion of the undergraduate experience is with the GTAs, particularly in introductory and large service classes. In today's climate of declining enrollments, the retention of students is vital toward maintaining growth in programming. Student attrition is greatest in science degrees during first- and second-year programming, so it makes sense to

engage undergraduate students with the best faculty and graduate student instructors during these times.

For undergraduates, interactions with their GTA are more frequent than with their professor. GTAs personalize the undergraduate learning experience for these students through caring, informed instruction, yet very little time has been devoted to the training of these individuals for this critical job.[5] There is a significant amount of pressure and accountability placed on graduate students who are often underprepared for the responsibility.

The American Chemical Society (ACS) Committee on Professional Training have written and on multiple occasions edited the ACS Guidelines for Bachelor's Degree Programs. The committee states, "the participation of upper-class chemistry undergraduates and graduate students in the instructional program as teaching assistants both helps them reinforce their knowledge of chemistry and provides a greater level of educational support for students they supervise. If undergraduate or graduate students serve as teaching assistants, they must be properly trained and supervised."[6] Yet, the ACS guidelines do not mention how that training should occur. The Higher Learning Commission (HLC), responsible for accrediting many higher education institutions, states that:

> With the exception noted in the bullet immediately following, faculty teaching in undergraduate programs should hold a degree at least one level above that of the program in which they are teaching. If a faculty member holds a master's degree or higher in a discipline other than that in which he or she is teaching, that faculty

> member should have completed a minimum of 18 graduate credit hours in the discipline in which he or she is teaching.[7]

It is generally recognized that a need exists to have a background in the discipline to teach. The ACS states the need for training and supervision, and the HLC specifies the discipline specific training required, yet there is not a specific mention of pedagogical training.

Herrington and Nakhleh argued "that the lack of progress in laboratory teaching is our failure to consider the laboratory instructor."[8] The GTAs, generally, are the most influential factor impacting laboratory instruction, and play a large role in the retention of undergraduate students in a science degree.[9] The impact of GTA teaching is large not only to the undergraduate students they service, but also to the department for which they work and the scientific community as a whole. This interaction of GTA and undergraduates is a key opportunity to impact society with respect to science knowledge and appreciation.

For many GTAs, the uncertainty of teaching becomes more apparent. GTAs generally have an understanding of the expectations of being a graduate student, but not as graduate instructors.[6, 10] Some graduate students are coming straight from an undergraduate program themselves and have hardly transitioned from that mindset. There can be unease in regard to the duties, commitments, and expectations associated with the role of instructor.[11] This group of individuals, who represent a large portion of instructors interacting with students in introductory laboratory classes, are thus required and expected to be quality and prepared instructors. As Od-Cohen and Hadari describe, "the

transition from a state of student-teacher and practicing teacher is immediate and lacks the much needed gradualness in order to adjust to the novice teacher's reality."[12] GTAs are often placed into situations unprepared and unaware of their impact and amount of contact with students.

As described by Herrington and Nakhleh, teaching assistants should possess three characteristics: a GTA should be knowledgeable in their subject area, know how to communicate at an appropriate level with their students, and demonstrate concern for students by being available and approachable.[13] Undergraduate students attend post-secondary institutions with a desire to obtain a degree they can use in their future career. Understandably, these same students have high expectations for their classes and their instructors and they are not impressed when a GTA does not engage them in outstanding examples of learning. Many of the major complaints of students in introductory courses are unprepared and uninterested GTAs assigned to their laboratory.

Our institution provides university-wide training opportunities for GTAs, but these are more focused toward GTAs in lecture-based courses and not as applicable to the science laboratory GTAs. It has been clearly expressed that GTAs play an important service role for students, but concern over their training remains prevelant.[14] Key differences between science instruction and other disciplines includes the use of specific strategies to improve students' scientific literacy and understanding of the nature of science.[1] Likely, these strategies are not included in weekly laboratory meetings with laboratory coordinators due to this time being reserved for logistical and experiment-specific information. There is a need at our university for science discipline specific training, relevant to the challenges faced by GTAs in science laboratory courses.

Purpose

The purpose of this study was to develop a GTA training curriculum specific to laboratory science instruction. The lack of GTA training prior to laboratory teaching was the gap to be addressed, and this study created and implemented this type of training for GTAs. The results of this work were assessed and are presented in this report. My research questions included:

1. What attributes do students seek in a TA?
2. What attributes do Lab Coordinators seek in a TA?
3. How has the teaching approach changed as a result of the Teaching Assistant Intervention Activity?
    a. How are student interactions impacted by the Teaching Assistant Intervention Activity?
4. What aspects are TAs interested in learning more about regarding their teaching?

The study described has created a method to engage GTAs in thoughtful pedagogical learning through the use of constructivist ideas. The Teaching Assistant Intervention Activities (TAIAs) created were aimed at building pedagogical content knowledge in GTAs through utilization of scenario-based examples. Assessment of the project included individual interviews with GTAs, observations of GTAs teaching laboratory sessions, observing interactions during small group instruction utilizing the TAIAs, and gathering of student perspectives of GTA teaching through open-ended student surveys. Analysis of the described data included mixed method evaluation utilizing qualitative and quantitative analysis. The creation of TAIAs, implementation of

the activities with a sample of GTAs, and the method of analysis are further discussed in Chapter 3, with results and inferences in Chapters 4 and 5.

CHAPTER 2—REVIEW OF LITERATURE

Overview

This chapter will include the review of literature relevant to a new strategy in a professional development project for chemistry graduate teaching assistants. My work will include the following theoretical and methodology ideas which drive my work: constructivism, pedagogical content knowledge (PCK), scenario-based teaching, and the integration of Process Oriented Guided Inquiry Learning (POGIL).

Constructivism

The constructivist perspective, or constructivism, acknowledges and incorporates past experiences into the acquisition of new learning and applying meaning to this knowledge.[15-16] This meaning is built through interactions with the environment and others, reflecting on the situation, then modeling and forming explanations.[17] The learner becomes a part of the situation through participation or acting in order to best obtain knowledge about the topic.[15] Complete immersion into the subject leads to better understanding. Constructivism is "not a theory about teaching; it is a theory about learning" and is a lens to which teaching decisions can be made.[17]

Constructivism is part of my story and is a large part of how I view my own learning, both in chemistry and in the field of teaching. My own approach toward teaching is formulated in the constructivist approach. During my teacher training at my

undergraduate institution, constructivism was mentioned and discussed during my educational psychology class. The constructivist learning approach was also mentioned in my science teaching methods course as an avenue to aid students in learning the compounding ideas within the discipline. After beginning to teach at the high school level, interacting with students and seeing how they were making connections, constructivism helped me guide students to build their knowledge based on their experiences. When I started graduate school, constructivism continued to be powerful as I realized how new knowledge fit with previous knowledge and past experiences. Taking graduate level physical chemistry was the turning point for me regarding accepting the concept of constructivism. I recognized that all of the other years of chemistry courses finally fit together; physical chemistry showed how all of the concepts, regardless of the subject matter, built on one another. While taking these advanced chemistry courses as a graduate student, I was also faced with teaching undergraduates for the first time. I was able to use my experience of preservice teacher education and teaching high school to plan for my teaching assignment. Although college teaching presented its own challenges, I was able to use my past teaching experiences to bolster my current teaching in the undergraduate laboratory.

Constructivism represents an excellent theoretical approach toward effective GTA training. Much like the students build their content knowledge in chemistry through constructivism, GTAs can build their instructional practices knowledge using a similar theoretical approach while training to teach. Through exposure to constructivist learning and teaching, GTAs can then take this model and use it with their own students.[18] Content topics in chemistry are connected between learning sessions in a course and

between courses. Building knowledge of how students learn on a week-to-week basis is also connected and therefore meets the constructivist model.

Social Constructivism

One described and researched form of constructivism is social constructivism, presented by Lev Vygotsky.[19] The presented method of GTA training in this study utilizes social constructivism, where knowledge is constructed through examining past experiences and interactions with others.[20] Allowing the GTAs time to converse with one another, share ideas, and synthesis solutions while sharing their beliefs, can promote a deeper understanding of how to teach.[21] This group work philosophy was foundational for Vygotsky's development of his theory of the "zone of proximal development" (ZPD).[19] ZPD is described as "the distance between the actual developmental level (of a student) as determined by independent learning and the level of potential development as determined through learning under the guidance of a teacher, or in collaboration with more capable peers."[19] This philosophy is relevant to both undergraduate students and GTAs. Just as undergraduate students learn from one another as they study in a discipline, so do GTAs learn about teaching through collaboration and interaction with their peers.

The study described utilizes constructivist approaches as the broad theoretical basis, through a phenomenological study, and case studies of participants. The phenomenological aspects of the study aims to describe "meaning" for a group of people during their "lived experiences of a concept or phenomenon."[22] This study targets the understanding the GTAs possess regarding pedagogical knowledge. Though, since each

GTA has differing teaching approaches, a case study on each is also appropriate to examine individual changes. Constructivism is a connecting topic within the study of pedagogical content knowledge, teaching using scenario-based examples, and process-oriented group inquiry learning (POGIL).

Pedagogical Content Knowledge

Instructors often teach in similar ways as how they were taught, regardless of the effectiveness of that method. Many instructors focus their pedagogical approach to the classroom only with the goal of highlighting the content being studied, not recognizing that different delivery methods might impact student learning. Additionally, information about how students learn might also lead to different strategies that are not focused only on the content. Quality instruction relies on the instructor's content knowledge, teaching beliefs, and prior knowledge; effective instruction requires all of these topics and more.[23]

Pedagogical content knowledge (PCK) as described by Shulman is "the most useful form of [content] representation…, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a work, the ways of representing and formulating the subject that makes it comprehensible for others".[24] PCK includes an understanding of what makes content easy or difficult for students. PCK also enables the teacher to identify and respond to preconceived misconceptions brought to the class by students and how to mitigate these misconceptions to promote true learning.[24] PCK is the combination of the information to be learned (content), the knowledge of how to students best learn that information, and consequently, how to teach for best understanding and retention (pedagogy). PCK is important because it promotes holistic teaching. Instructors

are not only sharing their content knowledge, but also acknowledging that students have different preferences in regard to their learning and it is important to acknowledge these preferences and adjust accordingly. The development of teacher PCK is anticipated to have the largest influence on teachers' classroom actions.[16]

There is an expectation that GTAs are proficient within the content of the class being taught, in addition to, the expectation they are knowledgeable about experimentally specific information. However, GTAs are not proficient in how to effectively disseminate these examples of knowledge to the students while also managing the laboratory classroom environment. Since GTAs are usually early in their teacher development, their PCK is low. Although GTAs are often expected to be the expert in the laboratory classroom regarding the chemistry subject matter as compared to the undergraduates, GTAs are still novices regarding pedagogical knowledge.

An example of the novice level of GTA PCK is described by Rodriques and Bond-Robinson. They found that science GTAs were ineffective at promoting higher-level thinking skills during class activities.[25] Higher-level thinking skills involve learning that requires more cognitive skills, such as analysis, evaluation, and synthesis from Bloom's Taxonomy.[26] These skills are prevalent in science, desired by the scientific community, but are not easily developed. GTAs are not likely taught this during meetings to prepare for weekly labs and therefore receive little instruction about higher-level thinking teaching strategies.

The skills of teaching the content require studying, coaching, and reflection by the GTA and senior teaching mentors. Gess-Newsome states that through reflection of

"specific classroom events", instructors can "begin to identify the particular instructional strategies, discourse patterns, and managerial techniques that best promote pupil participation and learning in that particular classroom setting."[27] As with any new skill, practice is the key to success. Therefore, developing scenario-based learning from actual laboratory events will provide GTAs with the opportunity to practice prior to engaging in the laboratory classroom. Through this process GTA PCK development can be started.

Teaching Utilizing Scenario-based Examples

A scenario-based example includes a short narrative about interactions that have occurred/may occur in any situation. Through developing scenario-based activities which describe teaching situations, GTAs would have the opportunity to learn from these scenarios. Many entities utilize scenario-based examples (or short case studies) such as medical and nursing programs, law schools, business programs, and human resource departments, just to name a few. Teacher education is another avenue where this method may be advantageous. Referring back to social constructivism, "Meaningful, contextualized, whole activities" were emphasized by Vygotsky "as fundamental units of instruction rather than rote skill building bereft of context".[28] Scenario-based examples include all three attributes listed, and provide instructors with a representative experience in which to practice.

Young and Bippus from California State University Long Beach, used potential student-teacher scenarios/case studies to inform GTAs of situations they may encounter in their teaching, and utilized experiences from prior GTAs and/or current graduate faculty in their department in the development of these scenarios.[29] These scenarios were

used as part of a three-day training seminar, and afforded the GTAs an opportunity to compare the theory with reality, and reflect and discuss the best course of action for each situation. This example required other GTAs in the training to "act-out" student behaviors and specific situations, allowing GTAs a "pilot test" of their teaching skills.[29]

Marbach-Ad et al. developed a GTA training program that utilized experienced GTAs and faculty members to share stories they have from their prior teaching experiences.[30] This study found that in the two years, 2009 and 2010, 87% and 95%, respectively, of the GTAs attending the training felt the "experience stories" were either "Beneficial" or "Most Beneficial".[30] This method is similar to what might be found in pre-service teaching methods courses. Utilizing actual events as training tools greatly enhances the learning experience for the GTAs. Through the use of scenarios, the GTAs are trained to determine what pedagogical tools are most effective for their own teaching style.[6]

From my experience attending secondary education teacher training and GTA training, the examples used were broad, not usually in my subject area and not relevant to the laboratory experience. Plus, when discussing the best course of action or appropriate response, I wanted an accurate representation of what I could expect when teaching. Utilizing scenarios that often occur in the chemistry laboratory was important in facilitating conversations and provided the GTAs with a primary source of information from which to learn. GTA training using classroom specific scenario-based instruction is worth researching and provides GTAs with an accurate representation of what they will be asked to do.

POGIL

Process-Oriented Guided Inquiry Learning (POGIL) is a learning process that aims to shift the lesson from teacher-centered to student-centered. The instructor begins operating more in a facilitator role, rather than using didactic teaching. According to POGIL, there are two broad aims associated with this learning process: 1) "to develop content mastery through student construction of their own understanding, and 2) to develop and improve important learning skills such as information processing, communication, critical thinking, problem solving and metacognition and assessment."[31]

The POGIL philosophy utilizes many of the same principles mentioned already; constructivism, both academic and social, teaching higher-level thinking skills, problem solving through examples, and reflection of their learning process.

In addition, POGIL states that the activities are designed with three main characteristics in mind:

- They are designed for use with self-managed teams that employ the instructor as a facilitator of learning rather than a source of information.
- They guide students through an exploration to construct understanding.
- They use discipline content to facilitate the development of important process skills, including higher-level thinking and the ability to learn and to apply knowledge in new contexts."[31]

The three ideas listed above are all useful for the GTAs in their own teaching, so modeling GTA training similarly is appropriate.

So far, POGIL includes many difference disciplines: anatomy and physiology, biology, chemistry, biochemistry, engineering and math, computer science, and psychology.[31] Through my high school teaching, I was introduced to the chemistry POGILs and successfully implemented them in my own classroom. The students worked as a small team, each with a specific job description describing the tasks he/she was responsible to complete. Jobs included: recorder or record keeper (records the group's answers and turns in the group copy), facilitator (keeps the group on task), speaker or presenter (the only group member allowed to ask the instructor questions), and reflector (ensures all are heard within the group and ensures cooperation within the group).[31] Implementing specific jobs for each student encouraged participation and shared responsibility to promote cooperative learning within the group. The small group discussions promoted social constructivism and allowed student to provide assistance to one another, and from the instructor, as needed.[12]

The POGIL program has been designed to teach students their specific content knowledge. So, why couldn't there be a series of activities for new and future teachers to teach them how to teach? My time teaching with the chemistry POGILs and witnessing success in my students learning the content, encouraged me to utilize parts of the POGIL approach in GTA training. The training materials presented are not officially associated with the POGIL organization but have loosely used guidelines presented by this organization in their development.

Semester-long Training Advantages:

New instructors, particularly GTAs, do not have enough experience to know the impact of educational theory.[32] And as chemistry & biochemistry GTAs, they have not come to campus seeking knowledge about educational theory. Their goal is to focus on research in their discipline to earn their PhD, a research-focused degree. Generally, the GTA position is viewed as a mechanism for funding the student to complete research and is not viewed as educating the GTA best practices in teaching. However, it is now recognized that these same individuals will be the next generation of faculty, and educational theory will be an essential topic for preparing for the faculty position.

The GTA does not have the time to become involved in course work in educational theory, but when provided in small doses such as weekly training meetings, the information may allow GTAs to implement subtle changes to their teaching and potentially witness the impacts. GTAs have expressed that there is a need for basic classroom management, handling challenging students, encouraging productive discussion, and projecting confidence and competence to the class.[6, 29] Allowing GTAs to cover information in small amounts over the course of the semester promotes ideas to be built upon and allows conversations about implementation of these ideas.

CHAPTER 3—METHODOLOGY

Overview

The research project started in the Summer of 2018 with undergraduate-teaching assistant interactions and faculty interviews to create activities for all chemistry graduate teaching assistants (GTAs) to increase their pedagogical knowledge. Activities were

created in the summer and fall 2018 semesters. Two main cohorts of chemistry GTAs participated, Fall 2018/Spring 2019 included six GTAs, and Fall 2019 included eight GTAs.

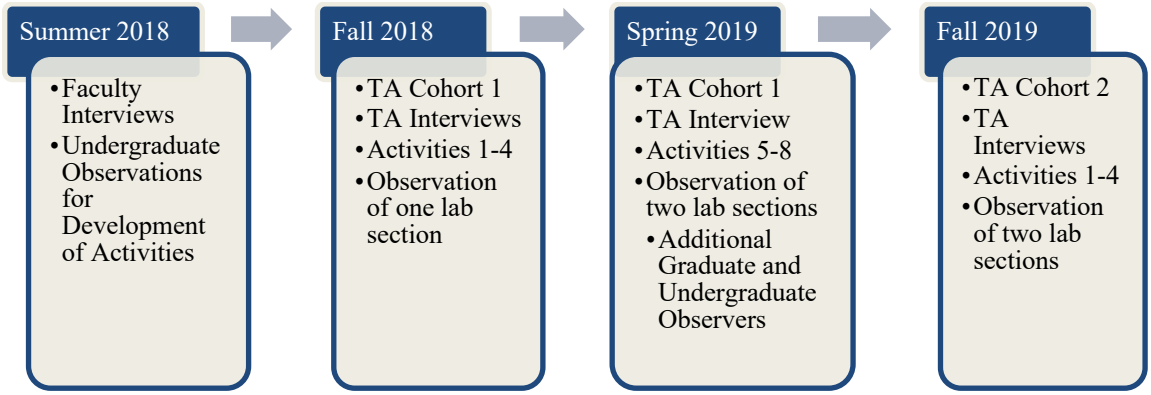

Figure 1: General Research Project Timeline

TAIA Design Phase

Summer 2018 undergraduate student-TA interactions were observed and conducted to gather scenarios for the Teaching Assistant Intervention Activities (TAIA) activities. During that summer session the researcher observed six laboratory sessions. These observations included recording positive interactions between students and the instructor, and interactions that could be improved upon as deemed by the researcher. Recorded details included verbal and nonverbal interactions between students and instructor. This immersion into the laboratory classrooms informed the researcher of challenges faced by GTAs and students. Open and axial coding methods were utilized to identify topics for the TAIA activities.

Chemistry and Biochemistry faculty were also surveyed to determine coordinator expectations (surveys are in Appendix A). Some starter questions were provided to help

faculty discuss their thoughts on their work with GTAs. Faculty were initially provided paper copies of the consent forms and the starter questions. A follow up email was sent two weeks later after a low initial response rate, where the consent and starter questions were included digitally. Overall, three survey responses were returned to the researcher. The responses were analyzed, looking for trends and specific attributes the faculty looked for in their GTAs. Some codes included: increased student interactions, engagement, adequate background information, and safety. Since many of our first- and second-year GTAs work with first-year chemistry students, I was particularly interested in responses from faculty who taught these classes.

Using the faculty interviews, observations of summer laboratory sections, and personal experiences, scenarios were written as examples for GTAs as part of eight TAIAs. The eight topics discussed included: safety, interpersonal skills and behaviors, analysis, laboratory techniques, group process, working with differing-abled students, assessment, and higher-order thinking skills. Additional topics considered but not included in this initial set were: classroom management, motivation, differentiation, and English language learners. In each TAIA, the scenarios became increasingly complicated and making it more difficult to decide on the appropriate GTA course of action. Most TAIA activities included four to five differing scenarios, all focused on a similar topic. TAIAs were reviewed by the researcher, the researcher's advisor, and the laboratory manager, then edited for grammar and clarity of the situation being described before implementation.

Implementation and Data Collection

Two cohorts of GTAs were included in the study: cohort 1 included first- and second-year GTAs between Fall 2018 and Spring 2019; cohort 2 included first-year GTAs in Fall 2019. GTAs from both cohorts were selected by convenience sampling from the chemistry department at a midsized, midwestern university. Initial contact with potential GTAs occurred in person and by email with an invitation to the project, with further detail being provided at the initial interview.

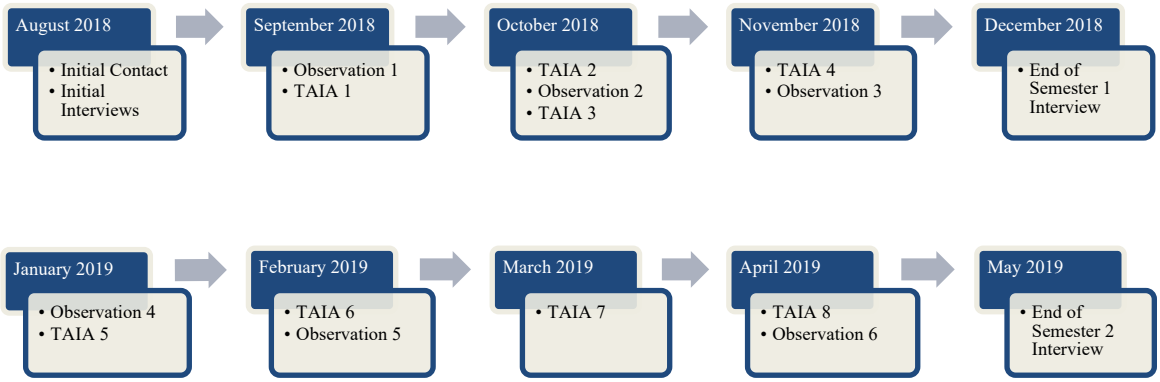

Figure 2: General Schedule of Interviews, Observations, and TAIA sessions for Fall 2018 and Spring 2019 semesters.

The typical schedule shown in Figure 2 involved GTAs in an initial interview at the beginning of the semester before they began teaching their assigned laboratory section, then an initial observation of their assigned teaching laboratory. Then GTAs participated in two TAIA sessions, were observed in another assigned teaching laboratory, followed by two more TAIA sessions, and a third assigned teaching laboratory observation. Finally, during the last weeks of the semester, the same interview questions were asked again in a second interview.

This schedule was the same for all GTAs; the difference came in the depth of the discussion within the TAIA sessions. The control group only discussed the topic in a general sense using an outside reference (pamphlet or short article regarding teaching strategies about the topic) included as a discussion aid. The experimental group had a similar discussion as the control using the same outside reference, but also completed the created TAIA.

Phase 1 Cohort

Cohort 1, a mixture between both first-year and second-year GTAs, participated during the Fall semester of 2018 and Spring of 2019.

Fall 2018

First-year GTAs were contacted during the chemistry department's summer orientation held a few weeks before the start of the fall semester for new, incoming graduate students. Second-year GTAs were contacted at the same time by email and in person. Selection occurred by way of convenience sampling from the chemistry department graduate students. Participation was voluntary, but encouraged by the department head and laboratory coordinators. A human subjects research proposal was approved and deemed "Exempt" by the Institutional Review Board (IRB) at South Dakota State University with approval number IRB-1802001-EXP (Appendix B). Signed consent forms were collected by the researcher prior to beginning the project.

All teaching assistants participated in a private, one-on-one initial interview with the researcher (interview protocol found in Appendix C. The protocol included a script of 17 questions, some with multiple parts. Questions asked about previous teaching

experiences, where they acquired their concepts about how to teach, and the GTA's past experiences as students. Most interviews lasted between 10-15 minutes. At the end of each semester, a second interview was conducted with the same interview questions to foster reflection about the semester.

After the initial interview, classroom observations were conducted by: the researcher during all semesters (observer #1), one assisting graduate student during the first semester (observer #2), and two assisting undergraduate students during Cohort 1, second semester (observer #3 and observer #4). All observers had studied education and looked to continue in an education career. This was the first observation experience for observers 2, 3, and 4, whereas observer 1 had completed 1 year of observations in the past. All observers were using the observation protocol found in Appendix D further explained below, for the first time with this cohort of GTAs. To ensure consistency among observers, training sessions were held between the primary researcher, who is also known as observer 1, and each assisting observer. The primary researcher provided an overview of the project and the definition of codes associated with the observation protocol to the assisting observers. The observers discussed examples of each code the observer might see, then discussed how to format and use the program associated with the protocol. A practice observation was conducted during a week where observations would not normally occur, with both observers present. During the practice observation, the observers discussed what code would be appropriate to record and why. After the observation, the observers again discussed the rational of their coding to ensure consistency; once conclusions were reached, observations proceeded individually.

During the first two weeks of the laboratory class (except for the week of orientation), the first observations for each GTA were conducted. The first observation was intended to establish a baseline about teaching for the GTAs, prior to any specific pedagogical discussions. For some of the GTAs, this was the first time they had taught, or the first time they had taught within the American education program. Due to scheduling conflicts, not all GTAs were observed in the same week, but GTAs who taught the same classes (CHEM 106, 108, 112, etc.) were observed in the same week. Table 1 shows the weekly observation and activity schedule for the Fall 2018 schedule.

Table 1: Cohort 1, Fall 2018 Observation and Activity schedule

Week Start Date (Monday)	Observation or Activities Week
August 27th	Initial Interviews
September 10th	Observations
September 17th	Observations
September 24th	TAIA 1
October 1st	TAIA 2
October 8th	Observations
October 15th	Observations
October 22nd	Observations with TAIA 3
October 29th	TAIA 4
November 5th	Final Observations
November 12th	Final Observations
November 26th	(If needed) Final Observations
December 3rd	Mid-Year Interviews

At the beginning of the semester in each laboratory class, the research project was briefly explained to the undergraduate students, and a consent form was handed out to be signed by the students. Participation by the undergraduate students was voluntary. The researcher began the observation and worked from the back of the classroom, interacting minimally with students and the GTA.

Observations utilized the Laboratory Observations Protocol for Undergraduate STEM (LOPUS) developed by the University of Nebraska—Lincoln.[33] This protocol included recording the activity of the instructor and students in 2-minute increments throughout the class period. This was found to provide a snapshot of the events occurring within the laboratory classroom.

The first observation of the semester was recorded manually on paper because the LOPUS online platform was not fully integrated onto the SDSU campus. Once administrative tasks were completed, the observers utilized the LOPUS online platform from the University of California, Davis to record the observations.[34] Figure 3 shows the opening page for LOPUS observations.

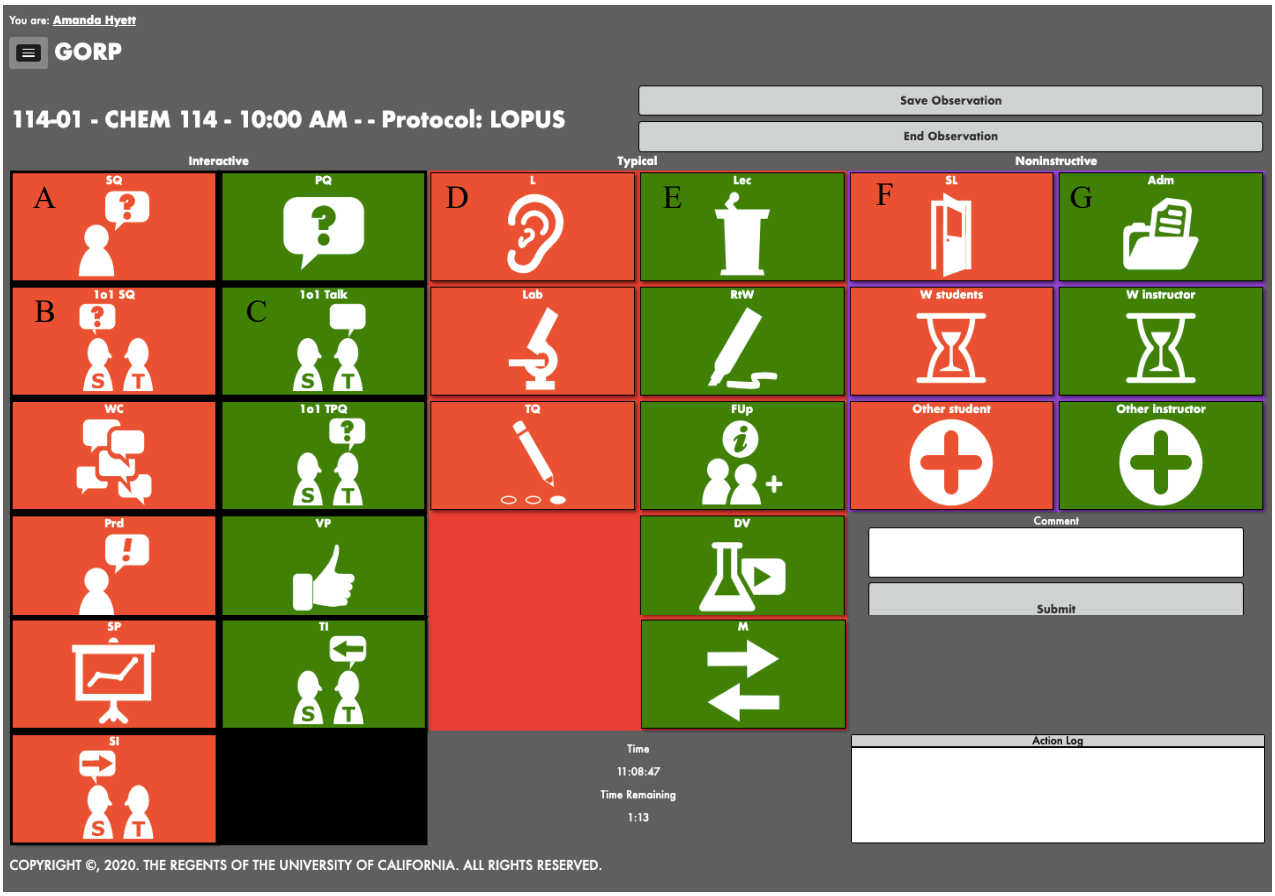

Figure 3: Opening page of online LOPUS program. Some example prompts easily recorded include: A: Student Question in front of entire class; B: 1-on-1 Student Question; C: 1-on-1 Talk initiated by GTA; D: Students listening to GTA; E: GTA lecturing to entire class; F: Student Leaving class; G: GTA performing Administrative tasks.

The platform defined codes for researchers to use in simplifying their observations. Some example codes are explained below, but additional information regarding the codes can be found in Appendix E[33] The platform was divided into two categories: Instructor and Student. Student actions are in green, and instructor actions are in orange. Further, the observation is divided into three more categories: Interactive (left two columns), Typical (middle two columns), and Non-instructive (right two columns). The observer would "toggle", or "click on" the corresponding action that the GTA or

student was doing. This would start a timer within the program to record how long this action took place. Examples of interactive toggling would be:

- student asking a question to the GTA in front of the entire class (*SQ, Figure 1:A*).
- student posing a question to the GTA individually (*1o1 SQ, Figure 1:B*).
- student did not ask a question of the GTA but is still looking for feedback (*1o1 Talk, Figure 1:C*).

When the interactions were completed (the GTA moves on from that group), that action would be toggled 'off', and the timer within the program would stop for that action. Examples of typical toggling would be:

- students were listening (*L, Figure 1:D*) to the GTA was giving their kick-off (*Lec, Figure 1:E*).
- students began working on the experiment, *L* would be toggled 'off', and the *Lab* would be toggled 'on'.

Finally, non-instructive actions included:

- students leaving the lab (*SL, Figure 1:F*).
- GTAs completing administrative tasks such as taking attendance, passing out previous weeks work, or cleaning (*Adm. Figure 1:G*).

To complete all observations required two weeks due to the number of participants and overlapping laboratory sessions. Each GTA was observed in one of their sections within those two weeks. The principal researcher (observer 1) observed 12 laboratory sessions, seven the first week, and five the second week, over the course of the observation schedule. Observer 2 conducted two observations, one each week during

each set of observations. Figure 4 outlines the weekly schedule of each observer during each observation set.

Week 1					
Lab Times	Monday	Tuesday	Wednesday	Thursday	Friday
7am			Observer 1		
8am		Observer 1		Observer 1	
9am					
10am	Observer 2				
11am				Observer 1	
12pm					
1pm	Observer 1				
2pm					
3pm					
4pm					
5pm			Observer 1		
6pm	Observer 1				
7pm					
8pm					

Week 2					
Lab Times	Monday	Tuesday	Wednesday	Thursday	Friday
8am		Observer 1		Observer 1	
9am					

10am	Observer 2				
11am				Observer 1	
12pm					
1pm					
2pm	Observer 1			Observer 1	
3pm					
4pm					

Figure 4: Fall 2018 Bi-Weekly Observation Schedule. Observer 1 in yellow: principal investigator; Observer 2 in orange: graduate student observer.

After the first observation, TAIA sessions began. The researcher and GTAs met in two different groups, the control and experimental groups. GTAs selected which time was most convenient for their schedule, thus placing them into either the control or experimental group and therefore making sample selection a convenience sampling process. At the initial meeting, the researcher explained the format for the sessions and set expectations about maintaining communication between individuals within the group, sharing ideas amongst the group, and not discussing the topic with others from the research project.

The first TAIA 1 session was held in week three of the first semester and the topic and title of the activity was "Safety in the Laboratory." An outside resource from the American Chemical Society's (ACS) Committee on Professional Training was utilized in both the control and experimental groups as a starting point for discussion.[35] This document was chosen due to being published by the ACS and its relevance to the specific challenges within the chemistry laboratory. The language was specific to chemistry personnel and discussed many current laboratory safety topics. Since safety is

a topic that is constantly discussed within the science community, GTAs were familiar with the topic. The same outside reference was used for both the control and experimental groups, with the change coming with the addition of the TAIA during the experimental group meeting.

The TAIAs (Appendix F) were formatted with scenarios, referred to as "Situations" in the documents, which were created from the primary researcher's observations during the summer 2018 laboratory classes, faculty laboratory coordinator feedback and undergraduate student interviews as described earlier in this chapter. These were the primary data sources for scenarios utilized in all TAIAs. Scenarios were utilized because of their ability to teach without the GTAs having to first experience the situation firsthand. Others have also found success in education training by using scenarios.[36]

The TAIA 1 session, included six scenarios, with the last being a more detailed, longer scenario with many opportunities for the GTAs to find areas of improvement. Topics included in TAIA 1 were: proper goggle use, the heating of an acid solution, proper disposal techniques, cross-contamination of chemicals, and proper laboratory attire. After reading each scenario in TAIA 1, the GTAs were asked three questions and given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- Is the student in any violation of any polices of the laboratory?
- Describe how you would have this situation play out in the more appropriate and safe manner.

The second TAIA 2 session, conducted during week four of the first semester, involved the topic and was titled “Interpersonal Skills and Behaviors.” The outside resource used in TAIA was obtained from the Eberly Center for Teaching Excellence at Carnegie Mellon University and was titled “Collected Wisdom: Strategies and Resources from TAs to TAs.”[37] A simple, concise checklist about “Being Proactive in Lab” was referenced and discussed in both the control and experimental groups of GTAs. Sample recommendations on the checklist included: walk around the room, know where the relevant equipment and supplies are located, and help students avoid errors that may cost lots of time. These topics, plus others, fostered discussions and elicited new ideas shared amongst the GTAs in each group. This document was chosen for its simplicity and relatability with the GTAs. This source was written by GTAs with the intention of directly helping other GTAs.

Topics included in TAIA 2 were: fair assistance amongst male and female students, responding to partially correct statements from students, students working in too large of groups, knowing students by name, including and answering all students questions in the class, and rushing students through their experiments to leave the class early. After reading each scenario in TAIA 2, the GTAs were asked three questions and given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?

- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

After the second TAIA session, observation two was conducted for the GTAs. The same schedule was held by both observers during weeks five and six of the study as during the initial observations. The purpose of this set of observations was to identify any changes regarding the GTAs behaviors in the areas of safety and interpersonal skills and behaviors.

The third TAIA 3 was completed in week seven of the first semester and involved the topic "Analysis." The outside resource obtained from the University of Toronto's Teaching Assistants' Training Program entitled "Questioning Techniques: Guidelines & Best Practices" was utilized as a starting point for conversation for TAIA 3.[38] Questioning is a large part of any classroom; particularly a laboratory class with unknown equipment, pressure to know the correct answer and perform the correct analysis. The control and experimental groups read through the pamphlet and discussed the topics within that were found to be valuable and applicable to the laboratory classroom. Example topics discussed included: encouraging students to become self-directed learners; being a good listener; relating questions to the course content, even if they are tangential; and preparing your questions in advance. This resource included a list of many simple recommendations GTAs could immediately apply to their classroom, and further references to current education research.

Topics included in TAIA 3 were: utilizing laboratory technology (Excel, LabQuests) for data analysis; using different approaches for working through unfamiliar mathematics problems; identifying GTA inattention which results in students working in

large groups instead of pairs; and deciding when to communicate relevant information to students about a particular aspect of the experimental analysis. For the first three scenarios, the same questions from TAIA 2 were utilized and GTAs were given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?
- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

For the last scenario in TAIA 3, since GTAs were asked to choose from a list of possibilities of when they would choose to communicate the information, the prompts changed. They were asked three questions and given the opportunity to suggest changes to the situation:

- Which of the three methods would you choose? What are some advantages and disadvantages to the other methods? Be specific and explain.
- How do the interactions between the TA and students promote a positive learning environment?
- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

The TAIA 4 activity was completed in week eight of the first semester and involved the topic "Lab Techniques." The outside resource obtained from the University of Michigan Center for Research on Learning & Teaching and entitled, "Strategies for Effective Teaching in the Laboratory Class" was used as a starting point for discussion.[39] This source was generated by GTAs from the University of Michigan's Physics Department for new instructors of other disciplines. The researcher again found relevance and relatability, as this outside source was written by GTAs from a large, midwestern university who taught a physical science discipline. Sample topics included: entering the class with a good attitude; being sure to start and end the class on time; demonstrating laboratory techniques; and being reminded the GTA's role as an instructor. This resource provided a full-circle, wrap-up reminder of what the GTA should be doing in the class. The TAIA 4 session was the last meeting as small groups for the semester as assigned laboratory classes were nearing the end for the GTAs. This resource initiated reflection by the GTAs on their teaching experience during the semester.

Topics included in TAIA 4 were: students asking each other questions before approaching the GTA; GTAs demonstrating a new skill; GTAs using questioning techniques to review the apparatus and equipment for the experiment; and students using appropriate glassware. For all scenarios, the same reflection questions from TAIAs 1 and 2 were utilized and GTAs were given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?

- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

After all of the TAIA sessions were completed the last observation was also completed. During this time the observer surveyed the undergraduate students in the class asking for feedback on their GTA (Appendix G). Student surveys were used for triangulation with GTA interviews and observations. Any topics repeatedly mentioned by the students were utilized for topic discussions in future semesters.

At the end of the semester, the principal investigator conducted another one-on-one interview with control and experimental group GTAs. The questions were the same as from the initial interview from August. This mid-year interview was utilized to see if any prior thoughts regarding teaching had changed for the GTAs after the completion of the semester and the teaching discussions.

Spring 2019

A small group (due to scheduling and research commitments) of GTAs from Cohort 1 repeated a similar observation and topic schedule in the Spring of 2019. Table 2 provides the weekly schedule of observations, meetings, and final interview.

Table 2: Cohort 1, Spring 2019 Weekly Schedule

Week Start Date (Monday)	Observation or Activities Week
January 28th	Observations
February 4th	Observations
February 11th	TAIA 5
February 18th	TAIA 6

February 25th	Observations
March 11th	Observations
March 18th	TAIA 7
March 25th	TAIA 8
April 1st	Final Observations
April 8-29th	Final Observations (University Closures due to Inclement Weather)
April 29th	Final Interviews

Several changes occurred in the observation of GTAs. Observer 1 remained the same, however observer 2 was not able to continue as scheduling conflicts prevented the participation of observer 2 for the Spring 2019 semester. In order to complete all the observations, observers 3 and 4 became involved in the work. As mentioned above, observers 3 and 4 were undergraduate students in education focused majors. Figure 5 outlines the weekly schedule of each observer during each observation set.

Week 1					
Lab Times	Monday	Tuesday	Wednesday	Thursday	Friday
8am					
9am					
10am		Observer 3		Observer 3	
11am					
12pm					
1pm	Observer 1				
2pm					
3pm					
4pm			Observer 1		
5pm					
6pm					
7pm					
Week 2					
Lab Times	Monday	Tuesday	Wednesday	Thursday	Friday
10am	Observer 1	Observer 4			
11am			Observer 4		Observer 1
12pm					
1pm					
2pm		Observer 1			
3pm					
4pm	Observer 1				
5pm		Observer 1			

6pm					
7pm					
8pm					

Figure 5: Spring 2019 Bi-Weekly Observation Schedule. Observer 1 in yellow: principal investigator; Observer 3 in red; undergraduate student observer; Observer 4 in blue: undergraduate student observer.

An additional change included observing two sections of each GTA's teaching laboratories in the same week (one GTA only taught one section of a class, so this GTA was only observed once this semester). These two sections for each GTA were observed to see if any teaching approaches were changed from section to section within the same week. As often as able, the first section of the week for each GTA was observed. This particular section is usually the most difficult to plan for as GTAs are unsure how students will respond to the experiment, if the equipment will operate correctly, and if the experiment will work to completion. Additionally, the first session is often the most stressful for GTAs, so the researcher was interested to see how the GTA managed this stress, and how that compared to a section later in the week.

The fifth TAIA session was conducted during week three of the second semester and involved the topic "Group Process." The outside resource, obtained from the George Lucas Educational Foundation on Edutopia and used as a starter for conversations was "5 Tips for Making Group Work Manageable"."[40] The five tips were: be clear and specific about the task; make production the outcome; model successful transitions and interactions; monitor progress, time and noise; and incorporate community builders. For many of the chemistry laboratories, the experiments were designed to be completed by a

pair of students. These students may need assistance with staying focused on the appropriate task, managing different personalities, and other challenges that arise in the laboratory. The chosen article provided a simple starting point for a discussion and reminded the group that collaboration by students is an essential part of the learning process.

Topics included in TAIA 5 were: equal work distribution among partners; impact of observing a pair, but not directly intervening; mitigating an uninterested and non-engaged student; and helping students with arguments to negotiate an outcome about the argument. GTAs were asked three questions and given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?
- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Each scenario was observed by the researcher and provided great discussion about different approaches to ensure all students were learning the material.

The sixth TAIA 6 session, conducted during week four of the second semester and involved the topic "Working with Differing-Abled Students." The outside resource, obtained from BestColleges.com, and used as a starter for conversations was "Etiquette for Working With Students With Disabilities."[41] Many GTAs were not familiar with

physical, mental, or emotional challenges that students face. The students bring those challenges with them to class, so including a discussion about how the GTAs can successfully navigate those situations is critical. This article was organized in a simple manner and was a great resource for the GTAs to explore each disability. Details regarding wheelchair users & mobility device users, deafness & hearing loss, blindness & visual impairment, speech, cognitive, and hidden disabilities were all explored in the article. The group discussed what challenges the different disabilities could pose for students, and consequently, the appropriate role and actions the GTA should take.

Topics included in TAIA 6 were: helping students conquer physical challenges in the laboratory; inclusion of students with cognitive challenges; providing appropriate accommodations; and working with Gifted students. After each scenario, the GTAs were asked three questions and given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?
- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

After the sixth TAIA session, the first GTA observations of the semester were conducted. The schedule, Figure 3, was followed by all three observers during weeks five and six of the study. The purpose of this set of observations was to see if any changes occurred regarding the GTAs behavior in the areas of group process and working with differing-abled students.

The seventh TAIA was completed in week seven of the second semester and involved the topic “Assessment.” The outside resource, obtained from Edulastic.com, used as a starter for conversations was “Formative Assessment: What is it?”[42] Assessment is a large aspect of the classroom, and is more than just grading laboratory reports. This reference outlined a lesser known assessment, formative assessment, that can be utilized as an ‘in the moment’ evaluation of students for instructors.

Topics in TAIA 7 were: using pre-laboratory assignments as a means for assessment; determining students’ knowledge regarding the procedure; evaluating students’ application and impact of bias on data; and discussing with the entire class common mistakes made by the majority of students. After each scenario, the GTAs were asked three questions and given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?
- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

The eighth TAIA was completed in week eight of the second semester and involved the topic “Higher-Order Thinking Skills.” The outside resource, by Alice Thomas, used as a starter for conversations was “30 Strategies for Enhancing Higher Order Thinking.”[43] This source provided an extensive list of tips, suggestions, and different methods instructors can use to engage learners of all levels. During the meeting,

GTAs selected two to three of the suggestions, summarized, then provided an example or explanation of how the suggestion could be used in their classroom.

Topics discussed in TAIA 8 were: different levels of thinking of students, and how to appropriately foster academic growth for all student abilities; referencing previous laboratory information; showing students how the content builds on previous material; and finding means of engagement with fellow classmates. After each scenario, the GTAs were asked three questions and given the opportunity to suggest changes to the situation:

- Would you have handled the situation differently? What would you do differently?
- How do the interactions between the TA and students promote a positive learning environment?
- Describe how you would adjust your personal behavior to improve the learning environment in this situation.

After the eighth TAIA session, the last GTA observations of the semester were conducted. Again, undergraduate students were surveyed, and asked for feedback on their GTA. Student surveys were used for triangulation with GTA interviews and observations.

At the end of the semester, GTAs were asked the same interview questions after teaching a new group of students. This interview was intended to allow reflection by the GTA after teaching two semesters and perhaps differing classes.

Phase 2 Cohort

The second cohort of GTAs included first-year Fall 2019 GTAs. All GTAs participated in the same initial interview as in the first cohort. Due to a smaller number of GTAs and the fact that a control group had already been conducted, the GTAs in cohort 2 were all involved in the experimental group.

All participating GTAs experienced the same discussion topics and TAIAs as described earlier for TAIAs 1-4 . Topic discussions utilized the same outside resources, TAIA activities, and schedule as in Cohort 1. Table 3 shows the weekly schedule for observations, activity meetings, and interviews for Cohort 2.

Table 3: Cohort 2, Fall 2019 Weekly Schedule

Week Start Date (Monday)	Observation or Activities Week
August 26th	Initial Interviews
September 16th	Observations
September 23th	Observations
September 30th	TAIA 1
October 7st	TAIA 2
October 21th	Observations
October 27th	Observations
November 4th	TAIA 3
November 11th	TAIA 4
November 18th	Final Observations
December 2nd	Final Observations
December 9th	Final Interview

All observations were conducted by the principal researcher, Observer 1. Figure 6 shows Observer 1's observation schedule.

Week 1					
Lab Times	Monday	Tuesday	Wednesday	Thursday	Friday
8am		Observer 1		Observer 1	
9am					
10am					
11am		Observer 1		Observer 1	
12pm					
1pm					
2pm					
3pm			Observer 1		
4pm	Observer 1				
5pm		Observer 1			
6pm					
7pm	Observer 1				
8pm					
9pm					

Week 2					
Lab Times	Monday	Tuesday	Wednesday	Thursday	Friday
8am		Observer 1		Observer 1	
9am					

10am					
11am		Observer 1		Observer 1	
12pm					
1pm	Observer 1				
2pm		Observer 1			
3pm					
4pm					
5pm		Observer 1			
6pm	Observer 1				
7pm					
8pm					

Figure 6: Cohort 2, Fall 2019 Bi-Weekly Observation Schedule. Observer 1 in yellow: principal investigator.

Again, at the last observation, the undergraduate students were asked to provide feedback through student surveys. In addition to the five questions asked of Cohort 1 undergraduate students, Cohort 2 undergraduates were asked if their GTA demonstrated growth in the four areas studied in group meetings: safety, interpersonal skills and behaviors, analysis, and lab techniques (Appendix H).

The GTAs were asked the same interview questions as Cohort 1 GTAs regarding the change in the GTAs behavior from the beginning to the end of the semester. At the end of the semester, the same interview questions were revisited after many of the GTAs had taught for their first time.

Method of Analysis

Undergraduate Student Surveys

Undergraduate student surveys were recorded in Microsoft Excel after all surveys were collected at the end of each semester. The surveys were grouped according to the laboratory class number (CHEM 106, 108, 112, 114, 326, 361, and 466) and further organized by section. Students responses were randomly assigned a number based on when their surveys were returned (lower number corresponds to a survey completed quickly). This student number was not used to identify students, but rather a means of organizing student responses. Student numbers included the section code and single digit 1-24. After all surveys were inputted, a different sheet was created for each GTA; all data for each GTA from that semester was compiled into their sheet for simplicity.

Often, students would include multiple statements answering each respective question, and would include different details regarding their GTA. These answers were separated into different rows (keeping student numbers) for clarity in the coding process. Initial coding included printing student responses, cutting out each response with explanation, organizing based on GTA and semester. Responses were then separated into initial categories during the open coding process: reasoning for helping, able to explain and answer questions, shows interest/caring, kick-off/helpful, and understand content. These specific topic groups were then clarified to codes of: personal characteristics, kick-off (pre-laboratory lecture) delivery and information, answers questions/good explanations, and understands content. These codes were very similar to Herrington and Nakhleh's themes for student and TA free-response answers, thus the researcher decided

to adopt the same categories.[13] The categories were: Knowledge, Communication skills, and Affective domain, also shown in Figure 7.[13] The categories included many of the same responses from students, and the researcher felt the categories would accurately reflect the data collected during this study.

Student survey data was coded into the three categories adopted from Herrington and Nakhleh's by the primary researcher and two chemistry education graduate students. GTAs were referred to by a GTA number, and any identifying characteristics regarding GTA identities were removed, prior to coding for all coders.

Theme	Subarea	What demonstrates this quality?	How does this help students?
Knowledge	Procedure, techniques, safety	Demonstrates and corrects technique	Helps students avoid senseless mistakes
		Tell students if something looks wrong, identify pitfalls in lab	Makes lab worthwhile
		Ensure student understanding of purpose and procedure	
	Chemistry concepts	Tie in lecture material	Some students do not see connections
		Identify practical applications	Creates interest in the lab and chemistry
	How students learn	Understanding of student learning, aware of typical difficulties	
		Understand that stuff is new and difficult for students	
		Read into student's actions	Students not good at voicing questions
	Teaching	Monitor and get involved with students	
		Do not sit back and talk to other TAs	
		Guide rather than give answers	
		Fair grading, useful feedback for lab reports	
Communication skills		Breakdown and rephrase complex material	Written instructions may be hard for students to understand
		Use layman and scientific language	Helps complete lab on time
		Speak in plain English	
Affective domain	Student concern	Never discourage or belittle student	
		Tries to get to know student	
		Gives individual help and attention	
	Wanting and willing to help	Takes time to explain well	
		Enthusiastic about teaching, wants to teach	Students more willing to learn
	Available and approachable	Available outside the lab	Not many people for students to get help from
		Friendly	Students feel more welcome to ask questions

NOTE: A comparison of the student free-response answers based on the demographic variables did not yield any distinct differences. In addition, due to the small number of TA responses, all student and TA responses were considered as a whole in constructing this table.

Figure 7: Excerpt of Table 3 from Herrington and Nakhleh with selected codes (themes) of student responses. (Reprinted from ref 11.)

The primary researcher and another graduate education student coded all student responses using Excel. The data validation tool in Excel was used to create a list of the three categories; this tool was used with all student responses and by all coders. The other

coder was provided the above figure, the research paper, and an explanation of how the responses were formatted and separated. Congruency between raters was established through similarity in coding selection.

GTA Interviews

Individual interviews between the primary investigator and GTA were transcribed during the interview, whilst being audio recorded. GTA interviews were read and statements were organized into categories congruent with TAIA topics or placed in an 'other' category if the statement was not directly related to a TAIA. For example, the kick-offs provided by the GTAs are very important for the students and were often mentioned in the student surveys. Therefore, specific mentions by the GTAs regarding kick-offs was noted. Interview narratives were constructed by the primary researcher to review interview responses and connect ideas mentioned by the GTAs.

Laboratory Observations

Observations were presented in two Excel formats from the LOPUS program: one tallied the number of times a specific code from Figure 2 was selected for every two minutes; the other format created a row for each code and included the exact start and stop times of when the code was toggled. While the data collected from every two minutes was initially what the primary investigator thought would be most useful, the data with exact times ended up being more utilized.

The number of seconds, then minutes of each code was determined; specific consideration was made for student-GTA interactions, GTA monitoring, and administrative time. Total times for the interactions, monitoring, and administrative were

calculated. Average time amounts were calculated from each observation set. The total times for interactions, monitoring, and administrative were divided by the corresponding overall laboratory class time and then converted to percentages.

Then, to explore the interaction times further, average time per interaction between student and GTA was calculated for each observation and once again averaged for each observation set. The Excel formula COUNTIF was used to count the types of interactions such as, GTA-initiated (1o1-TPQ) versus student-initiated (1o1-SPQ), verbal monitoring (VP), and small group discussions (1o1-Talk). GTA-initiated was summed to include 1o1-TPQ, VP, and 1o1-Talk. Student-initiated included 1o1-SPQ.

GTA Case Studies

Initial case studies were compiled for four GTAs. The primary researcher started with GTA 9 and outlined similarities between the student survey responses, statements from the GTA interviews, and comments and trends from the observations. Initial header topics included: rapport, interaction types and times, and kick-off. Only one of these header topics directly links to the TAIA topics: interaction types and times links to TAIA 2: Interpersonal Skills and Behaviors.

CHAPTER 4--ANALYSIS

Overview

The purpose of this study was to implement constructivist-oriented GTA training materials to teach pedagogical content knowledge and utilize scenario-based examples in

each TAIA. This chapter will start by describing the analysis of data completed to develop each TAIA. An explanation of how the various topics for which the TAIA focused will be provided. The second part of this chapter focuses on the data collection to establish a baseline of GTA pedagogical content knowledge and various teaching skills which include inferences drawn from the GTA interviews, laboratory observations, and undergraduate student surveys. These sources of information will allow the primary researcher to construct a case study of several GTAs as they begin teaching in the laboratory classroom at SDSU and then after the TAIA interventions. Using these case studies, the primary researcher was able to identify certain changes in GTA interactions and behaviors, thus suggesting the impact of the TAIA interventions on GTA behavior in the classroom.

Creation of TAIAs

After completing the observations during the Summer 2018 semester, all observation notes of student-GTA and student-student interactions were reviewed in anticipation of creating the TAIAs. These observations also included written assessments of the classroom environment including information presented on the board and during kick-offs, how the laboratory supplies were arranged, and examples of interactions between students and GTAs. The primary investigator reviewed the observation notes first by looking for any specific concerns that should be addressed, then by searching for more subtle teaching aspects to discuss with the GTAs.

A key element in chemistry laboratories is safety. In fact, during one of the general chemistry laboratory sessions, the observer noted a “lack of written safety

concerns on board and nothing mentioned in kick-off." This, in addition to other safety concerns were witnessed by the observer and prompted the creation of a safety-focused activity (TAIA 1). Examples of inappropriate safety behaviors included students pouring chemicals down the drain without proper neutralization or waste management techniques after being advised to do so by the GTA. Another common scene involved student cross-contamination of their workspace by wearing gloves throughout the entire experiment and analysis portions. One example was pulled from an upper-level laboratory course where students were heating acid without proper stirring and monitoring. Resultingly, the acid "popped" onto the student. The main objectives of TAIA 1 therefore included: 1) GTAs were able to identify their responsibility regarding potential hazards within the laboratory and assess ongoing hazards and 2) GTAs were able to practice the appropriate responses when identifying and encountering student actions which could have resulted in potential hazards.

The second TAIA was developed to address interpersonal skills and teaching behaviors. This interaction observed during a laboratory kick-off illustrates the need for the TAIA:

> GTA: "Looking at PV/RT =1, just looking at P & T, is it directly or inversely proportional?"
>
> Student 1: "Inversely"
>
> GTA: [Repeats the first statement without acknowledging Student 1's response]
>
> Student 2: "Inversely"
>
> GTA: [To Student 2] "Why?"
>
> Student 2: "Because it is on top and bottom."

> Student 1: [Showing signs of agitation by clicking fingers on table, lips pinched together]

Continuing, throughout the remainder of the kick-off, the GTA appeared to ignore (had body turned away, did not ask any questions) one side of the classroom, and instead focused on the opposite side. This example encouraged the primary investigator to include a topic regarding interpersonal skills and behaviors (TAIA 2). TAIA 2 focused on GTAs meeting the needs of their students through means of communication. This included academic, social, and emotional needs. The objective of TAIA 2 expected the GTAs to recognize their students' current status of competency through verbal and nonverbal communication. This involved practicing and formulating appropriate responses to verbal and nonverbal communication within the laboratory.

One reoccurring theme included students struggling with connecting their observations from the "wet-lab" portion to the application questions and analysis portions. The analysis students completed included algebraic calculations, reflections on potential applications for the data, and connections to broader concepts discussed in lecture and chemistry in general. This process usually occurred after data was collected and the "wet" portion of the experiment was completed. In many general chemistry experiments, the students are required to utilize available technology and associated programs. Sometimes, GTAs were observed completing the work within these programs for the students instead of guiding the students on how to use the program. Also, some students struggled with the algebra associated with the calculations needed to solve experimental problems. Often, the GTAs were not confident on teaching these skills. The

listed observations prompted the primary investigator to focus discussions on analysis (TAIA 3) in hopes of the GTAs would share strategies they had previously found helpful.

The analysis TAIA focuses on helping GTAs encourage their students to create a process to analyze their data. The objectives expected 1) GTAs to consider methods to help students learn a process for data analysis and 2) to practice pedagogical methods determined to be of high value for data analysis.

Often due to the number of groups and the lack of preparation and inexperience of the students, the apparatus set-up during a laboratory can be improperly constructed by students. Also, equipment, such as pipettes and other glassware, are incorrectly used by students. Demonstrations of proper use and set-up were rarely witnessed during the initial observations, thus prompting the need for additional instruction on teaching laboratory techniques for the GTAs (TAIA 4). The laboratory techniques TAIA focuses on helping GTAs instruct their students on proper and safe laboratory techniques. Objectives included 1) GTAs will evaluate and 2) practice different pedagogical methods which could be used to help students learn a process to proper laboratory techniques. Laboratory techniques discussed included working with laboratory technology (LabQuests), demonstrating proper pipetting techniques, setting up appropriate apparatus for the days experiment, and importance of using proper glassware.

Another common observation witnessed by the researcher was unequal distribution of the workload during the experiment by students. Generally, one student in the pair completed the “tactical” portion while the other partner recorded data and completed calculations if able. The observer rarely observed GTAs encouraging equal

participation and contribution. Therefore, focus on the group process was the topic of interest (TAIA 5). The group process TAIA focused on helping GTAs assist their students through their interactions with group members. Objectives were designed for GTAs evaluate and practice different pedagogical methods which could be used to help students learn the material and a process to work with their peers. The GTAs learned how to promote a productive work environment for all students.

The topic of what to do when students had clear differences in ability (TAIA 6) was sparked less from the summer observations and more from the primary investigator's previous teaching experience. This topic was reinforced during a set of observations in the fall 2018 semester. The GTA in the classroom had a pair of students who generally worked well together, but one became agitated easily and appeared to struggle with changes and unclear instructions. This pair always took longer than other groups to complete experiments and required kind, patient instruction from the GTA. While this was one of the more noticeable situations for which a GTA was likely underprepared for, there were many small occurrences that GTAs might not have noticed. For example, some students struggled with the social aspect of having a partner. On the other end, many of the students in the classes were very bright and this created other challenges for instructors. Instructors are then required to have prepared more information about the topic for these students and may be faced with more questions than the GTA was not prepared to answer. These encounters occur in classrooms every day but are not often mentioned during traditional GTA training. Therefore, TAIA 6 discussed differences in ability level of students and how GTAs might respond to these differences.

Objectives of TAIA 6 were to provide an opportunity for GTAs to recognize their responsibility of working with students of varying physical and cognitive abilities. The GTAs evaluated different pedagogical methods they could use to ensure all students felt welcome and were able to learn the material. And the GTAs were able to practice those pedagogical methods in order to promote a productive work environment for all students.

A component included with many laboratory classes is a pre-laboratory assignment or quiz. This preparatory work is important for the students to complete as it provides the GTAs with a snapshot of what the students know before attending class. Hopefully, discussion of these "pre-labs" occurs during the GTA kick-off or perhaps during small group discussions. These assignments are the first assessments of students that GTAs encounter each week. Some instructors view only post-laboratory reports or exams as assessment, which is inaccurate and ineffective. Using a formative assessment helps the instructor to support student preparation for the laboratory activity. Therefore, the subject of assessment was a relevant topic for discussion during TAIA 7. The assessment TAIA focused on helping GTAs with assessing their students and using that assessment to enhance student learning throughout the laboratory class. The objectives of this TAIA included 1) GTAs evaluating and 2) practicing different pedagogical methods which could be used to determine the level of knowledge displayed by students regarding the experiment and course material.

Finally, after the primary investigator listened to some student-TA interactions and found literature suggesting that GTAs did not promote higher-level (higher-order) thinking skills, the topic of the last TAIA developed.[44] Examples of interactions needing higher-order thinking include students needing extra direction for content growth and

scenarios with different means of engagement. The development of the GTA skill to encourage higher-order thinking may promote student learning in the laboratory and TAIA 8 provided GTAs with the opportunity to learn about and gain experiences in how to promote such activities. The higher-order thinking skills TAIA 8 focused on helping GTAs on encouraging their students to establish higher-order thinking skills. The objectives of the TAIA were for 1) GTAs to evaluate and 2) practice different pedagogical methods which could be used to assist students' ability to use higher-order thinking skills.

In addition to the observations mentioned above, chemistry and biochemistry faculty survey information was also considered for the development of the TAIAs. The primary researcher determined through these surveys that important topics were increased student interactions and engagement, adequate background, and safety. The topics of student interactions and engagement were included in the discussion and completion of TAIA 2. Emphasis on including adequate background information was included in nearly every week's discussion, and safety was included in discussion and completion of TAIA 1. Two of the topics specified by chemistry and biochemistry faculty evolved into specific TAIAs.

TAIAs were created based on the analysis of observation and survey data as described previously. With the creation of the TAIAs, the primary researcher was ready to implement these activities as part of a project to impact GTA teaching skills in the laboratory. The rest of this chapter focuses on how GTAs were impacted by the TAIA interventions.

TAIA Impact on GTA Pedagogical Content Knowledge

As described in the methods section, the TAIAs were implemented in a year-long professional development program for GTAs in the Chemistry & Biochemistry Department at South Dakota State University during the academic year (fall and spring) of 2018-19 and during the fall semester of 2019. All GTAs participated in weekly conversations while the experimental GTA group participated in additional TAIA conversations. Presented here are data collected to determine the impact on GTA skills and behaviors. First, student survey data describing GTAs will be presented followed by case studies for selected GTAs.

Student Surveys

The goal of the student surveys was to gather the student perspective of the GTA being observed. Observations were only conducted three times throughout the semester; whereas, the students interacted with the GTA all semester, and could have had differing (or the similar) experiences with their GTA not observed. In addition, one research question specifically asked what characteristics student preferred in a GTA. The student surveys are able to provide data triangulation with the observations and interviews, while also providing direct responses to one research question.

When describing their GTA, students made the most comments regarding their GTA's helpful characteristics which impacted their knowledge, as seen in Table 1. Students responded to the question, "What characteristic(s) of your Teaching Assistant (GTA) helps you learn the most about the material?" Students determined the characteristics they preferred their GTA exhibited and included them in the "helpful"

section of the survey. Responses were coded as “knowledge” when the student provided responses such as: information about the procedure, connections to lecture material, or comments about teaching or how students learn, etc. Comments such as personal characteristic comments (nice, approachable), GTA being helpful and willing to help, etc. were coded as “affective domain.” Responses were coded as “communication skills” when the student provided responses such as: softness of voice, hard to understand, talking really fast, etc. As mentioned in the methods section, these codes were utilized from Herrington and Nahkleh.[13]

Students responded to the question, “What characteristic(s) of your Teaching Assistant (GTA) does NOT help you learn the most about the material?” Students determined the characteristics they did not preferred their GTA to exhibit. This data is included in the “unhelpful characteristics” section of Table 1. When describing their GTA, students made the most comments regarding their GTA’s unhelpful characteristics in the categories of “communication skills” and “knowledge.” These two characteristics received nearly the same number of comments. Affective domain comments were mentioned much less as unhelpful. Examples of unhelpful characteristics included:), “makes me feel dumb when asking a question” (affective domain), “tells us ‘I can’t tell you that’ during the procedural process” (knowledge), and “going slightly fast” (communication skill).

Table 4. Student Survey Code Totals from 2018 & 2019

Helpful Characteristics			Unhelpful Characteristics	
Knowledge	505		Communication Skills	197

Affective Domain	355		Knowledge	196
Communication Skills	54		Affective Domain	86

The students in the Fall 2019 semester were asked four additional questions to see if they noticed any change in their GTA's behavior over the course of the semester. The students were asked to identify changes to characteristics associated with specific topics were from TAIAs 1-4, which were completed in Fall 2019. Table 2 shows the percentages of students indicating no change, an increase, or a decrease in these behaviors of their GTA during the semester. Overall, the majority of students did not report noticing a change in their GTAs safety or lab technique behavior and/or teachings. Change in how the GTAs approached the analysis portion was larger than safety or lab techniques. The largest change in behavior observed by students regarding the GTAs interpersonal skill and behaviors, where 41% of students stated they observed a change.

Table 5. Students Observed Changes

	Change in Safety	Change in Interpersonal Skills and behaviors	Change in analysis	Change in Lab Techniques
No change	87%	54%	65%	83%
Increase	10%	41%	29%	13%
Decrease	3%	6%	5%	4%

While change was not observed by students in all category, (only one with 41% change), the change in one behavior could indicate that the TAIA experience positively impacted the participating GTAs regarding that skill.

Interpretation of the student survey data required coding student statements. This coding process was analyzed for reliability. Inter-rater reliability between the primary researcher and a third-year chemistry education graduate student (Coder 1) was 75.56% congruency. Coder 1 found the definitions for the “knowledge” and “affective domain” to be similar and had difficulty at times deciding which one was more appropriate. Through this process an improved definition of each code was developed. Suring a second reliability test similar disparity in coding between the primary researcher and a second-year chemistry education graduate student (Coder 2) was found while choosing between “communication skills” and “affective domain” difficult. The resulting agreement of coding between coder 2 and the primary researcher was 70.24%. Coder 2 expressed uncertainty regarding if how the information was taught would be a reflection on their communication skills or their personality.

Individual GTA Case Studies

GTA 3

GTA 3 was a female, second-year, US citizen, domestic biochemistry graduate student, with a limited, but potentially impactful prior teaching experience before attending graduate school. Her involvement in the study came during her fourth and fifth semesters of her GTA experience teaching undergraduate students. GTA 3 participated in every research study meeting but did not complete any TAIA conversations.

Safety

GTA 3 did not mention safety during any of her interviews however examples of how safety was important in her classes can be found. One of GTA 3's first semester students commented that GTA 3 was "serious about safety" and "makes sure rules about safety are being followed." Another student included that GTA 3 "kept order in the lab" which helped the student to "finish and understand" the experiment. Keeping order is an important factor to prevent accidents and keeping all individuals safe and is a positive characteristic for a GTA.

During the Fall 2018 semester, no specific comments were made regarding safety during the observations. During the first observation set of the spring 2019 semester, one comment was recorded about the inclusion of safety during GTA 3's kick-off. The comment only included that safety was mentioned during the kick-off. Another comment made by GTA 3 at the end of her kick-off was for students to keep computers and other personal technology off of the laboratory benches until all experimental parts were finished. GTA 3 often stopped the class to make announcements, with some including

safety comments such as turning off hot plates, other specifics about equipment, and clean-up. During the first set of observations, two separate announcements were made about students cleaning up: 1) where to dispose of waste and glassware, and 2) cleaning expectations at the students work benches.

During the second and third set of observations in the spring semester, safety was again mentioned during the kick-off and noted in the second section observations. In the second set of observations, the students were working with pH probes and GTA 3 provided a demonstration of how to work with them safely. Goggles were not mentioned during any observation until the last observation of the spring semester. During this observation, GTA 3 had to remind the entire class to have their goggles on at all times. Just five minutes later, GTA 3 made an announcement about students not chewing gum. The last observation included announcements about students saving any excess chemicals they had left over for the next section.

While GTA 3 did not complete TAIA 1 on safety, her prior semesters of teaching experience, experience as a student, or conversations with her laboratory coordinator could have led to her emphasis on safety in the laboratory. Although this seemed through observations to only grow more near the end of the year-long observations. As with all professional development, GTA 3's participation in TAIA 1 could have increased her awareness and exposed her to different scenarios enhancing her preparation her for future classes.

Interpersonal Skills and Behaviors

GTA 3 worked to keep the relationship between herself and students as professional as possible initially. She found importance in asking the students questions to get to know them more. In this way she indicated her interest in the student as a person rather than just as a student taking her laboratory class. GTA 3 stated she tried to keep the lab "somewhat fun" and tried to joke with students when it was appropriate. She also stated that as a student she did not like when "it seemed like a hassle to ask questions of the professor."

GTA 3 stated she continued to try and make the class environment "somewhat fun" throughout the first semester of the study. One additional issue mentioned by her was the need to be strict with the students in the beginning of the semester and "demand respect." But she also included that she would "keep it light and joke," and "try and get a personal feel in the lab."

At the end of the first semester, GTA 3 reflected that her kick-offs needed to be more interactive for the students so they were "for sure paying attention." Though, as seen in the analysis section, GTA 3 stated her kick-offs became less interactive and included more explanations. GTA 3 expressed knowledge of the need for her to have more interactive kick-offs that included all information, but did not enact this change during the second semester.

After the second semester of the study, GTA 3 stated she was "more casual than most" with her students and echoed similar thoughts from past interviews regarding having "side conversations" with her students. Again, these conversations revolved

around her getting to know her students and her students getting to know her. Through these approaches, GTA 3 stated she was able to build rapport and connect with her students.

When asked to describe an *effective* GTA, she stated that "students will enjoy lab more when you are more interested in them as a person" and present the information in a "more personable" way. She continued that it was important to answer student questions first instead of doing other tasks in the laboratory. When asked to evaluate herself in terms of the examples of an *effective* GTA she provided, she stated she had no change over the course of the two semesters.

After the spring 2019 semester, GTA 3 said she had a student tell her that they felt she "got annoyed with questions." GTA 3 said she was happy that they student felt comfortable providing constructive criticism to her yet did not seem to respond to the point made by the student. Since GTA 3 did not complete the TAIAs she was not exposed to a scenario which presented nearly this exact situation. She could have reflected on the scenario and potentially avoided this situation.

GTA 3 identified the importance of teaching the whole person, not just the chemistry laboratory student. Her approach to getting to know her students and working to relate the chemistry information to them in a way to help them connect ideas shows her teaching knowledge. This knowledge though was not a product of TAIA as she was not part of those conversations. Her prior experiences likely led her to these insights.

Positive student comments regarding interpersonal interactions with GTA 3 for Fall 2018 included, "clear explanations", "helpful and kind", "friendly before class", and

“doesn’t make you feel stupid.” Students found GTA 3 to be “charismatic and professional.” They also preferred how GTA 3 “tried to be as clear as possible” in her explanations and would re-explain if needed. Conversely, students also found it unhelpful when GTA 3 “doesn't always see your hand raised”, sometimes could “be too busy to help and will get frustrated”, and “sometimes gets angry at students.” The characteristics students found to be unhelpful could be detrimental in GTA 3’s quest to build rapport with her students.

Positive student comments regarding rapport for Spring 2019 included, “kind, patient”, “easy to talk to”, “always in a good mood when answering questions”, and GTA 3 was “approachable” while having a "positive attitude.” On the other hand, two student comments included GTA 3 getting “mad” if the students took too long on the experiment or tried to get students out quicker. One student said GTA 3 was “not tactful” and this “made it more intimidating to ask questions.” The positive comments regarding GTA 3 were consistent between semesters, but so were the unhelpful comments. However, the number of unhelpful comments received were limited, so many students found GTA 3 helpful in their learning.

Observations for GTA 3’s Fall 2018 class included many interactions with students including short “check-ins” of only a few seconds to ensure correct results were being recorded. The classes were on task and focused on completing the experiment in a timely manner. Fall classes did not include many specific observations or comments about interpersonal interactions between GTA 3 and the students. Student and GTA interaction frequency during the Spring 2019 semester was higher than in the fall 2018 semester in all class periods.

Generally, the majority of class time for GTA 3 was spent interacting with students, as seen in Table 6. (Totals for Table 3 will not equal 100% due to other occurrences during the laboratory not mentioned here.) The two fall observations included more interactions than monitoring time with less time for administrative details. Interactions are defined as any verbal conversations had between GTA 3 and the students. These interactions included one-on-one interactions between GTA and one student, or the GTA with the pair of students working together, or the GTA to a small group of students such as two groups at the end of a laboratory bench. During observation 2 in the fall semester, GTA 3 was signing student laboratory notebooks per the experimental procedure, thus the increased amount of interaction time as compared to all other observations. Observation 3 in the fall was more consistent with the remaining observations. A little surprising was that during the first pair of observations in the spring semester, more monitoring and less interaction time were observed. Usually, the first few weeks of the laboratory class require more interaction with the GTA as students become familiar with classroom expectations. Slowly though, more time was spent by GTA 3 on interactions with students as compared to just monitoring their behavior and actions.

Table 6: GTA 3's Task Percentages

Fall 2018	Interactions	Monitoring	Administrative
Observation 2	71%	19%	5%
Observation 3	49%	27%	7%
Spring 2019			
Observation 1			
Section 1	36%	46%	4%

Section 2	32%	49%	5%
Observation 2			
Section 1	35%	49%	2%
Section 2	47%	33%	5%
Observation 3			
Section 1	46%	31%	8%
Section 2	43%	29%	7%

For the spring 2019 semester, GTA 3 consistently showed similar behaviors between sections in her time spent with students, observing behaviors and actions, and completing administrative tasks. The only noticeable difference between sections was during the second pair of observations. With the change to more interactions in the second section, it could be interpreted that GTA 3 felt this group of students needed additional directions. The overall time each section was in lab was roughly the same with section 1 taking 135 minutes, and section 2 taking 128 minutes. Yet the number of interactions in section 2 included 13 more interactions as compared to section 1. The length of interactions was slightly less during section 2. This indicated GTA 3 having shorter interactions with the students. Likely, since GTA 3 had already taught one section, she could anticipate student questions and could quickly answer these questions.

Both GTA 3 and student-initiated interactions contributed to the total number of interactions, as seen in Table 7. As previously mentioned, during observation 2 of the fall semester, GTA 3 was checking student work throughout the experiment per the procedure. This resulted in a larger total number of interactions and larger number of

both GTA-initiated and student-initiated interactions. While many of these interactions only lasted a few seconds, the act of GTA 3 approaching the groups triggered many students to ask additional questions since she was available. Resultingly, some interactions lasted 3-4 minutes. While these numbers were higher than other observations and sections, the number of student-initiated interactions was not too different from the first observation of spring semester.

Table 7. Interactions with GTA 3

	GTA Initiated	Student Initiated	Length of individual interaction (s)
Fall 2018			
Observation 2	73	62	53.88
Observation 3	32	60	39.94
Spring 2019			
Observation 1			
Section 1	6	54	46.85
Section 2	15	45	37.56
Observation 2			
Section 1	26	36	42.53
Section 2	31	44	42.10
Observation 3			
Section 1	16	27	16.63
Section 2	6	30	38.78

As the spring semester continued, the number of student-initiated interactions steadily decreased for each section. GTA 3 initiated interactions was variable for observations 1 and 3 but stayed relatively consistent during observation 2 among sections. For section 1 of observation 1 and section 2 of observation 3, the value of 6 GTA-initiated interactions was surprising. During the class period, GTA 3 was talking with students often, but this number suggests the students were comfortable starting conversations.

The average length of the interactions during each observation was around 40 seconds. Observation 2 in the fall was the longest at about 54 seconds and section 1 of observation 3 in spring the shortest at about 17 seconds. GTA 3 had clusters of questions from students at one time, then short times of monitoring or administrative. Generally, when one student or pair of students would ask a question, nearby students would be triggered to then ask their questions. This could be an opportunity for GTA 3 to explain similar concepts to a small group of students if they were all to have similar questions.

One specific interaction comment was made during the first observation set of the spring semester: "I'm trying to bring you to the answer without giving you the answer." A similar comment was made during the second observation: GTA 3 “Leads the students through the thought.” These statements speak to how GTA 3 worked to guide the students to learn the information. These are similar to the comments made by students made regarding how GTA 3 helped them answer questions as will be seen in the Analysis section.

Since GTA 3 did not complete TAIA 2, she did not participate in the conversations that were had regarding interpersonal interactions. While many of her students had a positive response to her teaching, some student comments discussed nonverbal cues she might have been giving her students that were unhelpful and unintentional on GTA 3's part. While there was not a scenario about the GTA becoming frustrated or seemingly angry at the students, discussing different scenarios related to interactions could have helped GTA 3 become more self-aware of her actions, facial expressions, and how she answers questions. Because she did not participate in the TAIA discussion of interpersonal skills, she was not able to reflect on this issue and the result was GTA 3 maintained a relative status quo regarding interpersonal skills.

Analysis

After the first semester, GTA 3 stated that students were asking questions, primarily about the content. She also stated the students asked questions on theory or were algebra-based how-to questions. After the second semester, GTA 3 stated she changed her kick-offs so they focused more on analysis and "what does it mean" questions. She found the kick-offs were less interactive and more explanatory. Though, she stated, she found she had fewer confused students and the "prep time aided in execution" of the experiment by the students.

GTA 3 also stated her students were more data analysis oriented but attributed this to the class itself, not necessarily her teaching. While answering student questions, GTA 3 said she "noticed a lot of disconnect when answering application questions." She said she focused more on the data with the student and less about the theory. She

continued that she felt the laboratories should focus on “how to interpret the data collected.”

Students in the Fall 2018 semester commented that GTA 3’s helpful characteristics included the “way she explains things helps us better understand things.” Also, she was “very great at helping us walk through the lab” and the “extra information she gives so the students have a better understanding” was helpful. Connecting GTA 3’s interpersonal skills to the analysis, one student said GTA 3 was helpful by, “being understanding…when I don’t understand something and being able to explain it in another way.” In addition, the “way [GTA 3] connects material in class to the lab and helps walk us through an explanation when we have a question.” Conversely, one student found it unhelpful when GTA 3 was “not being able to tell us why something happened.”

Students in the Spring 2019 semester echoed many statements made by Fall 2018 students. Comments included, “very good at answering questions and making sure we understood the answer,” “explains questions well and helps out a lot,” and “explains the chemistry behind the experiment.” One student stated that GTA 3 also “provided equations/goes over the worksheet in the kick-off” to help students know what data they are looking for during lab. Some students commented on how she answered questions with statements: “isn't lazy and tells us to figure it out,” and “won't just give the answer but helps us work for it.” At the beginning of the class, students stated that GTA 3 “starts to explain what we are doing and what we should see” and this helped them to “think critically and individually with guidance when needed.”

Since GTA 3 did not complete TAIA 3, she did not participate in the conversations that were had regarding data analysis. Nevertheless, students shared positive comments about how GTA 3 helped them in learning more about the material and experiment. When GTA 3 provided additional examples and ways of explaining material for the students, this demonstrated GTA 3's understanding of how students learn and awareness about what might work best for each student. Being flexible in her approach to her explanations greatly helped GTA 3 connect to her students and assist them in answering the analysis and application questions.

As shown above in Tables 6 and 7, interactions played a large role in the classroom. One large component of the number and frequency of interactions involved discussions about how to analyze the data collected. Generally, over half of the interactions between GTA 3 and the students included questions regarding the analysis portion of the experiment. While GTA 3 did not complete TAIA 3, the number and frequency of interactions could indicate GTA 3's understanding of the importance of interaction during critical moments. When students are trying to pull together ideas from lecture and the laboratory, having a guide to help correctly piece together the information is crucial. GTA 3 demonstrated that she could positively impact her students in terms of helping students through analysis. The number of questions also shows the importance of preparing the GTA to respond to this issue.

As GTA 3 mentioned in one of her interview questions, she noticed "a disconnect [for students] when answering application questions" and altered her kick-offs to include more analysis discussion. While this was not a specific scenario mentioned during TAIA 3, GTA 3 raises an important discussion point that should be included: flexibility. GTA 3

recognized that her students were struggling during the analysis portion and changed her teaching in an attempt to help her students more clearly understand the material. Since GTA 3 did not complete TAIA 3, we know she must have learned to do this from another source such as, watching previous instructors, discussions with fellow GTAs, or another resource.

Lab Techniques

GTA 3 stated that one change in her approach from introductory chemistry to general chemistry laboratory was a need to focus more on the procedure and laboratory techniques. She said her general chemistry class required more explanation during the kick-off due to apparatus and procedures being more complex compared to her introductory chemistry classes. After the second semester, she stated, "I feel that labs should be about techniques…" thus, adjusted her kick-off to reflect this desire.

When asked about teaching tips or strategies she had learned as a student, GTA 3 reflected on classes that were "demonstration heavy." She stated she found these classes to be "helpful to know what you are doing." GTA 3 recognized the importance of these demonstrations without completing the TAIAs.

As stated above, one student from the fall semester found GTA 3 "very great at helping us walk through the lab." This statement could be interpreted to refer to both analysis and laboratory techniques. GTA 3 ensured students were correctly completing necessary steps if stuck and staying on task allowing them to progress appropriately through the experiment. These were the general take-away ideas targeted to GTAs with

TAIA 4. Even though GTA 3 did not complete TAIA 4, she still recognized the importance of students learning the appropriate laboratory techniques.

Students in the spring semester commented that GTA 3 "gives clear and detailed overview of how to proceed with each step." Students found it helpful with GTA 3 was "forthcoming with information that is important to the lab during kick-off" and "goes through problem spots in the procedure." While students did not often mention laboratory techniques specifically in their comments, the above comments could be inferred to include GTA 3 teaching them techniques. Students did comment that they found it unhelpful when GTA 3 would try and rush them to complete the experiment. This idea mentioned by the students was important and often overlooked by GTAs. Since GTAs have additional responsibilities outside of their laboratory teaching, they may find themselves pushing students to finish the experiment so they can move onto their next task. Rushing the students could induce anxiety and limits the time the students feel they have to think through questions and make connections. This would be a great discussion point to include in future TAIAs. Though GTA 3 did not complete TAIA 4, she recognized the importance of providing students direction where trouble could occur regarding the experiment, but could have benefited from a reminder regarding pacing of the class for students.

Again, as shown above in Tables 6 and 7, interactions played a large role in the classroom. One large component of the number and frequency of interactions involved discussions about how to complete all parts of the experimental procedure. GTA 3 was available to answer student questions pertaining to equipment usage and correct laboratory techniques. She also would play the role of "troubleshooter" when unexpected

results occurred or when students did not have all the supplies the need (primarily glassware) to complete the lab. With one of the scenarios in TAIA 4 being about ensuring students are using appropriate glassware, GTA 3 was in line with correcting and fulfilling the needs of her students.

Group Process

GTA 3 stated she liked when her instructors created an interactive class. One example she provided was when the students participated in "Think-Pair-Share" when posed with new content. This activity could be great for students to complete as it removes some pressure of sharing ideas. The idea was then of the group's creation instead of from one single person. GTA 3 connected this engagement method from her time as a student to her time as an instructor without prompting from TAIA 5.

Students did not make any comments regarding GTA 3 and group process. One student did comment that GTA 3 "comes around [the classroom] a lot so we can ask questions and checks in to make sure the lab is going okay." While this does not directly relate to group process, it does speak to GTA 3 moving from group to group assisting whenever possible.

One suggestion made during the fall semester observations was for GTA 3 to have both partners explain a concept to her or have them alternate explanations or hypothesis. As with many groups, one student usually asked and answered questions while the other partner listened. If both partners are drawn into the conversation, both have an opportunity to ask and answer questions to increase their knowledge. A similar

scenario was practiced during TAIA 5. If GTA 3 had been exposed to this example, perhaps future interactions with groups of students would not happen in this way.

During the last set of observations in the spring semester, one comment was made about student group size. It was noted that during this class, many groups of three students occurred. As most of the experiments are planned and organized for completion by a pair of students, this usually resulted in one student participating less than the other two. Generally, one student was not involved with the happenings of the experiment or analysis. As mentioned in the previous paragraph, if GTA 3 had completed TAIA 5, she could have participated in conversation discussing how to include all students in the experiment and conversation about the experiment. Ideally, students could be in pairs instead of group of three but regardless, all students should be involved with the experiment and conversations about the experiment.

Working with Students of Different Abilities

Data from which no information was taken:

- GTA 3's Initial and Final Interviews
- Student surveys
- Observation data and comments

Assessment

Before assessment was discussed in the GTA study sessions, GTA 3 stated in her interview after the first semester was completed that she did not like when professors would ask students "questions that we didn't know the answer to." She found this class set-up to be "annoying" and continued, "ask questions that you know your students can

reasonably answer." Questions should be at an appropriate level for students to determine their personal construction of knowledge. It is also important to ask questions student could reasonable answer. While some questions should stretch students' knowledge by encouraging critical thinking, the answer should be attainable for students to determine. This will be an important discussion point to include in TAIA 7 in the future.

One student in each of the fall and spring semester stated that GTA 3 "set clear expectations" for the class. This aided not only the student to know what to do and how to behave but also GTA now had a baseline for what the outcomes she expected from her students. Setting expectations can simplify the instructor's assessment process as the students then know what they need to complete, learn, and do within the classroom. If expectations are clearly established, student can take responsibility for their learning and self-evaluate their progress. Again, this would be another great addition to TAIA 7.

As mentioned, the number of interactions as shown in Tables 6 and 7 could also represent assessment of the students by GTA 3. When GTA 3 initiated questions, she was assessing their knowledge on that question's content. She could have been observing their progress on the experiment and their interactions with each other with respect to how the students work together in a group. Not only could the instructor be assessing the students on content- and experiment-related knowledge (which GTA 3 was), but also assessing and facilitating interactions between students (relating back to TAIA 5; Group Process). Not much evidence is available to show this, but she could have recognized the value in these interactions if she was exposed to the TAIAs.

Higher-Order Thinking Skills

GTA 3 found that as a student she liked when one instructor took pieces of literature and helped students to apply it to their knowledge. The scaffolding process by which this instructor assisted students to increase their knowledge of the subject through connections to what the students were already learning. This process could induce higher-order thinking skills by the students and GTA 3 recognized this process. GTA 3 stated she provided students with “real-life examples” during her explanations and stated the students found this “beneficial.”

Students stated that GTA 3 provided “extra information she gives so the students have a better understanding” and the “way TA connects material in class to the lab and helps walk us through an explanation when we have a question” were two helpful characteristics. Providing students with additional information is a great method to encourage higher-order thinking in students. If the information is added to what the students already know, the students could take that information and apply it to similar situations. This is a great way to induce higher-order thinking skills in students and would be a great application of TAIA 8.

The same comment shared earlier during the first observation set of the spring semester: "I'm trying to bring you to the answer without giving you the answer" could also apply to higher-order thinking skills. Although we do not know the details of this specific interaction other than this statement, GTA 3 could have worked to expand the students’ knowledge through higher-order thinking skills. By sufficient and appropriate questioning, GTA 3 could lead the students to discovering the answer to their question on

their own. The students could then use this modeled behavior in the future to help them work through their questions. In a way, the students become autonomous in their learning by working through and teaching themselves new topics. While Scenario 4 in TAIA 8 discusses students getting to teach one another, a great way to learn the material, students teaching themselves is impactful as well. GTA 3 was assisting the students to come to their own conclusions, an example of students developing higher-order thinking skills.

Summary

Overall, although GTA 3 did not complete any TAIA, she demonstrated teaching strategies that were conducive to student learning. She successfully kept order in her classroom to keep students and herself safe while still maintaining positive rapport with her students. Through her time and experience teaching throughout the semester, her emphasis on safety in the laboratory grew. Had she participated in TAIA 1 this growth may have occurred earlier in the semester.

Regarding interpersonal skills and behaviors, she stated during her mid-year interview that she recognized the need to increase engagement in her kick-offs, but did not enact this change during the second semester. She also stated that that she felt she maintained her status as an effective GTA when describing the process of presenting the information in a "personable" way for the students and answering student questions. One student pointed out that he/she felt GTA 3 "got annoyed with questions." Had she participated in the TAIAs, perhaps this exposure may have allowed GTA 3 to reflect on the verbal and nonverbal cues she provided to her students. She worked to provide positive connections of the chemistry information toward her students' interests through

getting to know them. Her past teaching experience likely lead her to this practice. Since GTA 3 did not participate in the TAIA 2 discussion, she did not have an opportunity to reflect on her interpersonal skills and therefore was not able to reflect on these skills. The result was GTA 3 maintained a relative status quo regarding interpersonal skills.

Positive comments regarding how GTA 3 helped them learn more about the materials and experiment procedures during the laboratory. When she provided additional examples and ways of explaining material for the students, she demonstrated her understanding of how students learn and awareness about what might work best for each student. Her flexibility in her approach for each student greatly aided her efforts to teach the analysis and application questions and allowed her to connect to her students. The number and frequency of the interactions GTA 3 had with her students could indicate her understanding of the importance of interaction during critical moments. Overall, GTA 3 demonstrated that she could positively impact her students in terms of helping them through analysis. GTA 3's teaching techniques revolved around flexibility. She recognized when her students were struggling and adjusted as needed. This could have been a great discussion point for other GTAs had GTA 3 participated in the TAIA discussions.

GTA 3 recognized the importance of including demonstrations for her students without completing TAIA 4. GTA 3 was ready to help her students find the appropriate glassware and ensure they used it correctly during the experiments. She provided students with direction of where trouble could occur in the experiment based on experiences in other sections of the laboratory. However, while attempting to provide assistance to ensure students could finish in an appropriate amount of time, some students interpreted

the actions as GTA 3 rushing them to finish. She could have benefitted from a reminder regarding her approach to interpersonal interaction and the pacing of the class for students.

The teaching method of "Think-Pair-Share" was one GTA 3 connected from her time as a student to her time as an instructor without prompting from TAIA 5, where it was mentioned as an engagement strategy. She was observed moving around the classroom from group to group assisting whenever possible. An observer comment suggested GTA 3 could have alternated or had both students in a group answer her questions, as generally only one responded. A similar scenario was included in TAIA 5, which she did not complete. Therefore, TAIA 5 may have benefited GTA 3 in perfecting her Think-Pair-Share method.

GTA 3 made a point regarding assessment: questions asked from the instructor should stretch the student's knowledge, but answers must be attainable for students to determine. This was one point that will be added to TAIA 7 discussion in the future. Students appreciated that GTA 3 set expectations and communicated those expectations to the class. The students could then take responsibility for their learning and self-evaluate their progress. Again, this will be mentioned in future TAIAs. GTA 3 would have provided excellent learning opportunities for all GTAs if she had been involved in the professional development activities.

Providing extra information to students was something GTA 3 consistently included in her explanations. This was an excellent way for her to induce higher-order thinking skills in her students and a potential application of TAIA 8. Again, her

participation in the TAIA would have provided others with an excellent learning opportunity. She also worked with her students to help them become more autonomous in their learning by modeling questioning strategies with the assistance she provided.

Overall, GTA 3 could have been impacted by her participation in TAIA discussions in the following ways:

- Earlier growth through inclusion of safety, through TAIA 1;
- Exposure on the verbal and nonverbal cues she was providing to her students, through TAIA 2;
- Reminder of appropriate pacing for students, through TAIA 4.

GTA 3's participation in TAIA discussions would have also been an important opportunity for other GTAs because she had used these types of extension of TAIA applications in her labs:

- Adapting to the needs of her student by being flexible in her teaching approach;
- Providing direction to students of where trouble could occur regarding the experiment;
- Ensuring questions that are asked of students are at an appropriate level and ones students could reasonably answer;
- Establishing clear expectations so students can take responsibility for their learning and self-evaluate their progress.

GTA 4

GTA 4 was a female, second-year, US citizen biochemistry graduate student, who previously had taught one and a half years of high school science. The study occurred during GTA 4's third and fourth semesters of teaching undergraduate students at SDSU. GTA 4 participated in every research study meeting but did not complete any TAIA.

Safety

Only one student from either semester made a comment about safety. The student was in Fall 2018 and commented they found it helpful when GTA 4 went "over what we need to know before we start." While this student does not directly mention safety, this comment could indicate safety as this was one of many things mentioned during GTA 4's kick-off. While safety was not mentioned specifically in the observation data available, the student could be referring to a class period other than the ones which were observed.

Since GTA 4 did not participate in the TAIA discussions, she did not have the opportunity to discuss these topics. Perhaps if she had completed TAIA 1, she could have emphasized safety more in her kick-offs and conversations with students.

Data from which no information was taken:

- GTA 4's Initial and Final Interviews
- Observation data and comments

Interpersonal Skills and Behaviors

In GTA 4's initial interview, she stated that while her class was engaged with the experiment and material, there tended to be "more questioning from the instructor." This comment could be describing a more "instructor-centered" classroom. While this is not necessarily unhelpful for students, it could result in students only thinking about topics when asked a question, instead of thinking about the content in a way where they produce their own questions. Ideally, the classroom is "student-centered" where students direct their own learning with the instructor facilitating the classroom and ensuring students are covering all topics. The comment indicates GTA 4 recognized that the lab did not encourage this behavior from the students. While this exact scenario is not discussed in TAIA 2, it is a conversation that is important to include in GTA training discussions. As mentioned in the literature review, there is a shift in education to move from the lecture, instructor-centered environment to a more student-centered format. This conversation could be most beneficial to international GTAs, in particular, who are typically taught in an instructor-centered environment.

After the first semester of the study, GTA 4 stated one *ineffective* GTA quality was to be when "a student comes to you and asks a question and the response is 'go look in your book,'" and when the GTA "stays in the front" of the room and does not circulate to answer student questions. Again, the situations described by GTA 4 were not specifically included as scenarios in TAIA 2, but were topics discussed during the conversations that followed these activities. These two behaviors demonstrate to students the amount of engagement the GTA is willing to put forth for the class and the students tend to match this engagement. If emphasis can be made to the GTAs that their attitude,

movement (or lack thereof), and responses to students, matter and set the tone for how much effort the students will be willing to apply to the day's work, greater relationships between the GTA and students could be built. These relationships can lead to more learning, better retention of those students, and overall more enjoyment for all involved. All of these may possibly have come from interactions between the GTA and students. This showcases the importance of GTAs being engaged with their students and responding to students in a positive manner.

Students reacted positively to GTA 4 based on comments such as GTA 4 "is… attentive and easy to talk to" and she "wants us to succeed." One downside of being willing to help everyone though, was that some students found they had to wait for GTA 4's attention much of the time. Comments such as "very busy helping students and cannot always come help" and "devotes a lot of time to some people in the lab—frustrating." These comments suggest some students did not feel 'seen' by GTA 4. One student commented, "tone of voice sometimes makes TA sound mad." A student interpreting this behavior could result in the student asking fewer question in the future and having a lower rapport with GTA 4.

The second semester showed additional positive comments from students about GTA 4: "very approachable and helpful", "energetic about content", and "very happy to be here." There were no specific comments from students about interactions regarding unhelpful characteristics about GTA 4. The only potential comments included her sometimes using technology (computer, phone) as a precedence over the classroom at times, thus students could not get her attention. Although GTA 4 did not complete TAIA 2, based on student comments, students responded positively to her interactions. Though,

it is important to note that student did feel GTA 4 became impatient, perhaps due to the frequency of their questions. This is a characteristic GTA 4 should work to avoid and could have been made more aware of through the TAIA discussion, had she participated.

GTA 4's tasks during each observation are shown in Table 8. (Totals for Table 8 will not equal 100% due to other occurrences during the laboratory not mentioned.) GTA 4 has mixed numbers of interactions, monitoring time, and administrative time. Observation 3 in Fall 2018 and the second pair of observations in Spring 2019 show more monitoring time as compared to interactions than the other observation sets of Spring 2019. The slight increase in administrative time for the second set of observations in the spring was due to a number of glassware breakages, which GTA 4 had to clean up, after which she reorganized many supply drawers. The first observation set for spring included a substantial amount of interaction time between GTA 4 and the students. As mentioned, the first set of observations was usually in the first two weeks of the semester, so students often asked more questions about the laboratory than later in the semester.

Table 8: GTA 4's Task Percentages

Fall 2018	Interactions	Monitoring	Administrative
Observation 3	37%	44%	9%
Spring 2019			
Observation 1			
Section 1	54%	27%	7%
Section 2	47%	31%	11%
Observation 2			

Section 1	22%	41%	28%
Section 2	34%	37%	15%
Observation 3			
Section 1	34%	34%	3%
Section 2	30%	31%	27%

The type of interactions GTA 4 had with students varied from section to section, as shown in Table 9. By the end of the fall semester, her interactions were more student-initiated. The average interaction time was right at 40 seconds, which maintained in length until the last section of spring. Interestingly, only two observations included more GTA-initiated interactions, section 1 of the second and third pairs of observation in Spring 2019. These observations are consistent with a comment made by GTA 4 in her interview where she stated that her class included "more questioning from the instructor." The addition of the observation data below indicates there is likely chance GTA 4's classroom behavior did change, but not necessarily in the direction that created a more student-centered environment.

Table 9. Interactions with GTA 4.

	GTA Initiated	Student Initiated	Length of individual interaction (s)
Fall 2018			
Observation 3	29	52	39.94
Spring 2019			

Observation 1			
Section 1	54	66	43.40
Section 2	52	74	36.68
Observation 2			
Section 1	25	16	40.68
Section 2	18	37	47.56
Observation 3			
Section 1	40	34	46.11
Section 2	10	19	78.30

All other observations indicated students of GTA 4 initiated the conversations. An interesting comment during the second pair of observations included, “uses white board to explain something to a group.” GTA 4 took the interaction with students one step further by showing the information on the whiteboard. Although this specific example was not included in TAIA 2, it is a good example of how GTA 4 answered one group’s question.

Analysis

GTA 4 stated after the second semester that she learned to know which parts of the experiment and analysis the students would struggle with and decided to “wait to explain at the struggle times instead of all at once at the beginning.” This exact scenario was one described in TAIA 3 but was not discussed by GTA 4 since she was not exposed to any TAIAs. Hearing other GTAs viewpoints could have helped GTA 4 decide whether her idea to change her approach was an appropriate decision.

Students stated they liked how GTA 4 explained the material because it “makes the information easier to digest” and “allows me to figure out what I need to do faster.” Another student stated that GTA 4 “guides students to an answer without saying what the answer is” thus, encouraging the students to construct their thought without just being told the answer by the instructor. This is an analysis strategy but also promotes higher-order thinking skills, which will be described later.

One student stated GTA 4 “has things written on the board as soon as we get to class, this helps a lot.” They added, GTA 4 “doesn't tell us, she makes us answer and learn from our mistakes. Helps us learn new information from stuff on the board and intro [kick-off].” Another student added that GTA 4 “overviews the entire lab and makes sure we know what we are doing before we start” and this helps the students “understand where we are going in the lab so it’s a clearer vision than just reading.” These comments are positive statements from students and describe the beginning of class in a way that should be happening. GTA 4 was prepared for class with the whiteboard and kick-off ready for students, and left the information on the whiteboard to be available for students to use throughout the class period. While GTAs were encouraged use this action by experienced GTAs during the initial GTA training (this training occurs as part of the orientation program for new graduate students in our department), using the whiteboard in this way was also mentioned during various TAIA discussions including TAIA 3. GTA 4 was already completing these actions without additional instruction from the TAIAs.

During the first observation of the Spring 2019 semester, the observer commented that GTA 4 stopped the class shortly after dismissing them to complete the experiment and re-explained an analysis problem to all students. There were two GTA-student

interactions between when GTA 4 released the students and then stopped them again. While it was great that GTA 4 re-explained the concept, immediately stopping the students after they have begun halts their progress and does not always promote a good start for the students. While the specific details are not known about the topic discussed, depending on when the information would become important to the students, it could have been more useful later during the class. If more students had questions on the topic, then perhaps a whole class announcement would be useful. GTA 4 made a decision at that moment to stop class and share the information, creating a more instructor-centered environment; she decided what was important for the students to know at that time rather than deciding to allow students to ask their own questions. As mentioned at the beginning of this section, the exact scenario of when to share certain information was discussed in TAIA 3, but GTA 4 was not witness to this discussion.

About halfway through the first observation of the Spring 2019 semester, GTA 4 made an announcement about ensuring students utilized a particular analysis program associated with the equipment used in the laboratory. Within the 15 minutes following this announcement, GTA 4 received 10 student-initiated questions and participated in four additional discussions with students. While we do not know the specific topics discussed in the interactions, it could be interpreted that additional interactions resulted from this announcement. If GTA 4 ended up having a number of interactions resulting from the announcement, then perhaps she could have discussed the information from the announcement with the students in small groups instead of having the entire class stop and listen.

During the second observation of the Spring 2019 semester, GTA 4 included additional information in her kick-off as compared to the first observation. She wrote formulas and diagrams for the students to reference during the kick-off and throughout the experiment. This information was important for the students to know for the experiment, but also showed GTA 4's willingness to adapt and change her approach from class to class, when necessary. GTA 4 reflected on the challenges her first section faced and worked to help her second section avoid those difficulties. This was a topic that was discussed during the TAIA sessions, but not specifically pinpointed during TAIA 3.

Midway through the first section of the second set of observations for the Spring 2019 semester, GTA 4 attempted to explain an analytical problem to the class but "multiple groups were confused on a topic, so she went over it on the board in order to clarify." GTA 4 persisted through the explanation of the idea in order to help her students understand the topic. She adjusted her mode of delivery and taught to a smaller audience in hopes of helping her students. This adjustment was a topic that was discussed during the TAIA sessions, but not specifically pinpointed during TAIA 3.

Lab Techniques

After the second semester, GTA 4 stated that during her kick-offs she worked to get the students engaged with the materials. One method involved GTA providing demonstrations for students of how to set up equipment and utilize classroom technology (Vernier LabQuests). As the instructor, it was important to know troubleshooting procedures for these devices and to become familiar with the buttons and programs. TAIA 4 included a specific example of a GTA assisting students with classroom

technology and LabQuests. Although GTA 4 did not complete the TAIA session, the mention of this TAIA scenario indicates the relevance and pertinence of including the classroom technology within the activity. Continuing, even though GTA 4 did not complete the TAIA sessions, she recognized the need to introduce and demonstrate proper use of the technology, which was likely unfamiliar to students.

GTA 4 additionally stated that after teaching general chemistry laboratory for a second semester, she found she taught more laboratory techniques to the students. Three of the four scenarios in TAIA 4 include methods of teaching laboratory techniques to students. GTA 4, without completing the activity, recognized the need to demonstrate to students the techniques and proper procedures. Not all general chemistry students have experience with "wet-lab" chemistry equipment and were expecting to learn about new equipment when they took the class. GTA 4 appropriately taught the students about this new and unfamiliar equipment and how to properly use it.

One student commented that GTA 4 would "go over what we need to know before we start and what past labs have messed up." Another student stated that GTA 4 "provides disclaimers about where we could go wrong." This helped them because her "ability to explain things helps us learn and know what works most efficiently" and "disclaimers keep us aware of what could go wrong." Again, as mentioned in the *Analysis* section, GTA 4 recognized the need for adjustment from section to section and worked to help her students anticipate issues within the experiment. While one could argue it was important for all students to be faced with challenges so they could learn how to overcome them, some challenges could invoke too much stress on the students

and prevent some of the intended learning. GTA 4's approach was well received from students and met their expectations of what they needed from her as an instructor.

During the second observation of the Spring 2019 semester, a comment mentioned that GTA 4 stopped class and demonstrated how to use a pipette to students. Students were about 15 minutes into the "wet-lab" portion, after the kick-off was completed. This exact scenario was explored and discussed in TAIA 4. While GTA 4 did not complete TAIA 4, she did instruct students on the appropriate technique for using the glassware. Using glassware properly has been a topic that needs repeated attention throughout all laboratory classes regardless of the academic level. The students needed to use this piece of glassware fairly early on in the experiment and a demonstration of proper use could have been best conducted during GTA 4's kick-off. Nevertheless, she did perform the demonstration for the students to ensure the proper technique was being practiced.

At the beginning of the second set of observations for Spring of 2019, a comment stated that GTA 4 announced to the students "about what beakers to use." This was a common error made by students and could lead to incorrect values or an increase in wasted reagent. TAIA 4 included a similar scenario describing students using inappropriate glassware and possible talking points the GTA could use with students. Although GTA 4 did not complete this activity, she perhaps noticed students not using the right glassware and worked to prevent similar errors from other students.

Group Process

In GTA 4's initial interview before the fall semester, she stated that she used "share-pairing" to try to develop a quick response from the students. This method was congruent with the "Think-Pair-Share" strategy described by GTA 3. As mentioned, this was a strategy used by instructors to promote cooperative engagement with students and could take the pressure off students not comfortable in responding individually. When students could discuss ideas with others, they felt more comfortable sharing their ideas to a small group first before sharing with the entire class. This method could be useful in "breaking the ice" between students and promoting students to share ideas to one another. Again, this described scenario was not used in TAIA 5, but could be an available method for instructors to encourage collaboration between students.

After the first semester, GTA 4 stated that she started to "encourage [the students] to talk with other students" and that she together with the students "created a culture where students asked one another." She stated that at times, group benches had discussions amongst themselves. In this process, the students were looking to each other before approaching GTA 4. She continued that she found at times the students were asking her too many questions. She stated she encouraged "the students who have already had the idea explained [to them], explain it to other students." She said she would wait to ensure the explanations were accurate, then walk away when satisfied.

GTA 4 encouraged student groups to work independently and then work together to solve problems. This allowed her to complete other tasks as needed and help other students if they were unable to assist one another. Many times, similar questions are were asked of the GTA by multiple groups. Encouraging students to ask one another before asking the instructor could helped reduce repetitious interactions. This also promoted

greater student learning because the group being asked the question would have to talk through the idea and "teach" the other group. Still, caution and supervision should be utilized to ensure all students are receiving appropriate and correct instruction from the GTA and each other. This scenario was not one used in TAIA 5, but could be added as an excellent example of promoting higher-order thinking skills by student-led discussions.

One characteristic GTA 4 observed her prior instructors doing that she did not like was when there was limited talking amongst students during class. She found that "students who could answer quickly were rewarded" but that did not show that everyone in the class knew the content. The situation GTA 4 described is common in classrooms where students do not feel comfortable asking for clarification, or times when they do not want to be engaged with the material and just want the answer. Again, providing opportunities for students to talk amongst each other and learn from each other can be beneficial for all students. It could be helpful to "poll" students before accepting the correct answer as it could encourage students to continue thinking about the question instead of just accepting the first answer. This specific topic was not covered in any scenario in the TAIAs and GTA 4 was not witness to it during interactions which were captured during this study.

The last observation of the Fall 2018 semester included a comment from the observer that GTA 4 "explains concept to one student and then asks her to explain to her partner." This comment is in line with GTA 4's interview comment about how students worked together and asked each other questions. This can be a great teaching tool for both the explainer and the receiver. As mentioned, GTA 4 did not complete TAIA 5, but this is a method that could be utilized by instructors.

During the last observation of the semester, a comment was made by the observer that GTA 4 “encourages students to work together and help each other.” The inclusion of this comment aligns with GTA 4’s interview statements regarding her desire to have students collaborating and working together whenever possible. Having both data sources, the interview response and observation comment, confirms and indicates the presence of this action. Again, even though GTA 4 did not complete any TAIA she recognized and enacted a method to encourage class involvement and group discussions.

Data from which no information was taken:

- Student surveys

Working with Students of Different Ability

As mentioned above, one student stated that GTA 4 “guides students to an answer without saying what the answer is.” This teaching strategy assisted students of all abilities in their quest to learn the material. GTA 4’s assistance helped students who were struggling to understand where a question was leading them and could instill confidence in the student when he/she comes to the answer on their own without being explicitly told. While this was the ideal situation instructors should hope to achieve from all interactions, there are times where a quick answer will help students continue with what they are doing. One key to this approach was knowing the student to determine what and how many hints or guiding statements/questions the student needed to continue learning. This discussion occurred during many of the TAIA sessions as GTAs will face this situation during any topic or point in the experiment.

One student also mentioned that GTA 4 included information on the board for kick-off and during the experiment. This process helped students organize the information needed for the experiment while it also provided a larger print of this information. One scenario included in TAIA 6 referred to low vision students and approaches instructors could take to assist these students. While GTA 4 did not participate in the completion of TAIA 6, she could have gained in this area as a result of research session conversations, student requests, coordinator meetings, or past teaching experience.

Another student stated that "kickoff gives an idea said out loud; puts everyone on the same page; keeps formulas and important directions out to see." Much like explained above regarding the visual information, GTA 4 orally describing the experiment information was beneficial for all students. Reading then hearing the information assisted students in visualizing apparatus set-ups, connecting concepts, and determining big picture ideas. This specific scenario was not described in TAIA 6 but was an important discussion point GTA 4 might not realize she was already enacting.

Since GTA 4 did not participate in the TAIA discussions, she did not have the opportunity to discuss these topics. Perhaps if she had completed TAIA 6, she could have been more aware of these ideas.

Data from which no information was taken:

- GTA 4's Initial and Final Interviews
- Observation data and comments

Assessment

As mentioned above, one student said GTA 4 “helps you to think about the questions and doesn't just give you the answer.” This student found this helpful because “I learn the material more fully since I am in charge of my own learning.” And, after the first semester of the study, GTA 4 stated her teaching style changed to include “more time on the floor with individual conversations.” This method of interaction involved assessment of the students by GTA 4. When GTA 4 was asking questions of the students, she was using formative assessments to determine what they knew at that moment. The topic of formative assessments was discussed in TAIA 7 and in GTA discussion sessions. While GTA 4 did not complete TAIA 7, her prior teaching experience, initial GTA training, and/or other resources could have led to her implementation of formative assessments.

During the first observation of the Spring 2019 semester, the observer commented that GTA 4 asked a group of students if they knew the purpose of the laboratory experiment. The observer commented a suggestion of GTA 4 prompting the students to answer with additional questions instead of providing the students with an immediate answer. While this was not a scenario discussed in TAIA 7, the process of “questioning the questioner” was mentioned during TAIA discussion sessions as a suggestion to GTAs. This method promoted students to examine different avenues of answering their question on their own and is a common method used by seasoned instructors.

Toward the end of the first section of the last set of observations during the Spring 2019 semester, the observer commented that GTA 4 “asked kids to raise their hand based

on what trial they are on." This method of polling was a form of assessment and provided GTA 4 with information about how far along her students were in the experiment and only took a moment of her student's time. She could use this information to know which pairs might be falling behind and needed assistance, and which groups were on track to finish appropriately.

Higher-Order Thinking Skills

GTA 4 mentioned higher-order thinking skills herself when asked about what tips or strategies she picked up from her own instructors. This conversation occurred well before any discussion was held during the research group meetings on this topic. GTA 4 recognized the need for including higher-order thinking skills without the need of the TAIA.

When asked about the qualities that represented an *effective* GTA, GTA 4 included, "highlighting or underlining specific information." This was a method of scaffolding instructors utilized to assist students and promoted higher-order thinking skills. By building concepts, student could understand at a deeper level. GTA 4 did felt she possessed this skill and was ready "to pull out all the tricks to help students." Although GTA 4 did not complete any TAIAs, she could have learned this method from her prior teaching.

GTA 4 stated after the second semester of the study that she tried to send students emails each week to ask focus questions. When describing these questions, she referenced Bloom's taxonomy as tool used to help students think deeper about the content. Again, this was a form of scaffolding by GTA 4 helping her student to focus on

key ideas they would explore in the next experiment. The addition of these emails was more than usually asked of a GTA and exhibited her desire for her students to not only complete the class but also learn as much as possible. This was not an action recommended in the TAIAs, but could be mentioned in the future, particularly for struggling students.

One student stated that GTA 4 "guides students to an answer without saying what the answer is." Also, one student shared that GTA 4 "always has an analogy to help you better understand." The student said the analogies helped "students understand the material much clearer." All of the mentioned strategies helped students to expand their current knowledge to include more complex ideas. While GTA 4 did not complete TAIA 8, her prior teaching experience, research session discussion, and/or other resources could have led to include additional information and guide students with new connections.

Data from which no information was taken:

- Observation data and comments

Summary

Safety was not mentioned by GTA 4 during her interviews or in observer notes of her classes. One comment from a student indicated that GTA 4 spent time going "over what we need to know before we start," but the student does not explicitly mention a safety presentation. GTA 4's lack of participation in TAIA 1 resulted in her not being exposed to more ideas about including more safety comments throughout her class.

GTA 4's classroom showed indications of being more "instructor-centered" and less "student-centered" based on the number of initiated interactions made by her

compared to those initiated by students. In her initial interview, she did recognize this trend in her classroom. The transition toward a "student-centered" classroom would be an important conversation to include in future GTA trainings. Students responded positively to GTA 4's interactions, minus one student who mentioned she could become impatient. Overall, she appropriately interacted with students, but could have benefitted from discussion about how both verbal and nonverbal cues could be interpreted by students, a topic discussed in TAIA 2. GTA 4 worked to include all students in her explanations and provided alternate explanations when necessary.

When discussing analysis, GTA 4 stated she knew where students would struggle and waited to provide more explanation at specific times instead of telling the students all of the information at the beginning of the class. This scenario was discussed in TAIA 3, and had she participated, she could have reflected on other possible avenues for helping her students. A student commented that GTA "guides students to an answer without saying what the answer is." This is strategy that helps students with their analysis questions, but also promotes higher-order thinking skills, and is a recommended strategy for instructors. GTA 4 also provided students with a sufficient overview of the experiment and described the process at the beginning of class, even without sharing in the discussions during the TAIA, GTA 4 was enacting this practice. At times, GTA 4 did tend to bring the class into a more "instructor-centered" environment by stopping class and providing direction to students. Continuous practice of this strategy is not recommended and discussion about this should be included in TAIA 3 in the future. Finally, GTA 4 showed flexibility in her teaching regarding information provided to students during her kick-off and modes of delivery to smaller audiences.

GTA 4 included demonstrations in her teaching, particularly on classroom technology. She recognized the need to introduce and demonstrate proper use of the technology likely unfamiliar to students. She stated that she tried to include emphasis on laboratory techniques in her classroom, an important issue to her. One addition GTA 4 could have made was repeated demonstrations of proper laboratory technique, particularly around the use of glassware. This point was included in TAIA 4 and could have been a benefit to GTA 4 during her teaching assignments.

Regarding group process, although GTA 4 did not participate in TAIA 5, she recognized and enacted a method to encourage class involvement and group discussions. In her classroom, she encouraged her students to ask questions of each other whenever possible. This promoted a class culture of participation and gave students the opportunity to "teach" a concept to a classmate and enhance their own learning.

GTA 4, while perhaps not realizing it, was assisting students of all abilities when she provided verbal instructions as well as referenced written instructions in the laboratory manual. Reading and then hearing the instructions promoted visualization of the apparatus for the students, connected concepts, and helped students determine big picture ideas. Again, this occurred without prompting by the TAIA. GTA 4 would likely have provided excellent peer information had she participated in this TAIA activity.

One aspect of change for GTA 4 was in her emphasis to include "more time on the floor with individual conversations." These conversations would have included assessing the students to determine students' level of understanding of the topics. The primary form of assessment for GTA 4 was likely formative assessments through

questioning, which provides quick snapshots of the students' knowledge. Discussion regarding formative assessment occurred during the TAIA 7 group discussions and GTA 4 would have provided excellent discussion to peers had she participated.

Higher-order thinking skills were one area of teaching GTA 4 brought from her experience as a student; she found she preferred when her instructors promoted these skills. She mentioned utilizing scaffolding in her classroom by "highlighting or underlining specific information," sending students weekly emails with focus questions, and again, guiding students toward an answer without stating what the answer is. One student mentioned that GTA 4 "always has an analogy to help you better understand." While GTA 4 did not complete TAIA 8, her prior teaching experience, research session discussion, and/or other resources could have led to the inclusion of these strategies. GTA 4 would have provided additional resources to peers had she participated in TAIA 8.

Overall, GTA 4 could have been impacted by her participation in TAIA discussions in the following ways:

- Inclusion of more emphasis on safety in her kick-offs, through TAIA 1;
- Work to transition from "instructor-centered" to student-centered classroom, through TAIAs 2 and 3;
- Emphasis of teaching appropriate glassware usage through TAIA 4;

GTA 4's participation in TAIA discussions would have also been an important opportunity for other GTAs because she had used these types of extension of TAIA applications in her labs:

- Determining if a GTA promotes an "instructor-centered" classroom versus a "student-centered" classroom;
- Persistence with explanations for students by changing modes of delivery when needed.;
- Implementation of Think-Pair-Share in the classroom to encourage participation;
- Having students explain ideas to each other to promote engagement;
- Providing students with focus questions before they came to class.

GTA 6

GTA 6 was a male, first-year, international biochemistry graduate student, with two years teaching experience in high school biology and chemistry in his home country prior to attending graduate school. The study occurred during GTA 6's first and second semesters of teaching undergraduate students. GTA 6 participated in both the research study meetings and completed in the TAIAs 1-8.

Safety

One comment noted by the observer during the second observation of the Fall 2018 semester was that a student had closed-toe but open-backed shoes on after the start of the "wet" portion of the laboratory. While the student likely had socks on with his/her shoes (the second observation was during October), this footwear is still not appropriate for the laboratory and should have been addressed by GTA 6. Appropriate dress is discussed during GTA orientation, laboratory meetings, and was discussed in TAIA 1. GTA 6 should have recognized this safety violation and had the student change shoes. In this case, GTA 6 did not enforce the safety guidelines learned from any source.

Another comment made by the observer about a minute later was that a student entered the classroom late and after the completion of the kick-off provided by GTA 6. A general guideline provided to GTAs is that students need to be on time and should arrive before the end of the kick-off. This ensures the students hear at least part of the kick-off and information about that day's experiment, including any safety notes. Right after the student arrived late, there was an interaction between GTA 6 and a student for 19 seconds, but the specifics of this interaction are not known. It is unlikely GTA 6

approached the incoming student and briefed them on the day's experiment. GTA 6 should have talked with the student and explained the necessity behind them arriving on time. He should have provided a simplified kick-off for the student, including any and all safety highlights. This procedure should have been known by GTA 6, as this exact scenario is the very first example scenario in TAIA 1. From this observation, it seems GTA 6 did not apply what he learned from TAIA 1 to his classroom.

Throughout the second observation of the Fall 2018 semester, GTA 6 made many announcements to the class toward the beginning of the "wet-lab" portion being safety related. Announcement topics included: students not needing gloves, location of where to put waste product, and other procedural information. Much of this information could have been included in GTA 6's kick-off as this would have prevented the need for multiple disruptions of the experiment. The topics could have been grouped together and announced before students were released to begin the experiment. The issue was discussed in TAIA 3 after the completion of this laboratory which highlights the need for this conversation.

In both the Fall 2018 and Spring 2019 semester GTA 6 made many announcements during the laboratory. Most announcements were short and could have been stated at the beginning or told individually to each pair of students as necessary. The Spring 2019 semester included a smaller group of upper-level students who did not require the frequency of safety announcements.

During the Spring 2019 semester, the observer commented that GTA 6 was not wearing his goggles during the laboratory period in at least one instance. Regardless of

the activity, GTA 6 should have been wearing his goggles the entire time. This topic is repeatedly covered during GTA orientation, experiment preparation meetings, and discussed in the TAIA 1 meeting. Since this observation occurred during one of the last weeks of the first year, GTA 6 should have had a routine for wearing goggles by that time.

Data from which no information was taken:

- GTA 6's Initial and Final Interviews
- Student surveys

Interpersonal Skills and Behaviors

GTA 6 made a comment regarding interpersonal behaviors during his second interview, which occurred after his first semester of teaching. When asked to describe qualities of an *ineffective* GTA, GTA 6 stated that "not paying attention to the students" was one characteristic. He elaborated by including, "looking somewhere else, not engaging, working on their own work, not talking to the students with their problems." Since one main task of the GTA during the laboratory classroom is to assist students complete the experiment, the statement by GTA 6 was highly accurate and would in fact be a characteristic describing an ineffective GTA. Since TAIA 2 would have been completed, GTA 6's specific description of these interpersonal qualities could be linked to the TAIA 2 discussion.

Another interpersonal behavior related comment GTA 6 made during the final interview, after GTA 6 had taught his second semester, a semester of experienced undergraduate students. When again asked to describe an ineffective GTA he stated, "if

they are confused and [the students] email, if you do not respond to them, they feel that we (GTAs) are not concerned about the position." The fact that GTA 6 made this comment was important because it showed GTA 6 realized the impact out of class interactions can have on students. While the students were not able to read GTA 6's body language or hear his tone of voice, they could notice the amount of time it took for him to reply or the length of his explanations. In a time of increased emails and digital interactions, timely and thorough emails are valued by students. Email etiquette was not discussed during TAIA 2 but had been briefly mentioned in other meetings. GTA 6 demonstrated his awareness of the impact his digital interactions have on students.

Observation data of time spent through interactions, monitoring, and administrative tasks, Table 10, showcased an interesting trend. (Totals in Table 10 will not equal 100% due to other occurrences during the laboratory not mentioned.) GTA 6's total interaction with students decreased during the first semester slightly from 36% to 31%. The second semester showed an increase but started at a very low percentage of 14% and rose to 26% in the last observation. The Spring 2019 students were experienced undergraduate students who might not have required as much interaction and worked autonomously. This data could showcase a lack of student-GTA rapport established within GTA 6's classroom.

Table 10: GTA 6's Task Percentages

Fall 2018	Interactions	Monitoring	Administrative
Observation 2	36%	12%	28%
Observation 3	31%	31%	20%

Spring 2019			
Observation 1	14%	28%	21%
Observation 2	21%	20%	13%
Observation 3	26%	27%	10%

Evidence of a lack of student-GTA rapport included observations of only a few students maintaining attention during GTA 6's kick-offs. During the Fall 2018 semester, only 6-7 students were observed actively listening to GTA 6's kick-off information. One interaction between GTA 6 and a student during the last observation of the same semester appeared to have left the student visibly frustrated due to not getting a straight answer from GTA 6. Even though GTA 6 made statements during his interviews that he recognized the importance of interactions with students, unfortunately, it does not appear some interactions were positive.

Regarding actual number of interactions and time spent on each interaction, the numbers are mixed. As shown in Table 11, during the Fall semester GTA 6 appeared to hold a more student-centered classroom environment, and each interaction lasted between 38-45 seconds. Discussion during TAIA sessions revolved around analysis and laboratory techniques in the weeks between Observation 2 and 3. Therefore, the longer interaction times, as compared to later in the Spring 2019 semester, could be attributed to more lengthy explanations about these topics.

Table 11. Interactions with GTA 6

	GTA Initiated	Student Initiated	Length of individual interaction (s)
Fall 2018			
Observation 2	16	18	38.97
Observation 3	6	26	44.92
Spring 2019			
Observation 1	15	8	21.30
Observation 2	32	30	14.97
Observation 3	25	15	17.90

Semester 2 showed more GTA-initiated questions to students instead of student-initiated questions as compared to the fall semester. Observation 2 showed the largest number of total interactions with many interactions being about 15 seconds long and included nearly equal student- or GTA- initiated questions. These values indicate a transition back to a teacher-centered classroom, instead of a progression toward a student-centered environment. While the laboratory material level changed to upperclassmen, discussions during TAIA sessions in the second semester still encouraged a student-centered classroom. The content change to GTA 6's research focus topic could have caused him to revert back to a teacher-centered environment. Students commented that GTA 6 was very knowledgeable in the content and this could have caused him to want to share and show students instead of guide and allow them to complete tasks and challenges on their own.

Student statements from GTA's first semester regarding interactions included, "he explains how to do the experiment and explains questions" and he "doesn't make you feel unintelligent when asked questions." Other related comments mentioned GTA 6's willingness to answer questions, he "answers questions thoroughly", and was overall helpful to his students. From these comments, it was evident that GTA 6 has content information he was excited to share, and these students found his delivery positive and helpful.

On the other hand, one student stated GTA 6 was "impatient and doesn't explain things in a way I understand." Another said he "over-explained easy experiments" and "explained content too quickly." These students found issues with GTA 6's delivery. Perhaps GTA 6 was unaware of the level of knowledge his students did or did not possess. This awareness topic connects with TAIA 7 on assessment, which GTA 6 would not have encountered yet. Unfortunately, depending on when the encounters the students were describing occurred, they could have impacted the rapport between GTA 6 and the students and the likelihood of these students asking GTA 6 questions in the future. In GTA 6's case, this does not appear to be what happened as Table 8 shows an increase in student-initiated questions. The increased number could have been follow-up questions from student's initial confusion.

Second semester students found it helpful when GTA 6 responded quickly to their questions and emails. One student said GTA 6 was "approachable and always wants us to ask questions about the lab." Conversely, students included comments regarding how GTA 6 was struggling to understand their questions or interrupting them before they could finish a question. Specifically, one student stated, GTA 6 "either can't understand

our questions or doesn't allow us to finish our questions before interrupting us and answer the wrong question." Another student said GTA 6 "confuses me about experiments and rushes through important things." The unhelpful comments from students indicated GTA 6 was not taking the time to understand their questions and hear their thoughts before expressing his own. The students did not feel heard and this could be the reason behind the relatively large difference in GTA- and student-initiated interactions during GTA 6's second semester. Since the topic of this laboratory class was one GTA 6 was studying himself, he could have thought he knew the questions the students would have and tried to anticipate their questions. Unfortunately, the students did not appreciate this method. The TAIA 2 discussion would have happened during the previous semester, so the conversation might not have been on the front of GTA 6's mind.

During GTA 6's mid-year interview after his first semester of teaching he stated that he knew "those students that can answer and know the topic" and he would "help when [they] ask for it." He found his interactions centered around the content. He continued that "most ask questions because they are not well with the topics" and the "whole class asked questions." GTA 6's assessment of the root of student questions is appropriate and understandably correct; the students should have asked questions about the content and how it connected to the day's experiment. GTA 6 was also correct regarding his availability to students when they had a question, and as mentioned, the students also stated they found his availability helpful.

While the content of the class was different, GTA 6's approach to answering questions did not change for the better. Similar unhelpful characteristics were mentioned during both semesters of teaching. GTA 6 was confident in the material of both semesters

and had all of the components to be successful but struggled in how he conveyed his enthusiasm to the students. His enthusiasm came off to the students as impatience and possibly rude when he would often interrupt them.

Analysis

In his final interview, GTA 6 stated he "focused on the subject," would "give a little background, make them Google," then "they are able to get that knowledge." While it is unknown at what point during the laboratory that GTA 6 would recommend this strategy (prior to, during, or after the completion of the experiment) he stated he found a method that worked for his students. While generally it was expected GTA 6 be more of a resource for his students, in situations where students did not find his explanations helpful, their own research could be easier to understand. This was not an option discussed during TAIA 3.

Students in the Fall 2018 stated GTA 6 was helpful to "explain how to do things" by "showing how to do each thing and helps teaching how to do the problem/experiment." Many students stated he was "helpful" and was understanding when they had a question. While the students do not include specific times where GTA 6 was helpful, the analysis and application portions of the experiment included many student questions and discussions. Perhaps GTA 6 utilized ideas discussed during TAIA 3 to help his students work through these problems.

Students in both semesters found GTA 6 hard to understand due to his accent and possibly the explanations he provided. Students shared they became confused and felt they would "miss key information." GTA 6's explanations needed to be at an appropriate

level for the students and clear in delivery. As mentioned in the interpersonal skills and behaviors section above, students found GTA 6's method of delivery challenging to understand and generally too fast. GTA 6 should have slowed his delivery to allow the student to understand what he was saying and how it connected to and answered their questions.

A comment made by the observer in the second observation of the first semester included GTA 6 making many announcements about students completing the analysis portion of the experiment and how to perform some calculations, but not a specific explanation or demonstration of how to complete the calculation. While this TAIA had not been explored yet by GTA 6, it was expected that he might not have considered how to handle this situation. Perhaps a sample calculation could have been included in the kickoff for the students to refer back to later.

Toward the end of the last observation of GTA 6's first semester teaching, the observer noted that a "student becomes increasingly frustrated by not getting a straight answer." The same student ten minutes later is then "distraught about GTA 6 saying 'it's in the background'." This interaction could be included in both the interpersonal skills and behaviors section or the analysis section. It's presence in the analysis section is due to the topic of the interaction being about the application questions. While GTAs are advised to help students come to the answer themselves by using prompting questions, sometimes it could be best to analyze the situation and diffuse the student's frustration about the question. This could be done by providing the student confirmation on their answer, showing them where to find their answer, or telling them the correct answer, though this is typically not promoted. In this scenario, GTA 6 could have provided the

student with part of the answer and then showed them where to find the rest instead of telling them to look in the background information of the laboratory.

Laboratory Techniques

When asked to describe something GTA 6 liked from the initial GTA orientation which occurred when he first started working in the Chemistry and Biochemistry Department, he stated "giving the demo" for the students to be helpful. Providing students with a demonstration of how to use equipment or set up an apparatus could an important step to helping them visualize what they will be doing. GTA 6 took the information learned in the orientation training and reflected on its necessity. While this reflection was not a direct result of the laboratory techniques TAIA, it was still an important note about the impact small moments of professional development could have on GTAs.

After his second semester and teaching a more technical and equipment-driven laboratory, GTA 6 stated he found he had to overcome instrument issues during the class period. He said, "sometimes they stop," so we have "less options and have to solve the problems on our own." When GTA 6 had to adapt and overcome the challenge of equipment malfunction, he was demonstrating persistence to his students and how to adjust in the moment. In a way, this could be related to the scientific method when something unexpected happens, changes to the process have to occur.

Students in the Fall 2018 semester stated GTA 6 "helps throughout every procedure" and this helps them to "continue with experiments." This statement was encouraging regarding the guidance GTA 6 was providing to the student and was a

discussion point mentioned during the TAIA 4 sessions. Hopefully GTA 6 was providing adequate direction while still encouraging the students to perform the experiment and try the procedure on their own.

One student in the Fall 2018 semester found it unhelpful when GTA 6 was "letting us do the experiment with little to no instructions" as he "doesn't explain how things should be, so it makes it more confusing." GTA 6 should have provided students with some direction or paraphrased the procedure before they began the experiment. While TAIA 4 focused on teaching laboratory techniques, the students should have felt comfortable with the amount of instruction provided to them from GTA 6. Another student found it unhelpful when GTA 6 wouldn't "explain why something was wrong in the lab" as the student felt he/she was "not able to learn from mistakes." Although the GTA would not likely know why something might not work, this could be a wonderful opportunity to discuss and hypothesize with the students about why the experiment did not work. This could be a great teaching moment for the GTA and learning moment for the student. Students could learn just as much, if not more, from their mistakes compared to when everything goes according to plan.

One student in the Spring 2019 semester stated GTA 6 was "helpful and willing to demonstrate techniques" for the class. The student continued that GTA 6 "tried his best to help." Another student included, "going through the experiment before we start lab" was helpful as it "prepares me for what we will be doing and helps me understand why we are doing the lab." These statements connect to the discussion which occurred during the TAIA 4 session and could indicate GTA 6 utilized techniques mentioned during this session.

During the second observation of the first semester, the observer commented that "students [were] not using appropriate glassware to measure liquids." The same observation included the comment, "need for demonstrations of how to measure mass and volume using lab glassware/tools." This observation would have occurred prior to GTA 6's participation in the TAIA 4 discussion. As TAIA 4 discussed a scenario of students using inappropriate glassware to measure reagents, and further explained the need to show of how to use the glassware.

The final observation of the Fall 2018 semester again included at least four announcements during the laboratory with several about procedure specific information. Even though GTA 6 had completed TAIA 4 which discussed the need to demonstrate laboratory procedures and use of equipment in the kick-off, GTA 6 continued to make announcements during the wet-lab portion of the experiment. Because he was making these announcements ad hoc, he could have appeared as unprepared due to the number of last-minute interruptions.

After the start of the wet-lab portion of the experiment in the final observation of the Spring 2019 semester, GTA 6 said to the class, "follow the manual." Ten minutes later, he repeated this statement with, "follow the instructions." This comment was very similar to a comment made at the end of the first semester regarding information being in the manual. While the students should reference their manual throughout the experiment, GTA 6's delivery of this reminder was likely not helpful to students who had asked him questions about the procedure. It could be expected that the students would not be asking for his assistance if they knew the next step and being told to re-reference the lab manual was not helpful.

Group Process

The first observation of the Spring 2019 semester included a comment by the observer of, “most groups, one student is doing the manual work.” This scenario generally left one student waiting and watching while the other performed the majority of the experiment. This observation occurred before TAIA 5, so a GTA 6 had not had the discussion yet on helping students to work in group. However, GTA 6 could have approached the groups and ensured all students were participating in all aspects of the experiment and all were given an opportunity to complete the wet-lab portion. This is clearly an area where GTA 6 needed support in how to help students to work in groups.

Data from which no information was taken:

- GTA 6’s Initial and Final Interviews
- Student surveys

Working with Students of Differing Abilities

Prior to completing TAIA 6, during GTA 6’s second interview, he stated that “we are not teaching to the students, but more laymen’s terms.” He provided an example of an art student taking a science class, “then we should be able to explain” the material to “everyone.” GTA 6 was describing the necessity of working to include every student regardless of their ability or major and made this statement before any discussion occurred about working with students of differing abilities.

In GTA 6’s last interview, he reinforced his statement about teaching students of differing ability from his second interview. In a different section of the interview GTA 6 connected this by saying professors should teach by “using smaller chunks of material.”

The process of chunking the material is helpful for all students in their construction of concepts. Students of all abilities benefit when the material is described individually, then related to previous experiments and topics. GTA 6 connected this idea from his own classroom to his experience as a student and could have been reinforced during the TAIA 6 discussion.

During GTA 6's final interview, when asked to describe his teaching style, he stated he found "students are more focused" and he didn't "have to explain the basic concepts." While these students were upperclassmen, they did require a different approach due to their experience and ability levels. Since GTA 6 had completed TAIA 6, he could have utilized the information discussed in the session for teaching to these higher-level students. TAIA 6 might have made an impact on how GTA 6 approached his students and their abilities.

Student comments from the Fall 2018 semester regarding helpful characteristics included: "walks us through things," "helpful when you ask questions and [GTA 6] helps you find the answer," and the "writing on the board" to read when they couldn't hear or understand what GTA 6 was saying. The students were describing methods GTA 6 was utilizing to help breakdown the information and assist in guiding the students to the answer. These statements were congruent to GTA's interview statement regarding "using smaller chunks of material" to help explain a topic. The students were witnessing and being helped by the described "chunking" method.

One student in the Spring 2019 semester stated he/she found the "PowerPoints at beginning of lab and information helps me learn the content" and would "give [a] visual

for what we are going to do." Providing a visual method for students to read the information in addition to hearing it be explained was a great method to include for students of all abilities into the discussion. This was one topic specifically discussed during the TAIA 6 discussion, and the inclusion of this student statement could show GTA 6's enactment of this adaptive tool.

Data from which no information was taken:

- Observation data and comments

Assessment

During GTA 6's mid-year interview, when asked to describe his teaching style he stated he would first give a background (kick-off) then would "ask questions to know if they know the background." He continued that he would "know those students that can answer, know the topic." Through these comments GTA 6 was referring to assessing students to know what they know.

After the Spring 2019 semester and as mentioned in the *Working with Students of Differing Abilities*, GTA 6 stated he found he didn't "have to explain the basic concepts" to the upperclassmen students. This was expected as compared to the introductory chemistry class GTA 6 taught in the Fall. GTA 6 positively assessed the academic level in his student's abilities and adjusted his mindset and teaching accordingly.

In the final interview, when asked if he possessed any of the *ineffective* qualities he described, he stated that, "I have to ask the questions of the students" and "quiz the students much more." He continued that he was "wanting more assessment of the students to know their knowledge" and usually utilized oral questions. As discussed in

the Interpersonal Skills and Behavior section, the Spring semester for GTA 6 indicated a more instructor-centered classroom with more instructor-initiated questions to students. GTA 6 could have felt he needed to prompt the upperclassmen more than the introductory students to determine their amount of knowledge. When GTA 6 was utilizing oral questions during the class he was actively implementing formative assessment, one topic discussed in TAIA 7. The formative assessments gave GTA 6 in the moment information about what the students knew about the topic.

In the final interview, when asked about tips/strategies GTA 6 had learned from being a long-time student, he stated that he liked when there was a "test for students in the lab" to "know how much the students have handled the experiment, individually." This statement indicated GTA 6 recognized the necessity of assessing students to ensure everyone participated and learned from the experiment that was conducted.

During GTA 6's kick-offs, in both semesters, he would ask the students, "okay?" after delivering information, but then not allow them to answer or think about the presented information. If GTA 6 would have paused to allow the students to think about the topic, this could have been a great formative assessment opportunity for him to learn what his student knew coming into the laboratory. In the future, it would be beneficial for both the students and GTA 6 to pause before continuing. He could learn what topics need more explanation and which students were already comfortable with the topic.

During the third observation of GTA 6's first semester, he posed one question to students during his kick-off. In his second semester, the first observation included five posed questions; second observation included two questions to all students; and the last

observation included three questions during his kick-off. GTA 6 started the second semester working to include the students into his kickoff by asking them questions to find out what they knew, but then tapered off their involvement throughout the semester. Ideally, GTA 6 would have increased the amount of participation of his students to determine what they already knew and how he could help them solidify their knowledge through the day's experiment.

Data from which no information was taken:

- Student surveys

Higher-Order Thinking Skills

When asked about qualities that GTA 6 felt made an *effective* GTA during his initial interview, he included that the GTA should be updated on current topics within the discipline. He specified that "current research" should be known "so we can excite the students to do well in research or academia." The inclusion of additional information about the topic being studied was an extension of higher-order thinking skills because it provided students with an application of the topic. This inclusion could be used as an example to help explain or solidify knowledge and importance about the content. While GTA 6 had not discussed TAIA 8 yet, he still mentioned an example of something that could be used to promote higher-order thinking skills.

During GTA 6's initial interview, when asked about tips/strategies GTA 6 had learned from being a long-time student, he stated he preferred when instructors taught by "not including too much detail: explain simply first then move to complex." While not

specifically named, this is referring to scaffolding, a teaching strategy where material is gradually increased in complexity for the students. This strategy was suggested in the additional reading discussed alongside TAIA 8, which GTA 6 would have not had the opportunity to explore yet.

GTA 6's mid-year interview included him stating "giving them (students) time to think." This has been referred to as wait-time and is a good strategy to implement in the classroom. It promotes higher-order thinking by allowing students time to compile and expand on their thoughts and could be beneficial for all students regardless of their ability. While GTA 6 mentioned this topic prior to the completion of TAIA 6 (differing abilities) or 8 (higher-order thinking), observation comments stated he did not promote this action himself. Comments in both the second and third observations of the Fall semester, the semester prior to this interview, stated GTA 6 asked the students "okay?" after providing information, but did not allow time for them to answer or ask a follow-up question before moving on. Although GTA 6 recognized the benefits of wait time even before it was discussed, he did not demonstrate this action within his classroom.

Data from which no information was taken:

- Student surveys

Summary

GTA 6 missed safety violations in his classroom and often interrupted students by making announcements regarding safety information that could have been included in his kick-off. One violation included a student wearing inappropriate footwear and another

was conducted by GTA 6 himself by not wearing goggles during a laboratory period during his second semester of teaching. These are two commonly discussed safety standards in GTA training and were discussed in TAIA 1. GTA 6's participation in TAIA 1 resulted in his recognition of safety issues but not in practicing them perfectly.

Rapport between GTA 6 and his students was lacking at times in his classroom. Even though he made statements during his interviews that he recognized the importance of interactions with students, unfortunately, it does not appear some interactions were positive. While students appreciated GTA 6's knowledge about the content, approachability, and general helpfulness when they asked him questions, they found his explanations could be confusing and felt he interrupted them often before they could completely ask their question. GTA 6 was not taking the time to understand his student's questions or hear their thoughts before expressing his own. This likely caused negative discourse between GTA 6 and his students. GTA 6's approach to answering questions did not change for the better from the fall semester to the spring. While he was confident in his knowledge of the material, he struggled in the delivery and how he conveyed his enthusiasm about the topics to his students. His practice of his interpersonal skills and behaviors were not always received positively by students, and GTA 6 could have used reminders of the topics discussed in TAIA 2 throughout his teaching.

Students stated that GTA 6 was helpful and understanding when they had a question, perhaps during the analysis and application question portion of the experiment. It was inferred that GTA 6 utilized ideas discussed during TAIA 3 to help his students work through these questions. Many announcements by GTA 6 occurred when students were already working on the analysis portion of each experiment and the frequency of

these announcements was likely unhelpful to the students and may have caused greater confusion. One student struggled with GTA 6's teaching strategy of not providing students with answers to their questions every time. The student reportedly became "distraught about GTA 6 saying, "it's in the background." Information learned from the interpersonal skills TAIA discussion and analysis TAIA discussion should have aided GTA 6 in his teaching but were not referenced in these instances. GTA 6 may need a refresher course in the interpersonal and analysis TAIAs.

Regarding laboratory techniques, one student commented that GTA 6 "helps throughout every procedure" and allows them to "continue with experiments." This was encouraging regarding the guidance he provided to the student and was a discussion point in TAIA 4. Students appreciated when GTA 6 provided sufficient information about the experiment and associated laboratory techniques. These approaches to teaching in the laboratory were discussed in TAIA 4. Much like the announcements about safety, GTA 6 made many announcements regarding laboratory techniques and procedures. He continued to make these announcements during the wet-lab portion of the laboratory into the spring semester, after the TAIA 4 discussion. The frequency of these announcements could indicate that GTA 6 was unprepared for the laboratory. The observer noted that GTA 6 would tell students to "follow the manual" or "follow the instructions" often, including during whole class announcements. These statements are likely unhelpful to students and are recommended to be used sparingly. They also indicated that GTA 6 was not familiar enough with information in the lab to provide important help for students. TAIA 4 focused on providing demonstrations of procedures and GTA 6 did not use these methods.

GTA 6 struggled to encourage equal participation by all group members in his class. The observer noted that in "most groups, one student is doing the manual work." This scenario would have provided the perfect situation for GTA 6 to suggest that partners switch roles so they both were able to perform the wet-lab portion. This comment was made prior to GTA 6's participation in TAIA 5 yet was an issue GTA 6 needed more support to encourage students to share the workload within the group. GTA 6 did not embrace the suggestions made in TAIA 5.

A positive changed in approach occurred when GTA 6 moved from introductory chemistry to upper-level. He stated he found the students were "more focused" and he didn't "have to explain the basic concepts." Students in his spring semester class appreciated his PowerPoints as they "gave [a] visual for what we are going to do." The inclusion of this tool likely were reinforced through GTA 6's participation in TAIA 6.

GTA 6 utilized formative assessments frequently in his class and found he was "wanting more assessment of the students to know their knowledge." This was encouraging that GTA 6 had a desire to learn more about his students' knowledge of the topic. One area GTA 6 changed, but perhaps not for the better was the amount of student interactions he included in his kick-offs. During his second semester, he posed five questions initially, then two in the second observation and three in the final observation. Ideally, GTA 6 would have increased his students' participation throughout the semester by continuing with the higher number of questions. This was a pedagogical procedure discussed in TAIA 7 but not fully embraced by GTA 6.

Inclusion of current research was one topic GTA 6 looked to include in his classroom and mentioned this during his initial interview. Since TAIA 8 was not held until the end of the spring semester, GTA 6 mentioning this could not have been due to participation in this discussion. He also mentioned utilizing scaffolding in his classroom. This strategy was mentioned in the additional reading associated with TAIA 8, which GTA 6 had not explored yet. Finally, GTA 6 stated that it was important to give the students "time to think" when asking them questions. This was encouraging except during the observations, GTA 6 was observed saying, "okay?" after statements but not allowing students time to think or respond. Although he recognized the benefits of wait time, he did not demonstrate this action within his classroom.

Overall, GTA 6 may have been impacted by his participation in TAIA discussions in the following ways:

- His ability to assist students with their questions during the analysis and application portions, through TAIA 3;
- Assistance to students as they completed the experiment and practiced laboratory techniques, TAIA 4;
- Recognition of differing-abled students by ability, through TAIA 5;
- Reinforced methods of content delivery to students by way of PowerPoint presentations, through TAIA 6;
- Inclusion of formative assessments to determine his students' level of knowledge, through TAIA 7;
- Working to include current research and utilize scaffolding in his classroom, through TAIA 8.

GTA 6 needs opportunity to refresh some of the TAIA topics including:

- Appropriate enforcement of safety guidelines for his students and himself, TAIA 1;
- Frequency and timing of announcements, TAIA 2, 3, and 4;
- Working toward a student-centered environment instead of instructor-centered, TAIA 2;
- Patience and clarity when answering students' questions, TAIA 2 and 3;
- Assisting groups in working together and sharing the workload, TAIA 5;
- Enacting "wait-time" in his classroom, TAIA 7 and 8;
- Promoting more interactive kick-offs with more questions posed to students, TAIA 7.

GTA 9

GTA 9 was a male, first-year international biochemistry graduate student with a Master's degree. This GTA had taught grades 11 and 12 for about a year and had served as a graduate research assistant for one year at a previous institution. This semester was GTA 9's first semester teaching undergraduate students. GTA 9 participated in the research study meetings regularly and completed TAIAs 1-4.

Safety

When asked about qualities GTA 9 felt made an *effective* GTA in his initial interview, he stated that being "strict on rules in the lab" was important. As this was preluding to GTA 9's first semester teaching, this statement was encouraging to hear. This statement was also said before GTA 9 participated in the TAIA 1 discussions that occurred a few weeks later.

GTA 9 mentioned safety in his kick-off during the second and third sets of observations in the Fall 2019 semester. Safety was not mentioned during the first set of observations likely due to the students performing a dry-lab with molecular modeling kits and no chemicals or other laboratory equipment. Safety statements recorded in the second set of observations included location of chemicals in the classroom, ensuring students close lids and using appropriate laboratory equipment, and general safety reminder about using chemicals appropriately. The third set of observations included safety statements regarding laboratory appropriate dress and general chemical safety information not specified by the observer.

During both sections in the last set of observations, the observer noted that GTA 9 had to dispense chemicals for students per laboratory manual instructions. This process took up much of GTA 9's time in the laboratory but was safest for all students. The overall quantity of chemical dispensed was low but could have posed a hazard to students if dispensed inappropriately. While this was required, it was a necessary step and demonstrated to the students that experience and safety are important. GTA 9 chose the safer option for himself and students.

Data from which no information was taken:

- Student Surveys

Interpersonal Skills and Behaviors

When asked in his initial interview about qualities that make an *ineffective* GTA, GTA 9 stated it was important to "not over-familiarize myself with students" and added to not "being unnecessarily strict." After his first semester teaching, GTA 9 added the GTA "shouldn't be hostile, especially with questions." His comments showed consistency between from the initial interview to the last and were appropriate statements to make in regard to creating avenues to work and talk with students.

In his initial interview, when asked to describe teaching strategies he did not prefer from his time as a student. GTA 9 recalled professors who had "no sense of humor, monotone voice, no inflection" and was not pleased with these methods. In these instances, the professor was not maintaining students' attention and was not assessing their students to understand their emotions. The process of evaluating students' emotions was a strategy mentioned during the TAIA 2 discussion regarding nonverbal

communication. GTA 9's reflection on these behaviors before completing TAIA 2 indicated great awareness regarding nonverbal communication that occurs while teaching.

GTA 9's interactions were consistent through the first two sets of observations, then decreased during the last set. Table 12 shows the percentage of time GTA 9 spent on student-GTA interactions, monitoring students, and administrative tasks. (Totals will not equal 100% due to other occurrences during the laboratory not mentioned.) Different factors might have contributed to this change: 1) student confidence with the expectations and overall flow the laboratory, 2) the content was more approachable for students, 3) greater preparation during the kick-off and 4) preparation through each GTA-student interaction.

Table 12. GTA 9 Task Percentages

	Interactions	Monitoring	Administrative
Observation 1	46%	21%	12%
Observation 2	53%	20%	11%
Observation 3	38%	34%	13%

The number of total interactions between GTA 9 and the students remained fairly consistent throughout each observation, with the exception of section 1 during observations 2 and 3. Table 13 shows the number of GTA 9-initiated interactions, student-initiated interactions, and the average length of each interaction for each section.

Table 13. Interactions with GTA 9

	GTA Initiated	Student Initiated	Length of individual interaction (s)
Observation 1			
Section 1	38	25	53.98
Section 2	32	24	46.92
Average	35	31.5	50.45
Observation 2			
Section 1	55	35	48.81
Section 2	37	32	51.58
Average	46	33.5	50.20
Observation 3			
Section 1	53	38	30.52
Section 2	41	32	39.09
Average	47	35	34.81

GTA 9 appeared to maintain a slight teacher-centered classroom based on the number of GTA-initiated versus student-initiated interactions alone. The number of student-initiated interactions remained relatively constant through observations 2 and 3. Lower numbers were expected during the first class meeting due to reservations by students about the new environment and instructor. Section 1 of each observation does consistently contain more GTA-initiated interactions. This could be caused by GTA 9 “checking in” with

students more often and wanting to ensure that students were on track. This trend was not unexpected for the first section GTA 9 had taught.

One comment recorded by the observer during the first set of observations included, “GTA good with proximity; doesn't always need to intrude on the student’s progress.” Proximity was more so referring to physical distance between GTA 9 and the students. GTA 9 was respectful of his students’ personal space, both physical and intellectual. He was available to interact with students when needed but tried to avoid interfering if possible.

Another frequent comment from the observer was GTA called on students by their name from the beginning. He learned their names quickly and used them when asking them questions or when needing their attention. This action could increase the likelihood of GTA 9 having positive interactions and building a community within his classroom. TAIA 2 includes a specific scenario where the GTA uses the students’ names and the effect this could have on classrooms was discussed. GTA 9 included this aspect into his classroom and this action could have been emphasized through his participation in TAIA 2.

Students had many positive comments about GTA 9’s willingness to help and approachable/friendly nature. One student commented, “[GTA 9 was] willing to sit down and talk about the question; explains in more than one way”. Many students stated that GTA 9 was “willing to help”, “easy to talk to”, and “open to questions.” These statements were encouraging regarding GTA 9’s approachability and awareness about his verbal and nonverbal communication with students. Perhaps some reinforcement about verbal and

nonverbal communication from TAIA 2 occurred for GTA 9. Students reported having positive interactions with GTA 9, with any unhelpful characteristics focusing on his accent and a few comments on his teaching style.

In GTA 9's final interview, he described an *effective* GTA as being friendly and felt he had demonstrated this characteristic in his teaching. GTA 9 continued by commenting about embracing every question and suggested and that this applied to his interactions with students as well. These statements were in line with appropriate behavior by a GTA and were mentioned during various TAIA discussions.

GTA 9 appeared to have many interactions with his students and, again, grew in confidence over time. He showed consistency throughout the semester and fostered positive interactions at all opportunities. During the research study meetings, he provided suggestions to other GTAs regarding different ways of approaching students and how to speak with them appropriately and at their level.

Analysis

One student commented, "[GTA 9's] ability to show us the way to do things in a sensible way rather than just telling us to 'look at the text'." This statement could be included in the interpersonal skills and behaviors section or analysis, but since the student is likely referring to the application questions, it was included in the analysis section. The TAIA 3 session included discussion about appropriate methods in deciding the best method of helping students through problems. GTA 9 could have used suggestions from this activity in his classroom.

One student did not find GTA 9's "lengthy explanations" helpful because the student "got lost in the small details" and preferred "short and concise" explanations. As an instructor, determining how much information to include can challenging. In this case, the student was likely looking for the direct answer to his or her question and GTA 9 provided more information than the student was wanting. Finding the balance of providing the appropriate amount and level of information to students could be difficult and has been a topic of conversation in past GTA trainings. GTA 9 should have used nonverbal cues from students to determine if they were following his explanations.

Another student did not like when GTA 9 "questions my answers" because he/she did not know how to fix what they were doing wrong. Again, likely the student wanted a clear answer to their question and not have to analyze for themselves what could have been wrong. This method of "questioning the questioner" could be effective for both the GTA and the student and had been mentioned in TAIA 3. First, the GTA practices working with the student to determine the answer instead of just providing it, and second, the student comes to the answer themselves which provides ownership over their own learning. Generally, this method is recommended to educators and could be beneficial for the students in the long term.

During the first observation of the first section, the observer made the following comment, GTA 9 "clarifies the question [for the students], then provides the correct answer after the student attempted one response; students appear satisfied with the assistance provided." GTA 9 handled this question appropriately and better than most first-year GTAs. By clarifying the question, he attempted to reduce confusion and insured he knew what the students were asking. He then asked the student for their thoughts

before providing the correct answer. Although GTA 9 had not completed TAIA 3 nor participated in its discussion, the method he used to answer the student's question seemed to satisfy the student and allowed them to continue working.

The first observation of the second section included the following question from a student: "we can't make anything other than alcohols and ethers?" The GTA responded nonverbally by "shaking [his] head but doesn't appear to give further assistance" to the student. The GTA then left the students and did not further the interaction. While it is not known if the GTA provided a follow up or the students attitude to this response, it could be recommended to GTA 9 to check back in with the students soon thereafter. Though, it could have been important for GTA 9 to leave the students to think for a minute after answering their question. This has been a recommended strategy to help students work on critical thinking when used appropriately. A similar discussion happened during TAIA 3, after this particular interaction occurred, regarding the need to walk away from students after answering a question while still leaving the student thinking. Some students could be trying to obtain assistance with every question they have. It would be necessary to help them understand the GTAs role as guide rather than provider of all answers.

During the last observation of the first section, the following interaction occurred: GTA 9 and a student were discussing a question and they came to a conclusion; the student then phrased her answer as a question and GTA 9 responded with "What do you think?" GTA 9 had likely thought a conclusion was acquired which prompted the follow up question or it is possible GTA 9 might have wanted his student to have more confidence in his/her answer and wanted them to restate. This situation is similar to

previously described interactions of trying to determine how much confirmation to provided versus re-questioning the student.

Data from which no information was taken:

- GTA 9's Initial and Final Interviews

Laboratory Techniques

GTA 9's example of something he had to "learn on the job" after teaching his first semester was his need to practice the experiments before the students each week. He described that the "first four labs, I always came to lab on the weekend before." He "tried apparatus" during this time in anticipation of the students performing the experiment the next week. He continued that "later in the semester, I didn't practice the set-up and it was new and a little overwhelming in the moment." Since students have often been told to try and visualize what they will be doing when they are completing their pre-class reading of the procedure, it could be expected the GTAs practice the experiment. This scenario is a great example of the need for the instructor to have performed the experiment before the students so they have an understanding of where their students could go wrong. This action was recommended to the GTAs during orientation, but the suggestion is not always fulfilled.

One student in GTA 9's class stated in his/her survey that GTA 9 "tries to help manage our time in lab." Ensuring students had enough time to complete the experiment and application questions was a necessary task for GTA 9. Time management was included in the laboratory techniques section because of the importance time plays in correctly finishing the experiments while interacting with students. From this comment, it

could be inferred that the students appreciated GTA 9's approach and his desire for them to finish their experiment.

Another student stated, GTA 9 "guides students through lab procedure and questions." The inclusion of the word 'guide' was important because the student realized GTA 9's teaching approach to help students perform the experiment with assistance but the student still had control over their learning. This statement showed awareness by the student about the learning process and GTA 9's role in the classroom, and that GTA 9 was clear and consistent in his approach. He chose a teaching method that was appropriate and induced learning of the material by his students. This method was mentioned during TAIA 4 and throughout their GTA training.

During the first set of observations, GTA 9 asked students to assist during his kick-off through a demonstration of how to build structures with the molecular modeling kits the students were using that class period. By including students in the demonstration, GTA 9 was able to promote involvement and engage the class. The students who participated got to build molecules with GTA 9's help while the class watched and learned from their successes or errors. Student engagement in the kick-off was recommended to students during GTA orientation and was mentioned during TAIA discussions as well. GTA 9 included this engagement before the TAIA 4 session.

The first section of the second set of observations included GTA 9 "ensuring [the] student is getting only as much [chemical] as needed" as recorded by the observer. The second set of observations occurred just prior to the discussion of laboratory techniques

and TAIA 4. GTA 9 had already corrected a student before the completion of TAIA 4 and discussion that followed.

After the students began working, announcements by GTA 9 occurred but were not frequent. Announcement topics included reminding students about using an ice bath, dispensing of chemicals, and closing containers. The announcement topics included both information about laboratory techniques and safety. GTA 9's kick-offs were usually full of information, so he didn't always have time for more announcements. He could have pointed the notes out in the manual to still communicate the information to students and not need interrupt later.

During the last set of observations, GTA 9 demonstrated to students how to set up a titration correctly. Initially the instructions were to a small group of students but then GTA 9 stopped the class and showed everyone. The observer noted that "many students were not watching the demonstration; they were setting up for other parts of the lab." Likely this happened because GTA 9 had already released them to begin the experiment and then stopped the students while they were on different steps. GTA 9 could have included this information in his kick-off so more students could have seen it. The second section observation data showed GTA 9 adjusting his kick-off to include this demonstration for the students. With this being toward the end of the semester, it was surprising GTA 9 did not initially include the demonstration.

Group Process

Data from which no information was taken:

- GTA 9's Initial and Final Interviews

- Student surveys
- Observation data and comments

Working with Students of Differing Abilities

During GTA 9's initial interview, when asked to describe an example of something that happened for which he was unprepared for, he described how he "learned how to think like different categories of students." He continued that "not everyone likes and learns the same." Since GTA 9 only completed the first four TAIAs, he would not have discussed working with students of differing abilities. In addition, this comment occurred before the completion of any of the activities or his first semester teaching. GTA 9 was already prepared for the variety of students he would encounter in his teaching.

The observer noted that GTA 9 also helped students at the end of the period who might be working a bit slow to ensure they finish on time. The observer commented that he would check their work to ensure they were answering questions correctly to speed them along. As mentioned with GTA 3, rushing students could be detrimental to their learning and induce anxiety. Some students just need more time to finish the experiment and reflect on what they did and learned. Instructors of all levels should remember that the students are experiencing this experiment, laboratory equipment, and concept for the first time.

Data from which no information was taken:

- Student surveys

Assessment

When asked about qualities of an *ineffective* GTA, GTA 9 stated that himself was not prepared for questions from students about losing points and marking questions wrong. Through teaching his first semester, he realized he always needed a reason for "marking-off" points from students' assignments. This should have been a discussion point for the GTA orientation and will be included in future GTA training activities.

GTA 9 posed questions to his students during his kick-off to increase engagement and determine student familiarity with various parts of the experiment they were familiar with. His kick-offs were generally lengthy with the first two sections in the first set of observations lasting upwards of 25 minutes. During the first section, the observer only noted two posed questions to the class, but the second section kick-off included five posed questions. The first section during the second set of observations included three posed questions, with the second section having eight. Finally, in the third set of observations, GTA 9 posed eight questions to the first section and eleven in the second section. As the semester progressed, GTA 9 increased the number of posed questions he included in his kick-offs. This would indicate he was working to positively increase the engagement of his students with the material. While GTA 9 did not participate in TAIA 7, he actively worked to assess his students from the start of class.

During kick-off, the observer noted that GTA 9 would leave information on the whiteboard for students to reference throughout the period. Students could be refreshed of the information while listening to the kick-off but still have something to refer back to

once they began their application questions. This could be helpful if students did not follow along during the kick-off or if they became confused later in the experiment.

Data from which no information was taken:

- Student Surveys

Higher-Order Thinking Skills

After teaching his first semester, GTA 9 commented during his second interview that compared to high school students, the introductory chemistry students had a "level of knowledge" that "was higher." GTA 9 stated he "didn't have to include as many basics" for these students. The topics being discussed were more complex in the amount of information and level of comprehension by way of the students. GTA 9 recognized this difference and adjusted his teaching accordingly.

Similar to GTA 6, GTA 9 mentioned providing students with connections between the days experiment topic to "main points from research." This could be a great example of promoting higher-order thinking skills by providing examples to students of the importance of the days experiment. It could get them to think about how else the days experimental topic might be utilized in a real-world example.

Data from which no information was taken:

- Observation data and comments
- Student surveys

Summary

Overall, GTA 9 taught his students successfully and appeared to have created an environment of good rapport with students. He often called students by name, talked with them before class, and was attentive to their needs throughout the class. His kick-offs were thorough, if not a bit long initially. GTA 9 was observed including safety notes during his kick-offs in the second and third sets of observations, after the completion of TAIA 1 on safety.

GTA 9 seemed to have a good awareness regarding the impact of his verbal and nonverbal communication with his students. His classes leaned toward a more instructor-centered environment by virtue of the number of GTA-initiated interactions compared to student-initiated interactions, which is common for a first-year instructor. He was respectful of his students' personal space, both physically and intellectually. He worked with his students so they could discover the correct answers and build connections for themselves with his guidance. His students responded positively regarding his willingness to help and his approachability. Perhaps ideas from TAIA 2 regarding interpersonal skills and behaviors reinforced GTA 9's methods. He had many interactions with his students and showed consistency throughout the semester of inducing positive interactions. He also provided suggestions to fellow GTAs during research study sessions of ways to approach and talk with students at an appropriate level. He was willing to learn about teaching and share his experiences to help other instructors.

His approach to the application questions and analysis portions of the experiment were positive. GTA 9 handled student questions appropriately and better than could have

been expected for a first-year GTA. Likewise, when teaching laboratory techniques, GTA 9 was clear and consistent in his approach to teaching. He chose a teaching method that was appropriate and induced learning of the material by his students.

GTA 9 learned after teaching his first semester that he "didn't have to include as many basics" to help the students learn more complex information. Once he realized this, he adjusted his teaching accordingly and was able to include information that could stretch the students' knowledge. This topic was reference in discussion with TAIA 6, and GTA 9's flexibility in his teaching approach occurred without participation in this TAIA.

One topic GTA 9 brought up in his final interview involved marking-off points for grading. While grading information/techniques were included in orientation sessions, further direction and clarification may be required and be revisited regularly. This is a point of contention for students because any deductions should be justified. Grading is a form of assessment but was not specifically included in TAIA 7. GTA 9 acquired this grading awareness without participation in TAIA 7.

Overall, GTA 9 may have been impacted by his participation in TAIA discussions in the following ways:

- Additional emphasis on safety, through TAIA 1
- Reinforcement of appropriate verbal and nonverbal cues given to students, through TAIA 2;
- Appropriate, clear, and consistent handling of analysis questions and teaching laboratory techniques, through TAIAs 3 and 4.

GTA 9 needs opportunity to refresh one of the TAIA topics including:

- Utilizing nonverbal cues from students to determine if they were following his explanations, TAIA 3.

CHAPTER 5—CONCLUSION

In this chapter I will conclude with the findings of this study by revisiting my research questions. I will include the attributes Laboratory Coordinators and students seek in a GTA. Additionally, I will review how the teaching approach of the selected GTAs has changed as a result of participation in the Teaching Assistant Intervention Activity (TAIA). Also, I will review various mentioned aspects of teaching made by the GTAs discussed in case studies. Finally, I will offer recommendations for applications and future research as well as changes that will further enhance the impact of the TAIA professional development for GTAs.

What attributes do students seek in a GTA?

Students have preferences when it comes to the methods their instructors use to direct their learning and the classroom. When asked to share characteristics the students mentioned several topics to be "helpful" and provided many different comments in their responses. Below, the comments have been categorized according to the TAIA topics to which they align. Some comments were mentioned in multiple sections due to their adaptability across different issues. Overall preferences from students regarding GTA characteristics for each topic is included in Table 14.

Safety

Regarding safety, students preferred GTAs who were "serious about safety" and those who made "sure rules about safety are being followed." Students also appreciated a GTA who "kept order in the lab" to help them "finish and understand." One student found it helpful when the GTA went "over what we need to know before we start," which could have included safety procedures associated with the day's experiment.

Interpersonal Skills and Behaviors

Students found it helpful when their GTA communicated "clear expectations," was "helpful and kind," was "friendly before class," and "doesn't make you feel stupid." A GTA who was "charismatic and professional," "tried to be as clear as possible" in their explanations and would re-explain when needed was also preferred by students. When the GTA "doesn't make you feel unintelligent when asked questions," the students responded positively.

Characteristics such as being "patient," "easy to talk to," and "very approachable" were found to be helpful to the students. Quick responses to emails and questions were positive actions by the GTA. Additionally, students commented that when the GTA was "in a good mood when answering questions," "very happy to be here," and having a "positive attitude," these actions were cited as desirable by students. One student included when the GTA "wants us to succeed" he/she found their guidance more helpful.

Analysis

When working through analysis and application questions, students found it helpful when the GTA "explained things" in a way that "helps us better understand things." A GTA who was able to explain well was highly desired by the students. Another example of this provided by students was of a GTA who was "very great at helping us walk through the lab," and included "extra information." One student appreciated that the GTA was "being understanding…when I don't understand something and being able to explain it in another way." When the GTA "connects material in class to the lab and helps walk us through an explanation when we have a question." One student mentioned that when the GTA explained the information well, it "makes the information easier to digest" and "allows me to figure out what I need to do faster."

To help with analytical problems, students preferred a GTA who "provided equations/goes over the worksheet in the kick-off." When the GTA "has things written on the board as soon as we get to class, this helps a lot." Another student added that a helpful GTA "overviews the entire lab and makes sure we know what we are doing before we start." This helped students "understand where we are going in the lab so it's a clearer vision than just reading." The GTA "showing how to do each thing and helps teaching how to do the problem/experiment" were included as helpful characteristics.

Additional comments of helpful characteristics from students included: "isn't lazy and tells us to figure it out," "won't just give the answer but helps us work for it," "guides students to an answer," and "starts to explain what we are doing and what we should see." One student included the GTA's "ability to show us the way to do things in a

sensible way rather than just telling us to ‘look at the text’” was beneficial. A student included that their GTA was helpful by making “us answer and learn from our mistakes” this “helps us learn new information.”

Laboratory Techniques

When the GTA was “willing to demonstrate techniques” and was “very great at helping us walk through the lab,” were helpful characteristics mentioned by the students. When the GTA “gives clear and detailed overview of how to proceed with each step,” was “forthcoming with information that is important to the lab during kick-off,” and “goes through problem spots in the procedure” were also qualities mentioned by students. Students found it particularly helpful when the GTA “provides disclaimers about where we could go wrong” as the “disclaimers keep us aware of what could go wrong.” Being able to “continue with experiments” was a main goal listed by students. In addition, the students found it helpful when the GTA “tries to help manage our time in lab.”

Group Process

One student found it helpful when the GTA “comes around [the classroom] a lot so we can ask questions and checks in to make sure the lab is going okay.” The GTA was ensuring the students were on task, was available to answer any questions, and could have been ensure all students were participating.

Working with Students of Differing Abilities

Students preferred when the GTA “guides students to an answer without saying what the answer is,” and ones who provided information on the board for use during the

kick-off and experiment. One student stated that the "kick-off gives an idea said out loud; puts everyone on the same page; keeps formulas and important directions out to see." A GTA who was "helpful when you ask questions and helps you find the answer" were key characteristics mentioned. The inclusion of visual learning tools such a PowerPoints were mentioned to "give [a] visual for what we are going to do" and preferred by students.

Assessment

As mentioned in the *Interpersonal Skills and Behaviors*, students appreciated a GTA who "set clear expectations" for the class and upheld the students to these expectations. As mentioned, students found it helpful with the GTA "helps you to think about the questions and doesn't just give you the answer." This was helpful to students, so they were "in charge of" their "own learning."

Higher-Order Thinking Skills

To encourage higher-order thinking skills, students mentioned helpful qualities to include when the GTA provided "extra information…so the students have a better understanding." Additionally, the "way [the] GTA connects material in class to the lab and helps walk us through an explanation when we have a question" was another characteristic students found helpful. When the GTA "always has an analogy to help you better understand," the students responded positively.

Table 14. Students' Preferred GTA Characteristics

Safety:	**Interpersonal Skills and Behaviors:**	**Analysis:**	**Laboratory Techniques:**
• Maintains order; • Ensures safety rules are followed; • Reviews safety procedures.	• Helpful and kind; • Doesn't belittle students; • Approachable; • Has a positive attitude; • Wants students to succeed.	• Explains well and will explain in different ways when needed; • Includes additional information; • Connects the material to class; • Includes information on the whiteboard; • Guides students to the answer.	• Demonstrates proper technique; • Provides disclaimers about trouble spots in the experiment; • Helps students complete the experiment.
Group Process	**Working with Differing-Abled Students:**	**Assessment:**	**Higher-Order Thinking Skills:**
• Checks-in on them to ensure they are working through the experiment.	• Helps guide students to answers • Includes formulas and other important information in the kick-off • Are helpful • Included visuals in explanations	• Set clear expectations • Helps guide students to the answer	• Provides additional information • Connects laboratory material to lecture material • Utilizes analogies and other means of relating the content to the student

What attributes do Lab Coordinators seek in a GTA?

An emphasis on student interactions and complete knowledge of the content were two attributes lab coordinators looked for in a GTA. One coordinator said they "would

want the GTAs to be able to answer student questions correctly and respectfully." In addition, they "would expect the GTA is occasionally walking around the room observing the students, [and] asking if they have questions." A mention of the GTA ensuring the students were following the safety rules was also included. The lab coordinator stated that the GTA "should give an adequate overview to their students so they can successfully know what techniques and equipment set up they are using, what the goal is for the day…" Individuality in regard to the GTAs teaching style was mentioned, but the GTAs should all be giving a similar general overview of the background to the students.

How has the teaching approach changed as a result of the Teaching Assistant Intervention Activity (TAIA)? How are student interactions impacted by the TAIA?

The teaching approach for the GTAs included in the study changed slightly. GTA 6 included comments about appropriate GTA behavior regarding paying attention to students and not becoming distracted in other tasks. This topic was discussed in TAIA 2, and GTA 6's specific description of these interpersonal qualities could be linked to this discussion. He also included comments in his mid-year interview that would indicate connections to TAIA 2 regarding frequency of students asking questions and the need to help them. Student responses from the Spring 2019 semester indicated growth in GTA 6's willingness to demonstrate techniques. He discussed connected his experiences as a student to teaching by describing an instructor "using smaller chunks of material" to explain a concept. This strategy is great for students of all abilities; GTA 6 could have connected this strategy from his time as a student to TAIA 6. He included PowerPoint in his kick-off, a visual tool discussed in TAIA 6. Also, GTA 6 determined during his

second semester that his students were “more focused” and he didn’t “have to explain the basic concepts.” He adjusted his teaching to reflect the ability level of his students while also assessing their knowledge; this could have been a result of TAIAs 6 and 7.

GTA 9 included additional safety messages in his classroom after participating in TAIA 1. One student commented they found “[GTA 9’s] ability to show us the way to do things in a sensible way rather than just telling us to ‘look at the text’” to be helpful. He could have used experiences from participating in TAIA 3 to assist his students. A student commented that GTA 9 “guides students through lab procedure and questions.” His/her use of ‘guide’ was important because it spoke to GTA 9’s teaching approach of helping students perform the experiment but still the student still had control over their learning. GTA 9 was clear and consistent in his approach which was mentioned during TAIA 4 and throughout GTA training.

Student interactions were positively impacted through discussions about relevant pedagogical teaching methods described in the TAIAs. As mentioned above, students found certain characteristics of their GTAs teaching to be helpful, and some characteristics may have changed due to conversations that occurred during TAIA discussions.

What aspects are GTAs interested in learning more about regarding their teaching?

Topics that were not discussed in the TAIAs may be topics the GTAs were interested in learning more regarding teaching. These topics would be great additions to the TAIAs in the future:

- A scenario where the GTA becomes impatient or angry about students asking questions (TAIA 2);
- Promoting "student-centered" classrooms instead of "instructor-centered" (TAIA 2)
- Importance in flexibility in the classroom and adjusting when necessary (emphasis in all TAIAs, particularly TAIA 3);
- Encouraging students to do individual research (TAIA 3)
- Appropriate pacing of students as they complete the experiment (TAIA 4);
- The GTA practicing the experiment before class time (TAIA 4);
- Inclusion of strategies to increase student participation (TAIA 5);
- Asking students questions at an appropriate level (TAIA 7);
- Setting clear expectations (TAIA 7);
- Creating focus questions for students (TAIA 8).

Potential changes to TAIAs

Additional scenarios would be added to the TAIAs to increase diversity and to practice situations the GTAs may encounter. Scenario topics would be ones stated to be topics GTAs are interested in learning more about their teaching, above. This would add discussion points to the activities, allow GTAs to share experiences with one another, and promote better collaboration between the GTAs and between GTAs and students.

Changes about the study

If this study were repeated, I would have begun using the online, observation procedure from the first observation so additional data could be included. From this data, I could have expanded the information about number of interactions, interaction initiator information, and comments from the observer to use as a baseline of Cohort 1 GTA. This would have allowed for a more complete study of the Cohort 1 GTAs from the beginning of the fall semester to the end of the spring semester.

Given time restraints, the study for Cohort 2 only contained information gathered during the Fall 2019 session. For a more complete study, monitoring Cohort 2 during a second semester would allow for a more complete comparison of the two cohorts. This would allow the data to indicate more about the consistency of the TAIAs to engage GTAs in meaningful discussion.

Observation data only provided information about how many times and how long interactions were occurring in the lab. A type of data that would have provided meaningful information would be knowing more about what GTAs and students were discussion. In future work, I would audio record the GTA to listen to complete conversations which occurred during interactions between the GTA and students. This would provide more insight into the approaches GTAs took in implementing, or not implementing, ideas discussed during the TAIA discussions.

Finally, more direct interview questions would be asked of GTAs regarding their teaching preferences. Post hoc, the answers by GTAs from the interview questions asked were difficult to connect to the research questions. The interview process of GTAs did not yield the robust data needed to identify how the GTA was impacted by the variety of

professional development made available to them. Were they influenced to change their approach during TA training or weekly meetings with Lab Coordinators? Were they influenced to change due to weekly conversations with the principle investigator? Were they influenced by the TAIA discussions? These sources of data need to be more thoroughly investigated to truly know the outcome of TAIA professional development.

Recommendations to departments about GTA training

Training for laboratory GTAs should be designed specifically for that audience. Laboratory teaching involves different challenges compared to lecture teaching and the GTAs deserve to be prepared appropriately. Laboratory GTA training should include specific topics relevant to that discipline and content. While general training is provided at many institutions, the TAIA provides specific training for the chemistry GTA. It has been shown that learning is best when done within the context of the situation. The TAIA has provided such context for professional development of chemistry GTAs.

GTA training should be continuous throughout the GTAs teaching career. GTAs are professors-in-training. Their career aspirations include accepting a faculty position (research or instructional) at a variety of institutions. The preparation of GTAs for teaching, mentoring, or other concept sharing experiences is vital toward their future success and the continued improvement of education in these settings. Ongoing training will allow for improved understanding of educational processes and theories. Ideas mentioned during orientation are often forgotten about later in the semester or year, but if topics were built on one another, they could be greater emphasized. I recommend that the

TAIA could be the foundation for a professional development program that would prepare graduate students for their future careers.

Overall Summary of Work

The main outcome of this work was the development of an organized, contextual-based professional development program designed for the GTA in chemistry. This type of professional development had not been organized in the past in this way, and this research project has created a process by which GTAs at any institution can be engaged in pedagogical professional development that meets their specified need in the laboratory classroom. Some evidence of success has been outlined here and numerous suggestions for improvements have been given. I believe the TAIA professional development process could be adopted for use at many institutions and would bring about helpful changes to instruction at these institutions.

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APPENDIX A

FACULTY SURVEY DISTRIBUTED VIA EMAIL

Dear Dr. (insert name),

My graduate research includes identifying and implementing strategies that promote effective graduate teaching assistants (GTAs). This identification will include input from Lab Coordinators, students, and GTAs.

Therefore, I am seeking your input for what you look for in a TA who teaches in one of the Lab classes, which you coordinate.

Below are a few questions: you may answer these questions directly, or use them as a starting point to get your thoughts rolling.

1. Regarding content knowledge (and kick-off), how do you know your TAs have enough knowledge to successfully lead the lab section? What do you do to ensure the TAs know enough background information?
2. What do you look for regarding TA-to-student interactions or overall classroom management?
3. How do you maintain consistent grading throughout your sections?
4. Do you promote individual differences in approaches to teaching, or do you expect repetitiveness regarding delivery across sections?
5. How do you determine if any of your TA would deserve the Haskett Award?
6. When evaluating at the end of the semester, how do you decide whether the TA receives a Satisfactory or Unsatisfactory?

Thank you for your time, and I look forward to receiving your responses!

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPLICATION

Human Subjects Committee

HUMAN SUBJECTS APPROVAL REQUEST

South Dakota State University

___X__Exempt _____Expedited Review _____Committee Review

1. Principal investigator/researcher: Amanda Hyett Phone No. 605-688-6549

E-mail address of researcher amanda.hyett@sdstate.edu

____Faculty __X__Graduate Student ____Undergraduate Student ____Not SDSU Researcher

If student, faculty advisor Dr. Matthew Miller

College/School College of Arts & Sciences Department Chemistry and Biochemistry

(Please use an additional sheet to list names and contact information for others involved with the project.)

2. Project title Implementing and Assessing the Use of a New Strategy for Training Chemistry Graduate Teaching Assistants

3. Sponsoring agency N/A

4. Project period (contact with participants): From 01 / 31 / 2018 To 05 / 30 / 2020

5. Location(s) of study Campus of South Dakota State University, Avera Health & Science Center

6. Number of human participants to be selected Phase 1: 120 Undergraduate Students; Phase 2: 15 Faculty Members; 30 Graduate Teaching Assistants

7. Types of participants to be selected (check all that apply):

__X_Normal Adults ___Pregnant Women ___Prisoners

___Minors ___Fetuses ___Mentally Disabled or Delayed

8. Exemption requested? ___X___ Yes _____ No

__X_Educational Research ___Educational Tests ___Study of Existing Data

__X_Survey/Interview Research __X_Observational Research ___ Food Tasting

(The above do not automatically make a project exempt; it may require expedited or full committee review.)

9. Will any drugs, chemical or biological agents be administered to human subjects?

____ Yes __X__ No *If Yes, include documentation regarding safety from a source other than the manufacturer in METHODS.*

10. Will specimens or samples of tissues, body fluids, or other substances be collected from participants?

____ Yes __X__ No *If Yes, include details of collection, storage, labeling, use, and disposal in METHODS.*

11. Has each investigator involved in the study completed CITI on-line training and filed a copy of the certificate in the Office of Research and Sponsored Programs? __X__ Yes ____ No

12. ***Research Protocol:*** Complete a description of the proposed study following instructions.

13. ***Informed Consent:*** Attach copies of all forms which will be used to obtain the legally effective informed consent of human subjects or their legal representatives, or justification why informed consent should be altered or waived.

14. ***Additional Materials:*** Attach a copy of all surveys, recruitment materials, and any other relevant documents.

Authorized Signatures:

Principal Investigator _____ Date _____

I ____ do __X__ do not wish to appear before the committee

Advisor (if student project)_____ Date _____

Department Head or Dean _____ Date _____

Research Protocol

A. **Objectives:** This study will use new pedagogical techniques to train chemistry graduate teaching assistants (GTAs) with the goal of enhancing chemistry GTA abilities and undergraduate performance in chemistry laboratories.

B**. Participants:** Phase 1: Up to 120 Undergraduate students in Introductory Chemistry Labs. Phase 2: Departmental Faculty will be surveyed via email. Up to 30 GTAs will be observed and interviewed. All TAs will be from within the Chemistry and Biochemistry Department, and at varying years of experience as TAs. TAs will be grouped into two groups; and Group 1: Veteran TAs., and Group 2: New, Incoming TAs for Fall 2018.

C. **Time Required for Individual Participants:** Phase 1: No additional time requested.

Phase 2: All TA participants will meet for at least two interviews. Each will last approximately 45 minutes. Participants will be observed twice while teaching. Observations will last approximately 60 minutes. Group 2 TAs will meet twice monthly through their initial semester of teaching assignment for departmentally required activities associated with implementation of new aspects of TA training. These meetings will last no longer than 60 minutes each.

D. **Compensation to Participants:** No compensation will be provided.

E. **Benefits to Participants:** Benefit to TA participants will be increased training with possible improvement of their instructional techniques and preparation for future faculty careers.

F. **Methods:** Phase 1: The PI will observe Introductory Chemistry Laboratory classrooms to listen to student-pair interactions and to administer student surveys (Found in Appendix C). No conversations will be directly recorded, and only select conversations will be paraphrased. No names or identifying characteristics will be recorded. The paraphrased interactions and student surveys will be used for the development of TA training activities utilized in Phase 2. Phase 2: Department Faculty will be surveyed regarding important attributes for TAs teaching in their classes (Found in Appendix A). Also, TA will be interviewed (audio recorded with note-taking during the interviews) on an individual basis, on two separate occasions (Found in Appendix B). Initial interviews will be used to gather data about what strategies TAs currently use and would like to use in their classrooms. Interviewed TAs will then be observed while teaching. A follow-up, reflection interview will be conducted following the observation. Group 2 TAs will have twice-monthly through the initial semester of their teaching requirement about areas of teaching they find difficult. Activities will be used to discuss selected topics based information gathered from undergraduate observations in Phase 1. Final observations will be conducted for analysis of implementation of group discussion and activities.

G. **Risks to Participants:** Phase 1: No risk to participants. Phase 2: Information gathered from this study will not be utilized for evaluation of TAs for continued employment.

H. **Risk Reduction:** None necessary.

I. **Confidentiality**: Paraphrasing of student conversations, audio recordings and transcriptions of interviews, and observations will be kept on a password-protected computer. Any written information (observation documents) will be kept in a locked filing cabinet in the locked Chemical Education Research File Storage Room. Data will be destroyed three (3) years after the closing of the IRB.

J. **Recruitment:** Participants will be selected by convenience sampling. GTAs within the Department of Chemistry and Biochemistry will be asked to participate. Participation is voluntary.

APPENDIX C

GTA INTERVIEW INSTRUMENT

Interview Instrument

1. How many years (or semesters) have you been a Teaching Assistant (TA)?
2. How would you describe your teaching style? What does a typical class in which you teach look like?
    a. How did the students respond to your teaching style?
        i. Are they engaged? Do they ask questions?
        ii. How is your rapport/relationship with students in the class?
3. What classes have you taught?
    a. If you have taught different classes, was there a difference to your teaching approach in each class?
        i. If yes, how so? And why?
4. What qualities do you feel make an *effective* TA?
5. What qualities do you feel make an *ineffective* TA?
6. Evaluating yourself, you mentioned x, y, and z, regarding qualities of an *effective* TA, which of these qualities do you feel you possess? How did you acquire these qualities?
7. Again, evaluating yourself, you mentioned x, y, and z, regarding qualities of an *ineffective* TA, which of these qualities do you feel you possess? How do you work to counteract them?

8. Thinking back to the Chemistry & Biochemistry orientation, did you find value in the time you spent in the orientation?
    a. What did you like? What have you used from that training?
    b. What did you find unproductive, or something from the training you have not used at all?

9. Have you studied any teaching outside of the orientation you were given when you first arrived at the Chemistry & Biochemistry Department?
    a. If yes, what were these opportunities
        1. What have you taken from these opportunities and utilized in your teaching?

    b. If yes, have you attended any of the Center for Enhancing Teaching and Learning (CETL) workshops?
        i. If so, which ones?
            1. What have you taken from these workshops and utilized in your teaching?

10. Was there anything you had to "learn on the job" that was not included in the orientation or any outside opportunities (like CETL), but you had to work through on your own during the semester?
    a. Give an example, from your first teaching experience, of something that happened which you were unprepared for. How could orientation prepared you for this?

11. What have you learned from being a long-time student?
    a. What teaching tips/strategies have you picked up because you've seen your own professors use them on you?
    b. What teaching tips/strategies have you learned NOT to do because you've seen a professor use it on you?
12. Is there any additional information you would like to include?

Demographic information:

13. What year in graduate school are you?
14. What is your sex?

APPENDIX D

OBSERVATION PROTOCOL

The LOPUS Observation protocol was utilized for this study. Permission was aquired. Original Article citation:

Velasco, J.; Knedeisen, A.; Xue, D.; Vickrey, T.; Abebe, M.; Stains, M., Characterizing Instructional Practices in the Laboratory: The Laboratory Observation Protocol for Undergraduate STEM. *Journal of Chemical Education* **2016,** *93* (7), 1191.

JOURNAL OF CHEMICAL EDUCATION

Article

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Characterizing Instructional Practices in the Laboratory: The Laboratory Observation Protocol for Undergraduate STEM

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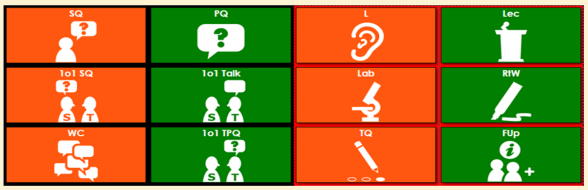
Supporting Information



ABSTRACT: Chemistry laboratories play an essential role in the education of undergraduate Science, Technology, Engineering, and Mathematics (STEM) and non-STEM students. The extent of student learning in any educational environment depends largely on the effectiveness of the instructors. In chemistry laboratories at large universities, the instructors of record are typically graduate or undergraduate teaching assistants (TAs). Despite the importance of their role in the education of undergraduate students, TAs' instructional practices have been largely understudied outside specific reform efforts. In this study, we developed a segmented observation protocol, the Laboratory Observation Protocol for Undergraduate STEM (LOPUS), in order to characterize TAs' instructional styles in a General Chemistry laboratory curriculum. LOPUS captures both students' and TAs' behaviors every 2 min as well as initiators of verbal interactions and the nature of these verbal interactions (e.g., data analysis, explanation of concepts). Analyses of 19 videos collected from 15 TAs resulted in the identification of four instructional styles: the waiters, the busy bees, the observers, and the guides on-the-side. We found that students' behaviors were independent of these styles and limited to performing the laboratory activities, initiating conversation with TAs, and asking TAs questions. Interestingly, students rather than TAs were initiators of most verbal interactions, regardless of TAs' instructional styles. Finally, we found that the nature of TA−student verbal interactions was related to the nature of the laboratory activity (e.g., only following step-by-step instructions versus carrying out extensive data analysis). Implications of these findings for future research investigations and TA training are discussed.

KEYWORDS: *First-Year Undergraduate/General, Second-Year Undergraduate, Upper-Division Undergraduate, Graduate Education/Research, Chemical Education Research, Laboratory Instruction, Professional Development, TA Training/Orientation*

FEATURE: Chemical Education Research

INTRODUCTION

To increase retention of Science, Technology, Engineering, and Mathematics (STEM) majors and enhance the scientific literacy of non-STEM majors, there has been a national call to transform postsecondary instructional practices in lower-level STEM courses.[1−4] These calls have resulted in numerous initiatives across institutions and STEM fields.[3,5−7] These initiatives have mostly been focused on instructional practices in the lecture hall, even though introductory STEM courses often also include a laboratory component. Indeed, students enrolled in an introductory chemistry course typically have a similar number of weekly contact hours with their lecture instructor as with their laboratory instructor. This lack of focus in transforming instructional practices in the laboratory may be connected to the limited empirical investigations conducted in these environments. The National Research Council report on the status of Discipline-Based Education Research (DBER) qualified the strength of conclusions drawn from laboratory studies in chemistry as limited.[5] This report called for more studies in laboratory settings, including explorations of the relationships between student learning outcomes and types of laboratory instruction. Although several studies have been published since

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APPENDIX E

ADDITIONAL INFORMATION ABOUT EACH OBSERVATION CODE

Table A. TAs' instructional behaviors captured in LOPUS

Bolded codes were co-coded with the nature of verbal interactions (Table C, Supporting information). Asterisks indicate codes were modified from or added to COPUS.

Type of behavior	Code	Definition
Typical instructional behaviors	**Lec**	Lecturing to the class
	RtW	Real-time writing on the board, document camera, etc.
	FUp	Providing follow-up/feedback on activity (after quizzes, lab work, etc.)
	D/V	Showing or conducting a demonstration (such as proper use of equipment), simulation, animation, video, or manipulating a physical model (*e.g.* molecular models)
	M*	Monitoring class or individual groups without interacting with students for at least 5 seconds; TA may or may not be moving while doing so
Interactive behaviors	**PQ**	Posing lab-related question or request to student/s with entire class listening (non-rhetorical)
	1o1-Talk*	Talking to individual student or group of students one-on-one
	1o1-TPQ*	Posing a question to an individual student or group of students in a one-on-one interaction
	VP*	Verbal monitoring ("how's it going"-like statements) and positive reinforcement
	TI*	Initiating a one-on-one interaction with an individual student or group of students, coded in conjunction with 1o1-Talk or 1o1-TPQ
Non-instructive behaviors	Adm	Performing administrative tasks, such as lab set-up or clean-up, handing out/retrieving assignments and materials, including laboratory equipment
	W	Waiting, not interacting with students, generally unavailable to students for at least 5 seconds, for example reading notes to self
	O	Other behaviors (see Table C)

Table B. Students' instructional behaviors captured on LOPUS

Bolded codes were co-coded with the nature of verbal itneractions (Table C, Supporting Information). Asterisks indicate codes were modified from or added to COPUS.

Type of behavior	Code	Definition
Typical instructional behavior	L	Listening to TA, video, or student presentations as a class and obviously paying attention (looking at TA)
	Lab*	Performing the lab activity
	TQ	Taking a test or quiz
Interactive behaviors	**SQ**	Asking the TA a lab-related question with entire class listening
	1o1-SQ*	Individual student or a group of students asking the TA a lab-related question
	WC	Engaging in whole-class discussion, including explanations, opinions, and judgments, often facilitated by the TA
	Prd	Making a prediction about the outcome of a demonstration or experiment, including thought experiments
	SP	Giving verbal presentations that require students to explain their data/experiment/results to the rest of the class
	SI*	Initiating one-on-one interaction with the TA, coded in conjunction with 1o1-SQ
Non-instructive behaviors	SL*	Leaving the lab for the day
	W	All students are waiting and not performing any kind of activity due to technical difficulties, waiting for instrument to operate or reactions to occur, TA otherwise occupied, etc.
	O	Other behaviors (see Table C)

Table C. Other behaviors

Behaviors that were not directly related to the instruction of the laboratory were coded as Other (*O*). For example, coders used *O* to describe students and TAs engaging in off-task conversations, such as the weather or an upcoming sporting event. Assignment- or grade-related matters, such as submitting reports or online homework, were also coded as *O*. A list of *O*-coded behaviors are provided below.

Behaviors coded as 'Other' (*O*)
Students • **Reading and signing a safety protocol** • **Retrieving assignments or laboratory reports** **TAs** • **Listening to a student read the safety protocol out loud** • **Speaking to another TA, the lab coordinator, or one of the authors** • **Leaving the room** • **Reminding students about class meetings or upcoming exams** **Students and TAs** • **Engaging in conversations about grading matters or homework** • **Engaging in off-task conversations**

APPENDIX F

TEACHING ASSISTANT INTERVENTION ACTIVITIES (TAIAs)

TAIA 1

Safety in the Laboratory

Objective 1—Teaching Assistants (TAs) will be able to identify their responsibility regarding potential hazards within the laboratory.

Objective 2—TAs will acquire the skill to actively assess ongoing hazards within the laboratory.

Objective 3—TAs will practice the appropriate responses when identifying and encountering student actions which could result in potential hazards.

Why? Safety is a major component within any research or teaching laboratory. Safety concepts should be the same level of importance as chemistry concepts for the students to gain from the activity. The majority of accidents and unsafe incidents that occur could be prevented with a little planning and forward thinking. Unfortunately, accidents do happen, and it is essential to be prepared and know how to respond. Your role as a Teaching Assistant (TA) includes: (1) accepting the responsibility regarding potential hazards, (2) assessing ongoing hazards, and (3) knowing the appropriate responses when identifying and encountering student's actions which could result in hazardous conditions within the laboratory.

Directions: Provide multiple examples to the answers of each question. Consider all aspects of the Situations, those discussed and those omitted.

Situation 1:

The TA has conducted the kick-off to get the students started on the lab and has released the students to begin. About 5 minutes after the students have begun working, a student walks in late. The student is not wearing goggles upon entering the lab and does not put any on before starting to work with his assigned group.

The TA indicated to her forehead and told the student to put his goggles on. The student did as directed and proceeded to continue working with his group.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently

2. Is the student in any violation of any policies of the laboratory?

3. Describe how you would have this situation play out in a more appropriate and safe manner.

Situation 2:

A student is looking to heat a solution of water and sulfuric acid (H_2SO_4). The solution has formed a layer and was not stirred prior to heating. Once heated, the small region of water heats more readily than acid (top layer) results in bumping and "spatter" of the acid. The spattered acid struck the student in the neck. The student was wearing goggles and a lab coat but was distracted by classmates and talking with the instructor.

Questions:

4. Would you have handled the situation differently? If so, what would you do differently?

5. Is the student in any violation of any policies of the laboratory?

6. Describe how you would have this situation play out in a more appropriate and safe manner.

Situation 3:

Student 1: "Can we pour this down the drain?" [While holding a 150 ml beaker containing a solution from the titration of H_2SO_4, $Fe(NH_4SO_4)_2$, $KMnO_4$, $(NH_4)_2Ce(NO_3)_6$].

TA: "Yes" [nods their head]

Student proceeds pours all three trials down the drain.

Questions:

7. Would you have handled the situation differently? If so, what would you do differently?

8. Is the student in any violation of any policies of the laboratory?

9. Describe how you would have this situation play out in a more appropriate and safe manner.

Situation 4:

Students listen to their TA during the kickoff, answering appropriate questions, adjusting for any changes to the lab procedure, and note that the TA mentions to wear gloves while dispensing the chemicals. The TA dismisses the class to begin working and begins to circulate around the room. Students are working safely in their area with gloves and goggles on throughout the entirety of the lab. The TA notices that Sam, a student from one group, leaves the room. Sam returns to lab a few minutes later on and continues collecting data on the LabQuest for each trial. After data has been collected, his partner Alex retrieves his laptop and proceeds to transfer the lab data from the LabQuest to his laptop. At the conclusion of the lab session, all lab equipment is returned to the appropriate locations, the lab area is wiped down, and gloves are disposed of properly.

Questions:

10. Would you have handled the situation differently? If so, what would you do differently?

11. Is the student in any violation of any policies of the laboratory?

12. Describe how you would have this situation play out in a more appropriate and safe manner.

Situation 5:

It is Spring semester, the weather has become warmer during the day, and you have an afternoon lab. As students begin filtering in, you notice that when a student bends over, their back is exposed from where their shirt does not cover. After the kickoff has been completed and the students begin working you notice that a student is wearing a t-shirt, shorts, and tennis shoes. You address the student and the student leaves to change clothes. The student returns in a timely manner and continues working. Thirty minutes into lab and after answering a student's question, you notice they have on a t-shirt, sweatpants, and sandals with socks covering their entire foot. Their partner is wearing pants that do not meet their shoes, and that have holes in the knee area. One of the students who has been in lab becomes agitated at being told they are in violation of the dress code. The student refuses to leave because they are almost done, and you agree to let them complete the lab in their current attire. Meanwhile, all other students are wearing the appropriate attire.

Questions:

13. Would you have handled the situation differently? If so, what would you do differently?

14. Are the students in any violation of any policies of the laboratory?

15. Describe how you would have this situation play out in a more appropriate and safe manner.

Situation 6:

You have just walked into your lab that starts at 4pm. Immediately, students begin filing in and taking their places at the benches. Since there are still a few minutes before lab begins, you step out of the room to use the restroom. You are only gone for a few minutes and return before 4pm. Upon return, you begin writing notes on the board to help you with your kick-off. At about 4:08pm, you survey the room, noting who is absent. At 4:10, you begin your kickoff. During the kickoff, you give a thorough background on the lab for that day, explain and demonstrate the glassware needed for the experiments, and outline important equations the students will need. The students are then told to put on their goggles and start the lab. Following the kickoff, a student points out to you that one of the reagent bottles is low, and you call the stockroom to get more. Students are not able to work on this section of the lab and must work on another section.

You stay at the front, in the "TA space" by the whiteboard checking emails and again reading through the lab until a student asks you a question 20 minutes later. When the student approaches, you notice that they have a gap between their shoes and the bottom of their pants. As it being nearly 45 minutes into the lab, you decide to let it go this time, but tell them to make sure they have appropriate clothing on for the next lab. At the same time you are answering this student's question, a student drops a test tube rack, and two break. The student doesn't know what to do, so they begin brushing the broken glass into a pile with their hands and some paper. After answering the initial student's question, you look around, notice the broken glass, and properly clean it up. While walking to the broken glass container, you notice a student pouring something down the drain. A waste bottle was provided but the student is not utilizing the container. You tell the student that in the future, they need to use the waste container, and do not ask what they poured down the drain.

The experiment the students are conducting requires them to acquire 5mL of 6M H_2SO_4 for three reactions. You notice that a pair of students has a beaker, unlabeled, that has over 50mL of solution. You ask what solution is in the beaker and encourage the students to share with the groups around them since they do not need that much solution.

About an hour and a half of the lab has passed and you have one group that has completed the lab and is beginning to complete the analysis portion. Their area is clean except for a few empty beakers. They have gotten out their computers and taken off their goggles. Meanwhile, other groups are still working with chemicals and glassware. You comment to the nearly finished group that there were still items left at their bench and that their bench was not clean.

Many groups have finished and left at this point. Afterward, you notice that two groups did not put away their glassware from their water bath. You ask one of the remaining groups to rinse out the beakers and put them away in the drawers.

Questions:

16. Would you have handled the situation differently? If so, what would you do differently?

17. Is any student in violation of any policies of the laboratory?

18. Describe how you would have this situation play out in a more appropriate and safe manner.

TAIA 2

Interpersonal Skills and Behaviors

Objective 1—Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to meeting the needs of their students.

Subcategories: academic, social, and emotional needs

Objective 2— TAs will acquire the skill to recognize their student's current status of competency through verbal and nonverbal communication.

Objective 3— TAs will practice and formulate appropriate responses to verbal and nonverbal communication within the laboratory.

Why? As you look around a classroom, you will see 24 individuals with specific needs which include academic, but also social and emotional. Will you be able to look at them and assess these needs? Which signs will they provide to indicate and how will you assess those signs to indicate the competency of each student?

Situation 1:

You have two students that are working alone. One student—male—was part of a group of three but decided to work by himself. Another student—female—her partner came for the first 15 minutes but left to take a phone call and has not returned. You notice that the female student is still reading over the experiment and has not begun to gather supplies. Therefore, you decide to help her gather supplies and end up setting up the apparatus for her. At the same time, the male student has been working alone and as not asked for assistance except for quick questions on reagent locations. Periodically you check on the female student and help keep her going.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

You have begun your kick-off and have asked a question of your students. One student, who is on your right, answers with a response that is almost the correct answer but might not phrased in a way that is scientifically appropriate. You re-ask the question again without responding to the original student. A different student on your left answers with a response very similar to the first but with the wording you had in mind. You praise the second student for her answer. The first student becomes agitated and starts tapping her fingernails on the desk in irritation. The kick-off continues, and you ask another question of the class. The second student answers again correctly, and you praise her for her answer. You finish the kick-off and the students begin working.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

You have an odd number of students that day in lab, thus resulting in a group of three students working together. One student is seen getting the supplies (glassware, chemicals, LabQuests, etc.), while the other two are standing waiting for everything to be gathered. Later on, you notice that the same student who was gathering supplies, is also the student conducting the lab experiment with the others not participating. These two are often seen

looking up and around the lab and not communicating with each other or the other group member.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

TA: "Ben, thank you for reminding me, I forgot to mention to include that we should be using 2mL of the potassium bromide instead of 5mL."

TA: "Class, can I have your attention? Ben has remined me that we should only be using 2mL of the KBr instead of 5mL. Thank you."

Student: "Well, why can't we use 5mL?"

TA: "Becky, we are wanting to ensure the reaction goes to completion but using the extra 3mL would create additional waste we do not need."

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 5:

During the kick-off, you ask the class a question regarding the equipment being used for the lab that day. One student on your left side answers your question correctly. You continue explaining the experiment and pose another question regarding the purpose of doing this experiment. You turn your back to the right side of the classroom when a different student on your left side answers correctly. You finish the kickoff and allow the students to begin working safely.

The students begin working, and you migrate toward the left side to monitor students and wait for questions. You are so focused on watching this side of the class, you miss a group of students looking around for you on the other side of the class. Instead of asking you a question, this group asks a neighboring group who is also confused on where to begin.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 6:

You are scheduled to teach an evening lab that runs from 5pm to 8pm. Earlier in the day, you set a reaction to run for three hours, and started it later than you planned at 4:30pm.

At the end of your kickoff, you tell the students they need to get through the lab quickly and efficiently with a “goal” of them finishing at least half an hour early.

At 7:15pm, you are working to get the last few groups out of the class by doing some of the problems they are struggling with on the board.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

TAIA 3

Analysis

After completing this activity:

Objective 1— Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to encouraging their students to create a process to analyze their data.

Objective 2—TAs will evaluate different pedagogical methods which could be used to help students learn a process for data analysis.

Objective 3—TAs will practice pedagogical methods determined to be of high value for data analysis.

Why? Many students struggle with connecting the data they collected with the purpose of collecting that data. It is your responsibility to assist in their comprehension of the information they collect. Through this activity, you will discuss and practice different pedagogical methods to help students learn a process for data analysis.

Situation 1:

Your students have completed the lab experiment and now have a table of data to analyze. The students are at first unable to retrieve the data from the LabQuest. In their frustration, they manually copy over the data into an Excel spreadsheet. The students are not familiar or comfortable with Excel and are unsure what to do so they can create a graph of the data and add a treadline. You quickly brush them away from the computer and quickly make the graph for them and include all necessary information. The students are unable to keep up with what you are doing.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

Your lab for the day includes quite a few problems involving math. You have noticed that your students struggle with these problems and often become frustrated. You attend lecture regularly and know how the lecture professor approaches and completes the problems. For most students, this method works. But, for this particular group, they did not attend the lecture on this topic and are completely lost. You know that many of the problem follow a pattern, so you work through one problem with them on the board, assisting them through it and providing tips. You leave to check on another group. When you return, the students are still frustrated and unsure where to start on the next question. This time, you help get them started, but make them talk you through the steps. By the end of class, the students are becoming more familiar with this type of problem and are able to work independently with little guidance.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

Your students have completed most of the lab and have moved onto the post-lab questions. Since most of the glassware is put away, you begin grading the previous sections reports and rarely look up. Meanwhile, your students begin working in larger

groups instead of working as pairs. Many students look to see if you are available to answer a question but decide to just guess on their answers instead of bothering you. One pair ends up stopping and just waiting for 5-10 minutes without proceeding. Only one student approaches your desk in a 30-minute period to ask a question.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

It is titration week! A week full of conceptual information regarding what is happening and calculations to verify this knowledge. There is a lot of information to communicate with your students. You have three methods to choose from in conveying this information: (1) all during your kickoff at the beginning of the lab; (2) working with students in small groups once they have their data; or (3) talking with set of 2 students individually and circulating to every group during the lab session.

Below is some sample data that you are trying to explain to the students:

	Trial 1	Trial 2	Trial 3
Beaker mass (g)			
Beaker mass + 1:10 vinegar (g)			
Mass 1:10 vinegar (g)	16.440	15.594	15.185

Volume 1:10 vinegar (mL)	16.407	15.563	15.155
Volume NaOH to equivalence (mL)	13.837	13.443	13.270
Molarity of NaOH (M)	0.101	0.101	0.101
Molarity of 1:10 vinegar (M)	0.085	0.087	0.088
Molarity of undiluted vinegar (M)	0.852	0.872	0.884
Acetic acid content (% w/w)			
Mean acetic acid content (% w/w)			
Uncertainty			

Questions:

1. Which of the three methods would you choose?

2. What are some advantages and disadvantages to the other methods? Be specific and explain.

3. How do the interactions between the TA and students promote a positive learning environment?

4. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

TAIA 4

Lab Techniques

Objective 1—Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to instructing their students on proper and safe laboratory techniques.

Objective 2—TAs will evaluate different pedagogical methods which could be used to help students learn a process to proper laboratory techniques.

Objective 3—TAs will practice pedagogical methods determined to be of high value for promoting proper and safe techniques.

Why? Think back to your first laboratory experience in your chemistry career: were you nervous? Did you already know what to do? Were you familiar with the glassware: where it was located and how to use it? Did you know what deionized (DI) water was and why we use it? These are all questions your students cannot answer until they can experience the laboratory setting. Many of the students you will encounter have never conducted a laboratory experiment. They are unfamiliar with the techniques and practices of how to perform a safe experiment; therefore, they need your patience and guidance to make it through and learn a few things along the way.

Situation 1:

This is the first lab of the semester that the students have encountered the LabQuests. You have students at various points in the experiment: some have already begun and worked their way through the directions, others have not yet started the actual experiment but are gathering materials, and some are trying to decide what items to retrieve from their drawers and the benchtops. You see one group that has started working on the experiment and seems to have a good grasp on how to get the LabQuests going; they have all the accessories plugged in and operating. The group next to them has the materials but doesn't know where to plug in the accessories. You quietly ask the first group to help the second group with plugging in the accessories, while you help a different group with identifying appropriate materials. After this group-to-group encounter, you notice that the students begin first asking another group the simple questions before approaching you.

Questions:

4. Would you have handled the situation differently? If so, what would you do differently?

5. How do the interactions between the TA and students promote a positive learning environment?

6. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

The lab for the day requires the use of a glass pipette and manual pipette bulb. Since you know your students might not have ever encountered this equipment, you decide to demonstrate the appropriate procedure on how to use one, and then have the groups practice with water before allowing them to start the experiment. After the practice session, the students begin the experiment. When the students are at the point of pipetting, you still have to instruct some groups, but feel the students are more comfortable and are better prepared.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

Your experiment for the day includes an extensive set up of an apparatus and use of different types of equipment. Your kickoff is thorough and includes good discussion through questioning about the procedure and the reasons for each step in the procedure. You include drawings and reference information in the lab manual. Your groups are discussing amongst each other and with you about the days plan. The students seem engaged and excited for the days experiment.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

It is week eight of experiments. Your students are asked to make a solution of copper (II) chloride and are told to get 1.15g of solid $CuCl_2$ and mix with 50mL of deionized water. You notice many of your groups are using a 100mL beaker to measure out the water, instead of a graduated cylinder. You slowly work your way around to each group pointing out the importance of using the proper glassware. You initiate conversations with the students on how to know which piece of glassware to use and when to use each type.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

TAIA 5

Group Process

Objective 1—Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to assisting their students through their interactions with group members.

Objective 2—TAs will evaluate different pedagogical methods which could be used to help students to learn the material and how to work with peers.

Objective 3—TAs will practice pedagogical methods determined to be of high value for promoting a productive work environment for all students.

Why? Most all of your students will be working in groups to complete their procedure and finish their assignments. The group environment these students work in highly impacts their success in the class and amount of material learned through their experience. It is important to know how to help students through all group interactions.

Situation 1:

Students are working in pairs while working through a laboratory experiment. You observe that both students are participating and taking turns completing the work. When one student is working on the tactical manipulation of creating samples, the other student is observing. While observing, the student notices that their partner is using 2M NaOH, instead of the diluted base provided by the TA. The observing student quietly asks their partner which concentration they should be using; the pair discuss and refer back to the lab manual, then decide to use the diluted base. One partner completes trials 1 and 2 but observes for trial 3 while the other partner completes the tactical work.

After the "wet" portion of the lab is completed, the students move to analyzing their results. They have read the instructions but are still unsure. They look around for you, but you are facing the other side of the room. Instead of asking you, the pair decides to guess and moves onto another part of the lab.

Questions:

4. Would you have handled the situation differently? If so, what would you do differently?

5. How do the interactions between the TA and students promote a positive learning environment?

6. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

Students are working in pairs while working through a laboratory experiment. You can tell that both students want to participate during the lab experiment. One student is doing all of the relevant manual work, while only allowing participation by their partner through tasks deemed 'low risk' to the outcome of the experiment. It is evident to you that the bulk of the work is shared unequally between the students. The partner is only allowed minimal participation in regard to the manual aspects, observations, and recording of data. When you begin to notice this unequal sharing if responsibility, you walk over and observe the behavior. You choose not to intervene in hopes the partners will sort themselves out. After you leave, you hear the team discussing the next task, but the more dominate student does not allow their partner to have much of any input.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

Students are working in pairs while working through a laboratory experiment. You notice that one student does not want to participate during the lab—neither the

manual work, nor the discussion. This student will only record the data provided by their partner. The students have stopped engaging with each other and complete the experiment mostly on their own. The students complete each of their questions individually and without discussion with each other. Unfortunately, you don't notice the lack of communication between the pair until toward the end of the experiment. Still, you ask the pair for their understanding based on what they have completed. Only one of the partners can explain what has been completed.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

Students are working in pairs while working through a laboratory experiment. One pair seems to be disagreeing with which steps to take. The pair continuously argue, and you notice other groups becoming distracted. You attempt to diffuse the situation by asking the pair to refocus on the experiment instead of arguing. Temporarily the pair settles down. You leave to assist another pair of students. Again, the pair begin arguing and you feel the situation is escalating.

Question(s):

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

TAIA #6

Working with Differing-Abled Students

Objective 1—Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to working with students of varying physical and cognitive abilities.

Objective 2—TAs will evaluate different pedagogical methods which could be used to ensure students of all abilities feel welcome and are able to learn the appropriate material.

Objective 3—TAs will practice pedagogical methods determined to be of high value for promoting a productive work environment for all students.

Why? Your classes will be full of students with diverse backgrounds and abilities. Some may have physical challenges while others have different cognitive abilities. It is important that all of your students feel welcome and encouraged while in your classroom, no matter their differences.

Situation 1:

In your laboratory this semester you have a student who has difficulty using their arms. You do not know the reason for this but are made aware of it from the student on the first day. That first day, you have so much going on with taking attendance, ensuring everyone has the necessary supplies, and getting students going, you don't have much time to talk with the student or his partner. The two begin working together immediately and seem to be getting along as partners and as a working team. Later on during Week 3, you finally stop by and talk with the pair about how they are doing and any challenges they are facing. The student explains that although he doesn't have complete use of his hands and fingers, he is able to handle some glassware and perform some aspects of the experiment. Though, he mostly reads the procedure for his partner and keeps them on track and on time.

Questions:

7. Would you have handled the situation differently? If so, what would you do differently?

8. How do the interactions between the TA and students promote a positive learning environment?

9. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

It is Week 5: you notice that one of your pairs of students seems to be always taking longer than the other groups. When you ask the pair questions, one of the students seems to be able to answer relatively quickly, but the other student takes a bit longer to answer the question. You decide to purposely ask the second student specific questions regarding the lab, and don't allow her partner to answer first. The student is able to answer correctly but requires additional time and sometimes some prompting. When this student does not know the answer, you direct her to the lab manual, but she still is unable to find the correct answer. The background section of her lab manual is well marked with phrases highlighted and underlined. The student has not told you about any cognitive challenges, but you suspect one.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

One of your students talks with you on the first day about having difficulty seeing small printed text. You notice they do have glasses that appear to be of high strength. You tell

the student that they should provide a magnifying glass or some other aid to allow them to read the lab notebook but offer no other assistance. The student begins missing labs throughout the semester even though you have sent many reminder emails trying to reach him. You brush it off as just "one of those" students who couldn't make it through the course.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

One pair of students seems to get through the lab experiments in a reasonable amount of time and has earned high marks on their report sheets. After each lab, this pair always pulls you aside and asks very high-level questions about the material in the lab, lecture material, and chemistry or science in general. You know these students are part of the Honors Program because you have seen some information with their other papers. You suspect these students might be Gifted intellectually, but also seem to struggle talking and working with other teams of students. You work to answer any questions they have after lab, but also get them talking and conversing with other teams of students during the lab period.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

TAIA #7

Assessment

Objective 1—Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to assessing their students and using that assessment to enhance student learning throughout the laboratory class.

Objective 2—TAs will evaluate different pedagogical methods which could be used to determine the level of knowledge displayed by students regarding the experiment and course material.

Objective 3—TAs will practice pedagogical methods utilized within the education community to assess their students.

Why? Assessing students is more than just grading their reports after the completion of the lab. Assessment should be included before, during, and after the laboratory session to ensure students display strong content knowledge of the topic. There are two main forms of assessment: formative and summative. In the laboratory, much of the assessing you will be doing will be formative. This is assessing students in a shorter time frame, either in the moment or during that class period to better suit student learning. Summative assessments are more long-term such as group projects, unit exams, midterms, or final exams to see long-term progress of the students' gained knowledge.

Situation 1:

You students have submitted Pre-Laboratory assignments before your laboratory section. While reading and grading you notice that many of the students are not able to completely describe one of the concepts about spectroscopy. After finishing the grades for Pre-Lab assignments, you begin preparing for your kick-off for the experiment. Since the lab manual describes spectroscopy in great detail you assume that the students will likely realize their lack of knowledge about spectroscopy and through the reading become prepared for lab. You decide not include much of it in your kick-off. You simply mention the pages that have the spectroscopic information and move on.

Questions:

10. Would you have handled the situation differently? If so, what would you do differently?

11. How do the interactions between the TA and students promote a positive learning environment?

12. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

It is early in the semester. One group of students seem to not know where to begin. You approach the group and ask them, “How are we doing? Do you know where to start?” The students look at you and mumble a “Yea.” When asked what the first step was, the students cannot answer and do not reply. You get them to the correct page in the lab manual, and together you read the first steps and discuss what glassware and materials the group will need. The students get started and you move onto another group. Soon after, you return to the group and ask which step they are on. They respond with step 6, where they have completed set-up and are about to begin collecting data. You ask, “What is next? Why are we doing this?” The students cannot reply and look at each other in confusion.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

A group of three students is having a conversation about a topic other than what is being studied that day in lab. You suspect they are lost and not sure what to do next. You approach the group and ask what they have completed. It is determined they have completed the first trial but had difficulty with their data. Together, you and the group analyze the data. You find that every data point is lower than expected. You ask, "What could it mean if all of our data is below what we expect?" The students are unable to answer. "What was that word that we use to describe if all our data is either above or below the expected?" you ask. One student replies "Bias?" "Yep! Now what do we think could have caused a potential bias?" The group discussed possible reasons and suggested possible ways to improve their data. This demonstrates to you that, with prompting, they do have a firm grasp of what went wrong and how to remediate for the future.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

Lab has been completed for this week and you are grading lab reports. You notice that nearly all of your students are not answering a particular question correctly. Of the

students who did answer it correctly, you remember them asking you about it in class and discussing the answer with them. You make a note of the question to discuss at the beginning of the next class period.

At the beginning of lab next week, immediately after handing back lab reports, you bring attention to the question and begin explaining it to the class. After a complete explanation, you poll the students to find out if they now know the correct answer to the question. Only the students who got it correct the first time appear confident enough to answer. You decide to ask students to form pairs for a few minutes to further discuss the question. While listening to a few conversations, you determine the student do know the answer, but are hesitant to give their answers in front of all the students.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

TAIA #8

Higher-Order Thinking Skills

Objective 1— Teaching Assistants (TAs) will be able to recognize their responsibility as it applies to encouraging their students to establish higher-order thinking skills.

Objective 2—TAs will evaluate different pedagogical methods which could be used to assist student's ability to use higher-order thinking skills.

Objective 3—TAs will practice pedagogical methods which could impact student's ability to think in a higher-order, more complex manner.

Why? The object of any course, especially a science course, is to not only communicate new knowledge to the students, but also encourage deeper levels of thinking about the concepts. The students should be able to problem solve, think in abstract ways, and explain complicated ideas.

Situation 1:

Students in your class seem to have different levels of thinking skills based on your conversations and their submitted work. One student seems to be very confident, is able to answer questions from other students, and elaborates on their ideas. You are able to have advanced conversations with this student about how the material in the laboratory experiment connects to real world examples. Another student is less likely to correctly answer questions you ask and when answering, only is able to include basic information without much expansion. You work to get more detail from the student but are not able to make connections with the student on ideas.

Questions:

13. Would you have handled the situation differently? If so, what would you do differently?

14. How do the interactions between the TA and students promote a positive learning environment?

15. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 2:

The experiment for the day's laboratory session involves comparing the structures of different alkanes, alkenes, and alkynes. A few groups of students are having trouble with determining the difference between these three structures, and how the structural differences impact the properties. You do not encourage the students to refer back to previous laboratory experiments. The students only answer the questions with surface level answers and do not work to expand their knowledge.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 3:

You are introducing a new topic for the laboratory experiment. The students are expected to have some knowledge about the topic, but it may not be enough to fully appreciate the

days experiment. You decide to have the students create a list of words on the white board that are associated with the days experiment. One guideline is that the words have to become more advanced in their technical value. After the list is created, you stretch the activity and ask them to show how the words could be connected.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

Situation 4:

You approach a pair of students after watching them for a few minutes. They appear lost based on how far in the laboratory experiment they are compared to other groups. After some questioning, they tell you that they aren't sure where to go next and they don't know why they are doing the assigned steps. The pair of students across the desk appears to be moving through the experiment nicely, so you draw them into the conversation. With some help, you are able to have the second pair explain the experiment and get the first pair reengaged into the procedure. The original pair is now able to ask the second pair questions and keep moving through the procedure.

After a few weeks of lab, you notice the first pair seems more engaged in lab and appears more comfortable with asking the other group questions.

Questions:

1. Would you have handled the situation differently? If so, what would you do differently?

2. How do the interactions between the TA and students promote a positive learning environment?

3. Describe how you would adjust your personal behavior to improve the learning environment in this situation.

APPENDIX G

STUDENT SURVEY CONSENT FORM AND SURVEY QUESTIONS

Participant Consent Form

Participation in a Research Project

South Dakota State University

Brookings, SD 57007

Department of Chemistry and Biochemistry

Project Director: Amanda Hyett Phone No. 605-688-6549

E-mail: Amanda.hyett@sdstate.edu Date 1/31/2018

Please read (listen to) the following information:

1. This an invitation for you as an Undergraduate Student to participate in a research project under the direction of Amanda Hyett.

2. The project is entitled *Implementing and Assessing the Use of a New Strategy for Training Chemistry Graduate Teaching Assistants*.

3. The purpose of this study will use new pedagogical techniques to train chemistry graduate teaching assistants (GTAs) with the goal of enhancing chemistry GTA abilities and undergraduate performance in chemistry laboratories.

4. If you consent to participate, you will be involved in the following process, which will take no more of your time: your laboratory will be observed by the PI, and a short survey will be administered. The conversations observed will be paraphrased for use as in the development of training materials for chemistry GTAs. Your conversations or responses will not be linked to you by any identifying characteristics.

5. Participation in this project is voluntary. You have the right to withdraw at any time without penalty**.** If you have any questions, you may contact the project director at the number listed above.

6. There are no known risks to your participation in the study. No identifying characteristics will be recorded.

7. There are no immediate benefits to you.

8. There is no compensation for your participation in this study.

9. Your responses are strictly confidential. When the data and analysis are presented, you will not be linked to the data by your name, title or any other identifying item.

As a research participant, I have read the above, have had any questions answered, and

agree to participate in the research project. I will receive a copy of this form for my information.

Participant's Signature _____ Date _____

Project Director's Signature _____ Date _____

If you have any questions regarding this study, you may contact the Project Director. If you have questions regarding your rights as a participant, you can contact the SDSU Research Compliance Coordinator at (605) 688-6975 or SDSU.IRB@sdstate.edu.

This project has been approved by the SDSU Institutional Review Board, Approval No.: IRB-1802001-EXP

Student Survey

What characteristic(s) of your Teaching Assistant (TA) helps you learn the most about the material content?

How does each characteristic help you to learn the material in this class?

What characteristic(s) of your Teaching Assistant (TA) does NOT help you learn about the material content?

How does each characteristic NOT help your learning of the material in the class?

What is your expected grade in this class? A B C D F

APPENDIX H

COHORT 2 ADDITIONAL STUDENT SURVEY QUESTIONS

Think about your TAs behavior over the course of the semester in terms of **safety**; do you believe there has been any change? If so, what have you observed?

Think about your TAs behavior over the course of the semester, in terms of **interpersonal skills and behaviors**; do you believe there has been any change? If so, what have you observed?

Think about your TAs behavior over the course of the semester, in terms of helping you through the **analysis**; do you believe there has been any change? If so, what have you observed?

Think about your TAs behavior over the course of the semester, in terms of teaching **lab techniques**; do you believe there has been any change? If so, what have you observed?