

## DESIGN FEATURES OF AN EFFECTIVE AND THEORETICALLY GROUNDED TRAINING PROGRAM FOR UNDERGRADUATE TEACHING ASSISTANTS IN THE LIFE SCIENCES

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Research over the last decade has indicated that active learning and student-centered instruction lead to better learning outcomes in undergraduate biology courses than traditional methods such as lecturing. This shift in pedagogical approach has been applied to both high-enrollment lecture-based courses as well as smaller laboratory courses. In these laboratory courses, the primary instructor is often a graduate or undergraduate student teaching assistant. Such novice instructors often lack the pedagogical knowledge and experience to implement student-centered instructional practices such as inquiry effectively. Therefore, to fully realize the benefits of inquiry-based laboratories for undergraduate students, the instructors of these courses require support.

In this paper, we present a design case for a theoretically and contextually grounded professional development program that provides pedagogical support for undergraduate teaching assistants of a college biology laboratory course. Four undergraduate teaching assistants participated in our 12-week program. These participants were assigned weekly readings, turned in periodic reflective writings, and met with an experienced teaching mentor (Thompson) on a monthly basis. As designers, we grounded our design in the current literature but also built-in flexibility to be responsive to participants' needs throughout the experience. Participants found it challenging to reflect on pedagogical strategies early in their experience, but found the additional support provided by the program very useful as they developed. Finally, we discuss the participant feedback that is being incorporated into future designs of professional development programming.

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<https://doi.org/10.14434/ijdl.v11i1.24129>

## INTRODUCTION

Over the last decade, there has been a clear call to shift the instructional methods used for teaching undergraduate biology courses (Brewer & Smith, 2011; Olson & Riordan, 2012). We now know that active learning approaches to teaching science (such as students speaking with a partner, giving and receiving peer feedback, and other hands-on learning) lead to better science outcomes for undergraduate students as compared to non-active learning approaches (Freeman et al., 2014). In light of this evidence, many institutions of higher education have begun shifting their undergraduate biology curriculum focus to a more student-centered approach. This shift has been documented in traditionally lecture-based courses (McClanahan & McClanahan, 2002; Sivan, Leung, Woon, & Kember, 2000; Walker, Cotner, Baepler & Decker, 2008), as well as in laboratory courses where students spend their time participating in inquiry activities (Thompson, Neill, Wiederhoeft & Cotner, 2016; Weaver, Russell, & Wink, 2008, Cotner and Hebert, 2016).

Many laboratory courses have shifted from “cookbook style” experiences — where students follow procedural instructions from a laboratory manual to test a narrow, specified experimental question — to more open-inquiry and student-centered experiences. Despite this shift, there has been little change in the pedagogical practices of those teaching the laboratory section (Lord & Orkwiszekski, 2006). Moreover, laboratory course instructors are often graduate or undergraduate teaching assistants (TAs) with little-to-no teaching experience. As students themselves, their exposure to college-level inquiry-based labs may be limited, as the majority of coursework offered is content-driven and lacks fundamental aspects of inquiry, such as students posing their own questions and designing approaches to answer such questions. Though they are often the primary points of contact for many college laboratories sections, many TAs lack the experience necessary to facilitate science as inquiry effectively. Few TA preparation programs provide specific pedagogical support for TAs; instead, the focus is often on ensuring TAs have mastered the content they are expected to deliver (Dotger 2010). Therefore, when undergraduate TAs are asked to serve as facilitators of inquiry, they have very little experience or education to draw from.

While some studies have attempted to evaluate and describe effective preparation programs for graduate TAs (e.g., Barrus 1974; Clark & McLean 1979; Roehrig, Luft, Kurdziel, & Turner 2003; Rushin et al., 1997), comparatively little information exists for undergraduate TA programs, particularly in laboratory settings (but see Romm, Gordon-Messer, & Kosinski-Collins 2010 and Gormally, Sullivan & Szeinbaum 2016). Undergraduate TAs can serve as a vital piece of the academic puzzle, providing a level of instructor contact that cannot be facilitated by a faculty member alone in large college courses. Therefore, pedagogical support-focused

programs for TAs have the potential to improve the educational experience for many undergraduate students drastically. In this paper, we present the design case for a theoretically and contextually grounded undergraduate professional development program for laboratory TAs in introductory biology courses at a large research university. Our design team consisted of three faculty members and three graduate students that collaborated on the design and implementation of the professional development program. Initial design conception started with an informal conversation between Thompson and Cotner about the current state of pedagogical support for teaching assistants in their department. The entire design team was then assembled to complete the remaining design stages, which included the following: developing learning outcomes, deciding on theoretical program frameworks, identifying program materials, structuring program content sequence, and creating program activities/assessments. Here we explain our design decisions made and detail the specific design features of our program along with the design challenges experienced during its initial implementation.

## CONTEXT

### Institutional Background

Over the past 5 years, our institution has begun to integrate student-driven inquiry experiences into all of the biology laboratory courses taught through the College of the Biological Sciences. Given that the institution requires all students to take at least one biology course before graduating, nearly every undergraduate (both students majoring in a science discipline and students majoring in non-science disciplines) will have at least one scientific inquiry experience before they graduate. The number of laboratory sections offered necessitates the use of TAs in these courses. Each academic year, ~100 TAs are employed to teach in 115 lab sections. The TAs for our introductory biology courses have quite a bit of autonomy in determining how they run their classrooms (despite a defined laboratory curriculum) and are the primary points of contact for 16-24 students per laboratory section. The TAs prepare for each session, help develop lesson plans, run all laboratory activities, grade assignments, and also implement multi-week, open-ended inquiry labs.

In the process of transitioning to inquiry-based lab exercises, our team realized that obtaining the high level of student success that we expect to achieve from these experiences, requires better supporting the TAs in charge of facilitating these lab experiences. Therefore, we designed the *Building Excellence through Scientific Teaching* (BEST) program as a workshop series to support the implementation of Scientific Teaching (as defined by Handelsman et al., 2004) by TAs. Scientific Teaching is a pedagogical framework that emphasizes using empirically validated teaching strategies to facilitate student learning. It is composed of three core areas:

active learning, assessment, and inclusive teaching. These three core topics were used as the basis for our programming. The goal of the BEST program was to provide novice TAs with professional development that better equipped them to facilitate inquiry-based laboratory courses. After completing this 12-week program, we intended for each TA to be well-equipped to lead their students through a scientific inquiry experience and also to develop as a scientist and science educator. This paper describes the design and implementation of the first iteration of the BEST program.

### **Description of Focal Course**

The first offering of BEST centered on TAs for one non-majors introductory biology course. This course, "The Evolution and Biology of Sex," is a theme-based course that approaches the study of biology from the lens of the evolution of sexual reproduction and includes discussion of reproductive biology, sexual orientation, operational sex ratios, sexual selection, and mating systems. The "Sex Class," as it is called, has the dubious distinction of consistently enrolling the most science-phobic students at our institution. However, presumably due to the appeal of the content, it is the most popular of the non-majors offerings, filling to capacity before any other course. Students in the Sex Class tend not to have much interest in science in general, and rarely have extensive experience with advanced science courses in high school, for example, or science-focused extracurricular activities.

Sex Class TAs lead between two and four, 24-person lab sections, in a curriculum that includes single-week (or two-hour) inquiry labs (such as testing hypotheses about condoms, human sperm competition, and human population growth), a few "cookbook style" labs, and one multi-week inquiry lab.

### **Description of Enrolled Teaching Assistants**

Four undergraduate TAs voluntarily enrolled in the first iteration of the BEST program. All four participants had no prior teaching experience at the university, although one of the TAs had previously taught in a summer language program in their home country. Each of the TAs had taken advanced biology courses in the College of Biological Sciences but had not taken the specific course that they were now teaching. Three participating TAs were female, and one TA was male. One TA was an international student. To preserve the anonymity of the participants, gender-neutral pronouns are used throughout the text, and no pseudonyms are assigned. Instead, we present quotes from TAs in an unidentifiable manner.

Participating TAs each taught two lab sections of the focal course described earlier and completed the BEST program in addition to their required weekly TA meetings where laboratory logistics, safety instructions, and the upcoming week's lab content would be reviewed. TAs were compensated \$500 to encourage participation and honor the time

they devoted to the BEST program, which we anticipated being about two-three hours per week over the 12-weeks of programming.

## **EARLY STAGE PROGRAM DESIGN**

### **Description of Design Team**

Our design team consisted of three faculty members and three graduate students. Two faculty members (Brown and Roehrig) and two graduate students (Andicoechea and Zhao) represented the College of Education and Human Development. The College of Biological Sciences was represented by one graduate student (Thompson) and 1 faculty member (Cotner). The faculty members on the design team covered a range of career stages with one Full Professor and two Associate Professors. The designers from the College of Education and Human Development brought an established expertise in teacher professional development to the design team, whereas the designers from the College of Biological Sciences brought expertise in teaching undergraduate level biology and the framework of Scientific Teaching.

Thompson took the lead role on the design work, working closely with Brown and Cotner to conduct the literature review and identify the important design structures such as providing sustained support for TAs with weekly contact points, and the opportunity for an action research project at the end of the experience. The design team elected to use a literature review approach to defining critical design features to produce a theoretically-grounded program. After these design structures were identified, Thompson created the preliminary schedule of the programming and presented it to the design team to gather feedback on the scope and sequence of the design. This initial design phase occurred over an approximately three-month time period. After this initial phase, semiweekly design meetings were scheduled with the entire design team to review the program implementation, discuss the effectiveness of each design feature as it occurred, and decide if any modifications to the design plan were needed for the coming weeks. Andicoechea, Zhao, and Roehrig gave critical feedback on the design framework during these meetings, particularly focusing on effective ways to assess the impact of our programming.

The BEST program was implemented by Thompson, who also served as the experienced teaching mentor for program participants. Thompson was chosen because of scheduling availability (being a graduate student afforded a more flexible schedule) and because Thompson had served as both an undergraduate teaching assistant (3 years), graduate teaching assistant (additional 3 years) and co-instructor for a graduate-level course on facilitating student inquiry in science classrooms which was closely aligned to the experiences of the TAs participating in the program. This variety of experience gave Thompson a strong understanding of the

role the participating TAs were playing in their classroom and also the necessary experience to help mentor them in their teaching.

The semiweekly design team meetings continued throughout the implementation of the program in order to facilitate continued reflection and adjustment to program features throughout the implementation cycle. During these meetings, Brown, Cotner, and Roehrig focused on program assessment, such as writing interview questions to identify TAs attitudes towards student-centered teaching and determining the observation protocol for TA video analysis. Ultimately, the Laboratory Observation Protocol for Undergraduate STEM (LOPUS; Velasco et al. 2016) was chosen as the appropriate protocol because it most closely aligned with the context of instruction. Andicoechea and Zhao helped provide logistical support for Thompson during implementation (such as helping to organize the video recording of participant's lab sections). Collaboratively, the entire design team reviewed the effectiveness of each design structure, brainstormed ways to improve the programming, and decided if changes to the implementation plan were needed. Ultimately, Thompson made the final decision on implementation changes for the BEST program.

### **Design Exploration**

Based on his experience as in the College of Biological Sciences, Thompson felt that during his early years as a teaching assistant, he often lacked appropriate support for developing his teaching practice in a way that would better serve his students. In his experience, support for teaching assistants was limited to content coverage and basic logistical support. This background motivated his desire to explore this design project.

The design process began after a conversation between Thompson and Cotner about the lack of professional development offered to teaching assistants in the College of Biological Sciences. After this conversation, it was decided that an optional professional development program should be made available to teaching assistants in the College of Biological Science. To leverage the expertise of the College of Education and Human Development, Brown and Roehrig were then contacted about collaborating on the design of the program.

### **Identification of the Problem of Practice**

The design of the BEST program was initially identified by Thompson and Cotner. The College of Biological Sciences relies heavily on undergraduate and graduate student teaching assistants (TAs) to facilitate the laboratory sections of the introductory biology courses. However, historically, our undergraduate TAs have not been trained in pedagogy. Instead, our previous training efforts have focused on familiarizing TAs with the logistical needs and content of the laboratory

during weekly meetings that preview the upcoming weeks' lab activities. This has left many TAs struggling to facilitate inquiry in the laboratory effectively. For example, TAs often have trouble engaging students in laboratory material and motivating students to participate in laboratory activities actively. For TAs to achieve the goals of our inquiry-based biology laboratory courses they must understand both (a) the philosophical underpinnings of Scientific Teaching (b) strategies for facilitating student learning in an inquiry-based laboratory. Identifying this problem of practice allowed Thompson and Cotner to focus the unifying theme of the program on Scientific Teaching (Handelsman, Miller, & Pfund, 2007), because this framework was closely aligned to the professional development opportunities for teaching faculty members within the authors' department. After identifying this initial framework, Thompson started working with Brown to review the relevant literature and develop a complete theoretical grounding for the program in order to provide a strong base for the subsequent design decisions.

### **Literature Review and Theoretical Grounding**

The lead designers on the literature review and theoretical grounding were Thompson and Brown, with Cotner and Roehrig contributing support. We began the BEST program design process by conducting a literature search to identify the most important aspects of successful professional development programs for inexperienced TAs. Given the relative paucity of information on specific design structures important to TAs in biology, we expanded our literature search to include programming designed for TAs in various sciences and also K-12 teacher professional development programming. This expansion of the literature review was chosen because it allowed for a more completed understanding of the potential design features available to us, even if the context those design features had been previously applied in were not exactly the same as our context. The literature review was summarized by Thompson and Cotner and presented at a design team meeting to build consensus on the scope of the literature review. After discussing the literature review, the design team agreed to incorporate three specific features into BEST programming: weekly professional development activities, mentorship and coaching from an experienced teacher, and periodic classroom observations because previous work had identified these structures as important for promoting sustained changes in developing teachers. The full theoretical grounding and literature support for each of these design structures are summarized in Table 1.

### **Early Design Challenges**

Based on the initial meetings of the design team, there were several anticipated design challenges for the program. First, we anticipated that coordinating the schedules of TAs could be difficult for providing in-person programming.

| BEST PROGRAM GOAL   | DESIGN STRUCTURE  | THEORETICAL GROUNDING  |
|---|---|--|
| <b>Skills for Facilitating inquiry</b><br><br><b>Increased confidence in teaching skills</b>              | Weekly professional development programming focusing on Scientific Teaching   | <ol style="list-style-type: none"> <li>1. National call for increased engagement in Science, Technology, Engineering, and Mathematics (Olsen &amp; Riordan, 2002)</li> <li>2. Inquiry drives conceptual understanding for students (Minner, Levy, &amp; Century, 2010)</li> <li>3. PD is more effective when sustained over time (Garet et al., 2001)</li> <li>4. Effective PD is imperative for promoting inquiry-based teaching approaches (Pozuelos, Travé González &amp; Cañal de León, 2001)</li> </ol> |
| <b>Incorporation of summative and formative assessments</b>   | Coaching and mentorship from experienced facilitators of scientific teaching throughout the 1st and 2nd teaching semester | <ol style="list-style-type: none"> <li>1. Formative assessment promotes deeper learning by students (Higgins, Hartley, &amp; Skelton, 2002).</li> <li>2. Effective relationships with Thompson promote evidence-based teaching practices (Bradbury, 2010)</li> <li>3. Metacognitive-guided inquiry can enhance gains in inquiry skills (Brewer &amp; Smith, 2011)</li> </ol>   |
| <b>Increased confidence in teaching skills</b>  | Action Research Project   | <ol style="list-style-type: none"> <li>1. National call for Student-Centered learning (Brewer &amp; Smith, 2011)</li> <li>2. National call for increased engagement in Science, Technology, Engineering, and Mathematics (Olsen &amp; Riordan, 2002)</li> </ol>  |
| <b>Active Facilitation of Inquiry in the laboratory</b><br><br><b>Demonstration of Inclusive Teaching</b> | Classroom Observations  | <ol style="list-style-type: none"> <li>1. Classroom practices are major contributors to student learning (Smith, Jones, Gilbert, &amp; Wieman, 2013)</li> <li>2. National call for increased engagement in Science, Technology, Engineering, and Mathematics (Olsen &amp; Riordan, 2002)</li> </ol>  |

**TABLE 1.** Theoretical grounding table providing the literature basis for each of the design structures chosen for the BEST program. Each design structure was chosen to specifically achieve a desired program goal based upon our review of the literature.

Additionally, providing TA training required the collaboration from the course instructors the TAs were working for, another anticipated challenge. Our approach to addressing these anticipated challenges and additional unforeseen challenges is detailed next.

One of the biggest challenges early on was determining what types of support would be most closely aligned with the TAs' needs. Given the relative paucity about undergraduate teaching assistants in biology laboratory settings, it was challenging for the design team to predict what exactly TAs would need support on. To try and address this challenge, our team sent out a short survey to ask TAs about their support needs at the beginning of the semester the year before the BEST program was piloted. Specifically, TAs were asked if they would like more support in the tenets of Scientific Teaching and using evidence-based instructional practices. Of the 15 TAs surveyed, over 60% reported wanting additional support in inclusive teaching practice and facilitating student inquiry. While this confirmed that TAs desired support in these areas, it did not allow for TAs to report other areas that they felt they could use support in at that time. This oversight limited the information available to the

design team during the initial conception of the program, but it did provide a strong context-based grounding for the overall design of the program (i.e., the focus on the 3 tenets of scientific teaching).

Another major design challenge for this program was identifying an appropriate target audience for the pilot program. The current paradigm for TA support at our university relies on course-specific instruction. In other words, the supervising faculty members of each of the biology laboratory courses are tasked with creating and facilitating their own TA support materials and conducting their own TA meetings. This presented a bit of logistical challenge for our design because there was not a central mechanism for engaging a broad set of TAs in a unified development program. This challenge was discussed at length by the design team, and it was decided that Thompson and Cotner would contact the faculty members leading the other biology laboratory classes to try and coordinate a program that could be offered to all TAs. After initial meetings with Thompson, Cotner, and the relevant College of Biological Sciences faculty, it became clear that there were divergent priorities for the skills TAs needed in various laboratory courses and that

coordinating a single program that specifically focused on Scientific Teaching practices was very challenging because we could not build a consensus across the different courses on the fundamental skills TAs needed for each laboratory course. Therefore, the design team decided to offer the BEST program exclusively to TAs teaching in Cotner's course, as this allowed for the most autonomy and control over the design decisions and features for the first iteration.

As a design team, we also faced several challenges with respect to the artifacts of participant learning that we wanted to collect. For example, based on our literature review we had decided that opportunities for peer observations would need to be incorporated into our design plan. However, the logistical hurdles associated with implementing peer-observations and determining the most appropriate artifact to collect from this experience from TAs made us shift our thinking towards using a more familiar approach for our team. This is how we determined we would use video recordings (something we were already doing for a research project on TA instructional behavior). In this manner, we were able to both collect the video itself as an artifact of learning and use the same research observation protocol (described next) from our another project to have TAs gauge their own learning.

Additionally, encouraging participation by TAs presented a challenge for our team. Given that TAs at our university are often taking a heavy course load of their own, conducting research in a laboratory on campus, or participating in extracurricular activities, we predicted that an incentive would encourage TA participation. Therefore, the design team discussed multiple options for incentivizing TA participation and decided on offering TAs a supplemental stipend of \$500 for their participation in the 12-week program. The design team elected for a \$500 payment because it was our best estimate of an appropriate wage for the expected time commitment from TAs based on their contractual hourly wage. Upon reflection, a larger incentive could have been provided to try and encourage a larger number of participants.

## DESIGNING THE BUILDING EXCELLENCE THROUGH SCIENTIFIC TEACHING PROGRAM

### Guiding Principles

Based on the problem of practice identified by Thompson and Cotner, the guiding principles for BEST were modeled the three dimensions identified in the book *Scientific Teaching* (Handelsman, Miller, & Pfund, 2007). The BEST program was divided into three, four-week topics that covered active learning, assessment, and inclusive teaching. Materials to support TA development were largely selected by Thompson after a discussion with the design team at the semiweekly design meetings. This approach provided more contextual flexibility to meet the specific needs of

participating TAs and also to make adjustments to BEST programming throughout implementation. The general schedule for the BEST program is shown in Figure 1. A more detailed description of the weekly activities follows.

Within each of the three dimensions, TAs were asked to: (i) read materials selected (as described earlier) to increase their awareness and understanding of the specific topic, (ii) complete a reflective writing activity where they connected the readings to their own practice in the laboratory classroom, and (iii) participate in an in-person group discussion facilitated by an experienced practitioner of scientific teaching (Thompson) to provide mentorship and strategies for implementing scientific teaching practices. This particular sequence of activities was chosen by Thompson to maintain a consistent exposure-reflection-discussion framework throughout each dimension.

The majority of the program was delivered to participating TAs using the learning management system Moodle (See Figure 2). Moodle was chosen because it is the official learning management system used at our university, and as such all participants had a high level of familiarity using it as a classroom portal. Specifically, all readings and assignment directions were posted on Moodle. Each week, TAs completed any readings and assignments posted on the course page. The Moodle page was also used to set expectations for monthly in-person meetings by posting reflective questions for the TAs to come to these meetings prepared to discuss how they could apply their new learning to their own classrooms.

### Weeks 1-4: Active Learning

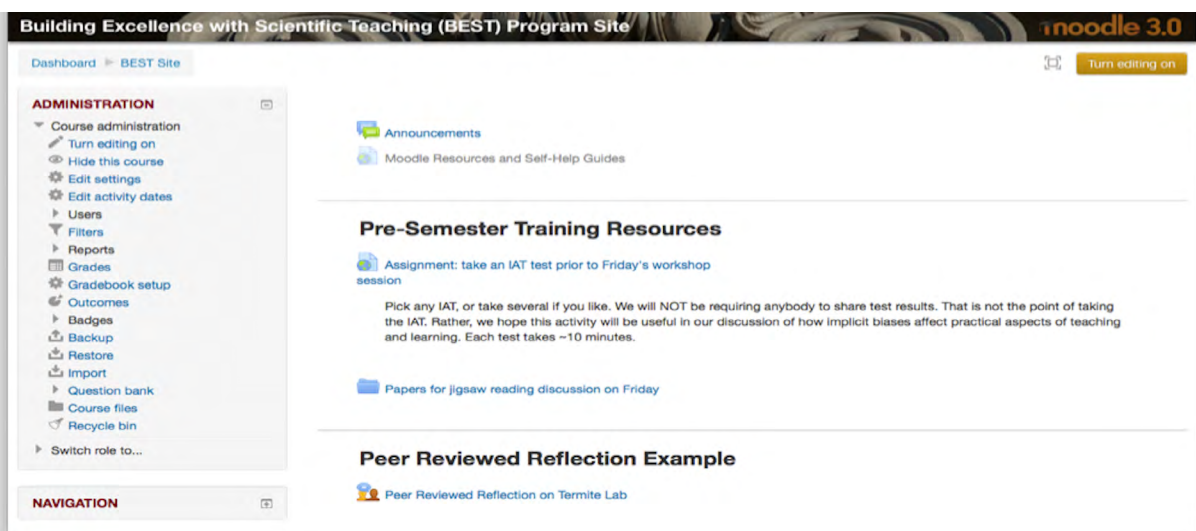
The first topic covered in BEST was active learning. We define active learning as any instructional method used to engage students in their own learning in a way that requires them to be active participants. In the context of the laboratory sections, active learning may manifest itself as active participation in the laboratory activities, student participation in a classroom discussion, or working in groups to solve problems. We situated our programming on active learning within this context, focusing our work with TAs on how to effectively engage all students within their lab sections.

#### *Week One: Introduction to Active Learning*

In week one, TAs were first asked to introduce themselves to one another using a commercially-available online video posting service called *Flipgrid* (<https://info.flipgrid.com/>). During their introduction, TAs shared their motivation for teaching as well as any previous teaching experience they had in other settings. They were also assigned two readings to complete during the first week: *Scientific Teaching* by Handelsman et al. (2004) and "Active learning increases student performance in science, engineering, and mathematics" by Freeman et al. (2014). TAs were required to submit a 1-page

| Week    | Scientific Teaching Dimension | Subtopic   | Readings and Assignment(s) Due  |
|---------|-------------------------------|--|---|
| 1       | Active Learning               | Introduction to Active Learning  | <b>Readings</b> <ol style="list-style-type: none"> <li>1. <i>Scientific Teaching</i> (Handelsman et al., 2004)</li> <li>2. <i>Active learning increases student performance in science, engineering, and mathematics</i> (Freeman et al., 2014)</li> </ol> <b>Assignments:</b> 1-page reflective writing                                |
| 2       |                               | Envisioning Growth   | <b>Readings</b> <ol style="list-style-type: none"> <li>1. <i>The power of believing that you can improve</i> (Carol Dweck Ted Talk)</li> <li>2. <i>Cooperative Learning: Making "Groupwork" Work</i> (Smith 1996)</li> <li>3. <a href="#">Think-Pair-Share handout</a></li> </ol> <b>Assignments:</b> Submit 3 questions about teaching |
| 3       |                               | Active Learning Mentor Meeting   | TAs meet with Thompson in person for discussion and feedback on facilitating active learning  |
| 4       |                               | <i>Process Oriented Guided Inquiry Learning</i> (POGIL) as a Teaching Tool | <b>Readings:</b> <i>Implementing POGIL</i><br><b>Assignments:</b> Online forum submission on using POGIL  |
| 5       | Assessment                    | The Importance of Assessment   | <b>Readings:</b> <i>Inside the Black Box: Raising the Standards Through Classroom Assessment</i> (Black and Wiliam 1998)<br><b>Assignments:</b> <ol style="list-style-type: none"> <li>1. Written reflection on assessment opportunities in their classroom</li> <li>2. Review of laboratory recording</li> </ol>                       |
| 6 & 7   |                               | Individual Mentor Meeting  | Each TA met individually with Thompson to review the video recording of their lab section from the previous week  |
| 8       |                               | Assessment Group Mentor Meeting  | TAs meet as a group with Thompson for discussion and feedback on using assessment in the classroom and to reflect on the usefulness of self-assessment in their teaching  |
| 9       | Inclusive Teaching            | Introduction to Inclusive Teaching   | <b>Readings</b> <ol style="list-style-type: none"> <li>1. <a href="#">Yale Center for Teaching and Learning Diversity and Inclusion Website</a></li> <li>2. <i>Inclusive Teaching Strategies</i> from the same website</li> </ol>   |
| 10 & 11 |                               | Creating an Inclusive Classroom  | <b>Readings:</b> <a href="#">Creating Inclusive Classrooms</a> handout from the University of Michigan<br><b>Assignments:</b> 1-page reflective writing   |
| 12      |                               | Inclusive Teaching Group Mentor Meeting                                    | TAs meet as a group with Thompson to discuss strategies for creating inclusive classrooms. TAs are asked to reflect on missed opportunities for inclusion and ways to improve in future semesters.  |

**FIGURE 1.** Schedule of activities for the BEST program. The semester was broken into three segments, each focusing on a different dimension of Scientific Teaching. Within each topic, participants were asked to complete a number of readings and assignments. Each topic was capped off with an in-person group meeting with the Thompson to debrief on the material and transition to the next topic.



**FIGURE 2.** Screenshot of the BEST Moodle portal. This online learning management system was used to share resources, collect assignments, and facilitate online discussions with all BEST participating TAs.

reflective writing using the two readings and their experience in the first week of teaching as guidance. Thompson created the following questions for TAs to respond to: 1) When did you feel that students were engaged in active learning? 2) When did you feel that students were not engaged in active learning? 3) Are there certain lab periods that were more active than others? 4) Did students behave differently during different lab activities? 5) What problems or struggles did you encounter when trying to facilitate active learning activities? These questions were chosen to get TAs to think about how student engagement is a function of both the students' personalities and also the structure of the course and teaching methods used. Ideally, this would help TAs realize that they can impact student engagement by changing their teaching methods, even if the structure of a particular laboratory experiment is not inherently active.

### *Week Two: Envisioning Growth*

In week two, TAs were asked to watch the TED talk by Stanford professor Carol Dweck, *The power of believing that you can improve*, and submit three questions about teaching that they had been thinking about to an online forum (Figure 3) to help prepare the agenda for the future in-person discussion. This assignment was designed by Thompson to allow TAs to contribute to the content of in-person meetings directly. This gave the program contextual flexibility that allowed for the content to change in response to TAs needs in real-time. These questions could be anything related to their teaching experience (things they noticed in their classroom, the prior week's readings, general questions about teaching, etc.). TAs were also provided materials specifically outlining how to implement a jigsaw activity (Smith,

1996) and [think-pair-share](#) to help link the conceptual topics from week 1 into concrete teaching strategies.

### *Week Three: Whole Group Mentoring Meeting*

In the third week, TAs had their first of three whole group mentoring meetings with Thompson. TAs met with Thompson to discuss active learning and brainstorm ways to facilitate active learning in their lab sections better. Thompson opened the meeting by allowing TAs the opportunity to raise questions about their experiences in the teaching laboratories. Thompson used these questions to facilitate a conversation with the TAs about ways to address their specific concerns. For example, one TA raised a concern about how they should assign seating for students within their lab sections. Thompson turned the question back to the group, asking each TA to discuss how they had decided how to assign seats (and therefore lab groups), and the group collectively weighed the pros and cons of different strategies. The design team felt it was important to start the in-person meetings this way because it provided the TAs with a voice to raise the issues they were struggling with and gave them an active role in setting the agenda for the meetings.

Next, Thompson facilitated a discussion about implementing specific instructional strategies (i.e., a think-pair-share) and addressed questions that were submitted in the week 2 forum. In the first interaction of BEST, TAs questions about active learning generally grouped into two categories: questions on student engagement and motivation as a barrier for active learning (through lack of participation) and how to facilitate student group work. To address these concerns, TAs were asked to share approaches they had

used in the classroom to increase student participation and were allowed to discuss which strategies worked and which strategies did not work with their peers. Thompson also provided feedback on the strategies that TAs were trying as well as other examples of techniques to implement to increase student participation and improve group dynamics.

At the end of the session, Thompson led a conversation on the literature readings and videos from weeks 1 and 2. The following questions were used to guide the conversation: 1) Did you find the evidence provided in the readings persuasive? Why or why not? 2) How have your students responded to active learning so far? 3) How does active learning relate to the video about growth mindset? These questions were meant to gauge the participants' attitudes towards using active learning strategies in their classrooms. Thompson specifically chose to start with the evidentiary basis for active learning because he believed the science background of the TAs would align well with an evidence-based argument for using certain types of instructional practices. The second question allowed participants to express how the abstract concept of active learning was actually manifesting in their own classrooms, an attempt to help TAs connect the literature evidence to their lived experience. The final question probed TAs to think more deeply about why active learning may be effective than other types of instruction and how they can help facilitate the mindset shift in their students that is needed to engage in active learning. The mentor meeting ended with Thompson using instructional modeling to demonstrate how TAs could facilitate a think-pair-share in the teaching laboratory in order to provide more practical support to a concern that had been raised by the TAs in their previous assignment.

#### *Week Four: POGIL as a Teaching Tool*

The final week of the active learning sessions was used to provide materials responsive to the concerns and questions raised by the TAs in the first 3 weeks. By reviewing the transcripts from the week 3 meetings and also the questions submitted by TAs in week 2, Thompson identified a consistent theme of TAs expressing concerns about facilitating group work in the laboratory.

Based on these identified concerns, Thompson selected materials in week four that focused on facilitating group work. TAs were introduced to the *Process - Oriented Guided Inquiry Learning (POGIL)* framework as a technique for facilitating group work within the teaching laboratories (Lamba & Creegan, 2008). POGIL is a very popular tool in undergraduate science education that uses self-managed groups to develop science process skills such as data analysis or hypothesis generation. Thompson was familiar with POGIL from previous conversations he had with members of his department, and based on these personal recommendations from colleagues felt that it would be a

good starting point for TAs thinking about more structured ways to facilitate group work. All resources were provided to the TAs via the class Moodle page. TAs were asked to spend some time exploring specific features of the POGIL website and reviewing available resources. Specifically, they were asked to watch the "[What is POGIL](#)" and read the page "[Effectiveness of POGIL](#)" to gain a better understanding of the POGIL process and show provide data on how effective it is in the classroom. After exploring these materials, TAs were asked to submit a reflective response to an online forum to the following prompt: "For this week's discussion points, please post 1 way you imagine you could use POGIL in your lab sections and 1 barrier you anticipate encountering." The goal of this particular reflection was to get TAs to think about how they could apply a new teaching strategy to a specific aspect of their own course. TAs were asked about barriers because it allowed Thompson to brainstorm ways to support the participants in overcoming these barriers for implementation. Each participating TA was then expected to review the answers of the other TAs and comment on ways they thought identified barriers could be overcome, with Thompson providing additional comments based on his own experience. This allowed the TAs to support each other as peers, while also providing the mentorship from Thompson to fill in as needed. Thompson also reviewed the forum posted and provided insight on additional ways that POGIL could be implemented in their lab sections that had not been brought up by the participants.

#### *Week 5-8: Assessment in the Classroom*

The second chunk of BEST programming focused on how to use assessment to promote student learning. In our context, this meant helping TAs identify ways to improve the types of feedback they were giving their students, primarily in the forms of formative assessments. For example, TAs were responsible for grading student reflections and providing comments to improve their understanding. TAs were also introduced to strategies for embedding micro-assessments, which includes checks for understanding and probing questions into their teaching methods.

#### *Week 5 & 6: The Importance of Assessment.*

In week 5, participants were provided with a reading by Black and Wiliam (1998) entitled "Inside the Black Box: Raising Standards Through Classroom Assessment" and were asked to reflect on opportunities they provided in their own laboratory classrooms for assessment of their students. This reading and reflection combination was used to get the TAs to think about how they could incorporate more formative feedback into their instruction because they could not control the summative assessments in the course. Additionally, TAs had one of their lab sections video-recorded for the first time in this week. Each TA was given a copy of their video-recorded lab section and asked to watch it before

**Active Learning Forum Section**

**Week 2 (3 questions)** • [Subscribe](#)

POGIL ▶

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**Week 2 (3 questions)**  
by [redacted] - Tuesday, September 20, 2016, 11:35 PM

Hello Everyone!

Please use this place to list three (or more) questions that have come up so far about teaching. These can be about anything related to your teaching experience (things you saw in the classroom, the readings we had for this course, general questions about teaching, anything you'd like). Feel free to respond to each others questions if you'd like (for example, maybe you also experienced a similar question during class so feel free to share that here).

[Edit](#) | [Delete](#) | [Reply](#)

---

**Re: Week 2 (3 questions)**  
by [redacted] Wednesday, September 21, 2016, 1:09 AM

Hey [redacted]

Here are some questions that I have had:

1. How do you establish yourself as an important resource for your students? I have offered them my office hours and email numerous times and many have taken me up on them, but I feel as though there are still students who do not know how to ask for my help.
2. What is the best way to respond to students who are making comments that are obviously negatively directed at me?
3. How can I keep students from getting frustrated with themselves and myself while working through difficult topics?

[redacted]

[Show parent](#) | [Edit](#) | [Split](#) | [Delete](#) | [Reply](#)

---

**Re: Week 2 (3 questions)**  
by [redacted] Saturday, September 24, 2016, 6:53 PM

Hi!

One question that I have struggled with these past couple of lab periods is how long to let a student struggle with a problem, and what are the best ways to give them hints as to the solution.

Additionally, I wonder what is the best way to teach people who don't really have the drive to learn or want to learn the material. Luckily, this problem hasn't come up yet, but I think it might later in the semester.

Finally, what are everyone's thoughts on activities like share and pair answers with your neighbors vs just posing the question to the class as a whole right away. I feel like I have seen students get very off track when I pose a share and pair questions vs just posing the question right away and that I waste valuable class time.

Thanks all!

[Show parent](#) | [Edit](#) | [Split](#) | [Delete](#) | [Reply](#)

**FIGURE 3.** Screen capture of the Moodle forum used to collect TA questions about active learning in week two.

the end of Week 6. Each TA was asked to evaluate their video using a [classroom observation worksheet adapted from the University of Nebraska-Lincoln's](#) resources for graduate teaching assistants. TAs were instructed to pay particularly close attention to the sections labeled "Presentation" and "Interactions" to assess their performance. This particular observation sheet was used because it had sections that specifically related to facilitating active learning, which was the previously discussed dimension of scientific teaching. This activity also served as an instructional model for providing formative feedback, as TAs reviewed their own performance and identified areas for further improvement.

*Week 7: Individual Mentor Meetings to Review Video Observations.*

After completing their own self-evaluation of their video recording, each TA met individually with Thompson to discuss their observations. Individual meetings were chosen to allow for candid conversation and feedback sessions for each of the TAs. Each meeting started by having the TA explain how

they had scored their own video section. TAs were asked to identify one area of strength based on their video analysis and also one area for future growth. After that, Thompson discussed their own evaluation of the video recording with each TA. Thompson provided examples from the video recording of both instances where TAs were actively facilitating inquiry and pointed out opportunities that the TA had missed or not fully utilized. Thompson and the TAs then discussed specific strategies that could be implemented by the TA in order to improve their facilitation of student inquiry in the teaching lab.

*Week 8: Whole Group Mentor Meeting on Assessment.*

The second whole group mentor meeting took place in the 8th week and primarily focused on discussing the paper that was read in week 5, "Inside the Black Box: Raising Standards Through Classroom Assessment." This reading was selected for the TAs because of its emphasis on formative assessment strategies. Thompson chose to emphasize formative assessments in this section because that more closely aligned with

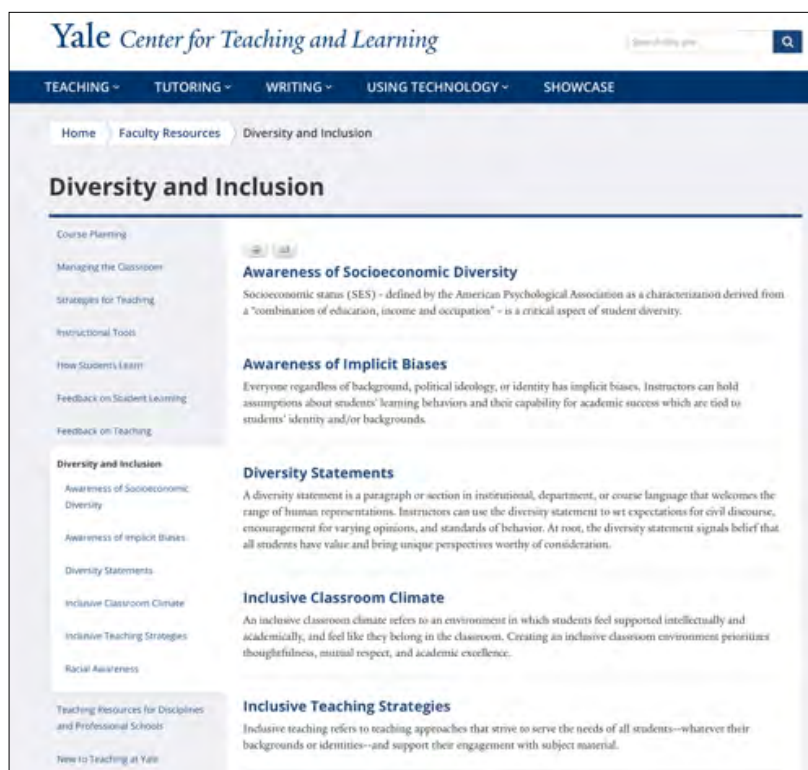
the level of control TAs had over their courses (they did not control the summative assessments). Thompson reviewed the article with the TAs to gauge their understanding of the importance of integrating formative assessments into their classroom and to collectively generate ideas for specific techniques for adding formative assessments into their lab sections. The meeting started with an opportunity to discuss concerns or problems TAs were experiencing. Thompson then facilitated this conversation as each TA brought up issues encountered. This initial period of the meetings proved to be very valuable in creating a culture of professional support among the TAs as they discussed things happening in their lab sections with peers. Thompson primarily served as sounding board for ideas and helped encourage the TAs to provide their own perspective on the topics brought to light. Occasionally, Thompson contributed some thoughts to the conversation, but mostly this time was used to strengthen the relationship between the TAs themselves.

#### *Week 9-12: Inclusive Teaching Practice*

The final topic covered by the BEST program was inclusive teaching. Inclusive teaching refers to using specific instructional approaches that equally value the voices of learners from a variety of backgrounds and abilities. Additionally, inclusive teaching works to promote a classroom environment that encourages participation by all students and respects the different needs of students within the classroom. For BEST TAs, this means facilitating their lab sections in a way that provides safe opportunities for students to discuss course material (given the nature of the course as discussed earlier, this includes facilitating conversations on topics such as sexually-transmitted diseases, sexual abuse, and assault, sexual identity and preference, and numerous other potentially controversial topics).

#### *Week 9: Introduction to Inclusive Teaching Practice*

To start the unit on inclusive teaching, TAs reviewed the [Yale Center for Teaching and Learning's webpage](#) on Diversity and Inclusion (Figure 4). Specifically, TAs were tasked with reviewing the materials under the "Inclusive Teaching Strategies" section header. This assignment was designed to be more freeform, allowing for the TAs to engage in specific strategies that they were drawn to or felt were most relevant to their own experience. This website provides a number of very useful strategies that TAs could implement in their own classroom, including soliciting student feedback on classroom climate and cultivating a feeling of inclusion within the



**FIGURE 4.** Screen capture of the Yale Center for Teaching and Learning's webpage on diversity and inclusion.

teaching lab. Example of the specific topics that TAs could choose to review are awareness of socioeconomic diversity, awareness of implicit biases, inclusive classroom climate, and racial awareness. These topics provided important lenses for TAs to apply to teaching with the intention of forcing TAs to more deeply consider the biases that may exist in their classrooms.

#### *Week 10 and 11: Reflecting on Creating an Inclusive Classroom.*

Following their week 9 introduction, TAs were given a [handout from the University of Michigan on creating inclusive classrooms](#). This document helps TAs identify typical problematic assumptions in STEM classrooms and provides practical ways to address these through teaching (Figure 5). For example, one assumption raised in this handout was that students would seek help when they are struggling with their learning. To combat this assumption, the handout reminds TAs to check in with their students to gauge their understanding and also consider ways to try and remove barriers (such as social stigma) for students seeking help with their learning

As a follow up to the reading, TAs were asked to respond to the material in a 1-page reflective writing assignment addressing the following four questions: 1) Why do some types of students seem to participate more frequently and learn more easily in my course or field? 2) How might my cultural

## Increasing Awareness of Problematic Assumptions

An important early step in developing competencies to address multicultural issues in the classroom is to raise your awareness of issues that are multicultural and how they might manifest themselves in classrooms. In this process, it is useful to give consideration to assumptions that you may hold about the learning behaviors and capacities of your students. You may also hold assumptions that are tied to students' social identity characteristics (gender, race, ethnicity, disability, language, sexual orientation, etc.). These assumptions may manifest themselves in your interactions with students. You may need assistance in order to become aware of your assumptions. You should consider getting to know your students to be an ongoing process related to developing a positive classroom climate that promotes excellence.

Below are examples of assumptions, how they might be dealt with, and how you might learn more about your students through the process of addressing these types of assumptions.

### Assumptions About Students' Learning Behaviors and Capacities

**Assumption:** Students will seek help when they are struggling with a class.

For a number of reasons, students do not always feel comfortable asking for help. In order to address this issue, you can request meetings with students as problems arise or make office hour meetings part of the course requirement (e.g., each student will meet with you after receiving his or her grade on the first assignment). The latter is an ideal method because it allows you the opportunity to meet one-on-one with every student. It also removes the stigma attached to going to office hours.

**Assumption:** Students from certain groups are not intellectual, are irresponsible, are satisfied with below average grades, lack ability, have high ability in particular subject areas, etc.

It is essential that instructors have high expectations for all students. For example, if a student earns a grade of C or lower, you should inform the student of the need for a meeting to discuss his or her performance. If students are absent, you should show concern about their absence when they return by asking if things are all right with them. If there are repeated absences, you should request a meeting with the student to discuss the situation. It is important for you to make initial contact with students; however, at some point, students need to take the initiative.

**Assumption:** Students from certain backgrounds (e.g., students from urban or rural areas, students who speak with an accent, students from specific racial or ethnic groups) are poor writers.

While the degree of writing preparation varies across the public school system in the US, students' regional background or group memberships do not serve as accurate predictors of the degree of preparation they received. Furthermore, you need to be sensitive to cultural differences in writing styles, recognizing that many standards apply to the evaluation of good writing. If a specific type of writing is expected for a given class, it may be useful to assign a short, ungraded assignment early in the term to identify students who may need additional assistance in meeting that particular writing standard.

**Assumption:** Poor writing suggests limited intellectual ability.

It is misleading to equate students' writing skills with their intellectual ability. Students have varying degrees of experience with "academic" writing. You have a responsibility to be explicit about what is expected and share with students examples of good writing done by other students. You should also alert students early on of their need to improve their writing and should suggest resources to them (e.g., Sweetland Writing Center consultations).

**Assumption:** Older students or students with physical disabilities are slower learners and require more attention from the instructor.

While there are many cultural assumptions about links between age or physical ability and one's intellectual capacity, these characteristics are not typically linked. Most classes do include some students who require extra attention from the instructor but such students cannot be readily identifiable by physical characteristics.

**Assumption:** Students whose cultural affiliation is tied to non-English speaking groups are not native English speakers or are bilingual.

If you feel that it is important to know whether students speak or understand other languages, you should ask this question of all students, not just those to whom you think the question applies; if there are concerns about students' academic writing skills, it would be best to meet with the students during office hours to discuss their work. One of the questions you could ask as part of your data gathering protocol is, "What were the languages spoken in the environment in which you were raised?" Following this question with appropriate probes would give you an opportunity to find out whether students are native speakers of English and, if not, how recently they became fluent. It is important to identify the source of students' difficulty with writing (or speaking), because identification of the factors that contribute to the problem will influence the actions taken to address the problem.

**Assumption:** Students who are affiliated with a particular group (gender, race, ethnic, etc.) are experts on issues related to that group and feel comfortable being seen as information sources to the rest of the class and the instructor who are not members of that group. AND/OR European American students do not have opinions about issues of race or ethnicity and members of other groups do have opinions about these issues.

One way to effectively deal with this set of assumptions is to pose questions about particular groups to the entire class rather than presuming that members of a certain group are the only ones who can reply. For example, questions could be phrased so that students would be able to share experiences of their friends or comments that they've heard as well as their own experiences. It would be best to let the class know that if any individual has experiences or information that she or he thinks would be beneficial to the class, she or he should inform you about such experiences or information. If you would like to hear from a particular student on a specific issue that relates to group membership, you should speak with the student privately instead of calling on the student when the issue arises in class. In this way, you can find out the students' ability to comment on the issue and willingness to do so publicly. This would avoid putting the student in an awkward position, particularly if the student lacks knowledge about questions related to his or her group.

## Week 12: Whole Group Mentor Meeting on Inclusive Teaching.

The final in-person meeting occurred during the 12th week of the program. As with previous in-person meetings, TAs were first given the opportunity to raise potential concerns or issues they were dealing with in the teaching lab. They leveraged the experiences of their peers to normalize and address these situations as needed. After this preliminary activity, Thompson facilitated a conversation about the value of inclusive teaching, drawing heavily on the materials presented to the TAs in the previous weeks. TAs were asked to reflect on their experience from the semester and comment on things they had done to promote an inclusive environment in their lab as well as comment on opportunities they may have missed. This reflective discussion allowed the TAs to acknowledge the complexity of creating inclusive spaces and talk with their peers about strategies that had been useful for them. TAs commented during the discussion that inclusive teaching was the aspect of programming that they felt least confident in and were least knowledgeable about.

## LEARNER EXPERIENCE OF THE COURSE

Several artifacts were collected during BEST to assess TAs' learning around program goals and inform design decisions. These include written reflections, transcripts from whole group mentor meetings, and video recordings (recorded with the consent of the participating TAs) of three laboratory sections. A summary of the learning artifacts collected for each program goal is provided in Table 2.

### Written Reflections

TAs submitted three written reflections during BEST, one reflection for each of the core topics.

The reflections were valuable opportunities for the TAs to surface their attitudes and understandings of each core topic. The writings also provide the design team useful metrics for assessing how TAs were thinking about these topics and approaching the challenges of implementing them into their classrooms, as well as guiding the agenda for upcoming whole-group mentor meetings. For example, in the first reflective writing about facilitating active learning, TAs voiced having struggled with facilitating a think-pair-share in their class. In response to this, Thompson specifically included an instruction modeling exercise for facilitating think-pair-shares into the first whole-group mentor meeting.

**FIGURE 5.** Screen capture of the [Creating Inclusive College Classrooms from the Center for Research on Learning and Teaching at the University of Michigan](#)

assumptions influence my interactions with students? 3) How might the identities, ideologies, and backgrounds of students influence their level of engagement in my classroom? 3) How can I change my course (activities, assessments, etc.) to encourage full participation and provide accessibility to all types of students? These questions were chosen by Thompson to help TAs connect all 3 dimensions of scientific teaching and to probe them to exam multiple perspectives on student engagement (i.e. both the student and instructor perspective).

| BEST PROGRAM GOAL                                    | ARTIFACT COLLECTED                                    |
|--|---|
| Skills for Facilitating inquiry                      | Reflective Writings, TA lab section video             |
| Increased confidence in teaching skills              | Reflective writings, whole group meeting transcripts  |
| Incorporation of summative and formative assessments | TA lab section video, whole group meeting transcripts |
| Active Facilitation of Inquiry in the laboratory     | TA lab section video, reflective writings             |
| Demonstration of Inclusive Teaching                  | TA lab section video, reflective writings             |

**TABLE 2.** List of learning artifacts collected to address each of the BEST program goals.

In their written reflections, TAs also pointed out instances that they had seen active learning work well in their lab sections, such as “When we went into our lab activity as well, I noticed that they retained information better if they were able to practice using it themselves, rather than to listen in theory. They asked me more intuitive and in-depth questions, rather than basic.” This allowed Thompson to also highlight these successes for the other TAs during the whole group mentor meeting.

Despite an appreciation for the value of active learning, the TAs also reported challenges with facilitating active learning in their lab sections. As an example, one TA mentioned having trouble getting students to participate: “When trying to facilitate active learning methods, I often encountered lack of participation or the idea that they were all safe due to the size of the lab. This often caused me to ‘wait it out’ when asking them a question.” This TA was trying to involve the students in more active discussions to enhance their learning, but successful facilitation was limited by a lack of experience and familiarity with strategies for overcoming such problems. By surfacing this struggle in the written reflection, the TA provided vital information to Thompson for identifying the most useful resources to provide in order to support the TA. In this case, Thompson used the reflection to start a brainstorming session with TAs during the whole group mentor meeting about how to encourage participation from more students.

### TA Lab Section Video Recordings

TAs had one lab section recorded three times throughout the 12-week programming. TAs agreed to have a commercially-available [SWIVL device](#) placed in their classroom to facilitate the recordings. The SWIVL devices were chosen by the design team for video recording because they provided high-quality audio and video that tracked the movements of the TAs within the lab. They also required less human effort to collect compared to a traditional video camera, because

the SWIVL robot rotated the recording device to follow the TA, eliminating the need for an additional person to disturb the class by following the TA around with a video recorder.

After each of the record lab sections, the videos were shared about with the TAs (each TA only received their own video) for them to review and reflect on their teaching. Because the expectation was set that TAs would only spend an additional 2-3 hours a week on BEST programming, TAs were only required to meet with Thompson once during the 12-weeks to have a specific review session about one of their teaching videos. These individual meetings with Thompson were excellent for addressing the specific concerns that each

TA had raised through previous assignments and provide feedback in response to very specific teaching strategies observed on the video recordings.

### Whole Group Mentor Meeting

Whole group mentor meetings were used as summative sessions for each of the three Scientific Teaching dimensions. The agenda for the whole group mentor meeting was set by Thompson based on the issues that had surfaced during the reflective writing for the topic and the TAs’ interactions. In this manner, the whole group mentor meetings provided a highly flexible capstone experience for each topic.

Overall, TAs found the whole group mentor meetings to be the most helpful type of experience they had. These sessions provided TAs an opportunity to not only interact with Thompson and get feedback on specific types of experiences they had in the lab, but these sessions also provided a structured time for TAs to meet with their peers. Having this time for TAs to discuss their laboratory sections and reflect on how they approached their teaching with their peers promoted a very positive culture of professional support.

The beginning of each session was reserved for TAs to drive the conversation, and granting them this time together allowed the teaching mentor to structure the rest of the discussion time to directly meet the needs of the TAs as identified by them. All of the TAs expressed an interest in increasing the number of in-person meetings, but the logistics of scheduling these meetings were challenging. Aligning TA schedules with the teaching mentors was not always possible. Some of these logistical problems could be overcome if TAs were required to hold a specific period of time during the week for mentor meetings (i.e., using a course-like structure where a condition of participation is available for the meeting time), but in our initial population this approach would have excluded too many potential participants.

## ASSESSMENT OF PILOT PROGRAM

### Positive Program Outcomes

Overall, participating TAs found the extra professional development to be a positive experience. All four TAs reported the additional training as highly valuable for the professional and career development and that they had learned many transferable skills that would benefit outside of the teaching laboratory. Having regular interactions with a teaching mentor encouraged TAs to be more thoughtful and reflective about their practice. Specifically, the pilot programming of BEST helped TAs gain confidence in their teaching practice and allowed them to identify specific areas for growth.

#### *TAs gained confidence in teaching and acquired new skills for facilitating student inquiry*

Over the course of their first semester of teaching, TAs developed a greater appreciation for the importance of implementing evidence-based teaching practices. When discussing strategies for active learning in the first mentor meeting, one TA mentioned “Well usually I try to like incorporate like think-pair-share in my lectures and ask them questions along the way. Um. I usually like go through lecture slides before class to like learn about any questions that I could ask them.” This TA was trying to incorporate active learning into their class, even at a very early stage (only 3 weeks of teaching experience at this point), although they admitted that “I think that like the big problem is that once again people are afraid to be wrong in front of their peers” when describing that the think-pair-share was not always successful at engaging students. In this way, TAs were communicating a desire to improve their teaching, but also a need for continued support and training on specific strategies to improve their implementation of new teaching methods. By the end of the semester, TAs began to see themselves more as facilitators of student learning, rather than distributors of content to students. This shift was evident in the TAs final reflective writing, as one TA put it “Usually, students are more likely to volunteer ideas when they are in a small group. *It will be the instructor’s role to facilitate that discussion and choose suitable topics for students to discuss (emphasis added).*”

#### *Reviewing Videos with TAs identified specific areas for improvement*

During their second whole group mentor meeting, TAs commented on reviewing their video recorded lab sections as one of the most valuable experiences in training. When asked about the most valuable experience, one TA replied with, “I liked the video you had us watch (referring to their video recorded lab section)” and the remaining three TAs all agreed with this. Another TA interjected that it was not only watching the videos of their own teaching, but also the opportunity to specifically meet with the teaching mentor

to receive feedback by commenting “just the video, it wasn’t that helpful...but (Thompson) really helped us see where we could improve.”

During the week 7 video analysis sessions, TAs were able to observe their strengths and weakness in regard to facilitating inquiry within the labs. All four TAs demonstrated the ability to use open-ended questions to engage their students during the lab and presented the course material at an appropriate level for their students. Three of the Four TAs actively encouraged collaborative learning during their observed section, and two TAs effectively differentiated their instructional methods to explain complex material to different groups of students.

Video review sessions also revealed some clear challenges for participating TAs. All of the TAs struggled with allowing for appropriate wait time for students to respond to open-ended questions that were posed. Additionally, three of the four TAs struggled with implementing formative assessment strategies such as checking for student’s understanding using probing questions. Instead, these TAs often offered a vague confirmation of understanding like “Do you have a question?” or “Everything going okay?” During the individual video review meetings, Thompson was able to point to these situations for TAs to improve their use of probing questions and other strategies for more accurately gauging student understanding.

### Areas for Program Growth

The first iteration of the BEST program identified a number of areas for further growth. For new TAs, support was most-needed on logistics and classroom management at the beginning of their first teaching semester. Our first iteration underestimated this need and did not provide any of this type of support for new TAs; instead we started by immediately focusing on the philosophical underpinnings of Scientific Teaching and how to implement evidence-based teaching strategies. During one of the mentor meetings later in the first semester, TAs expressed that they felt unprepared for earlier material and would have preferred certain readings later (such as the Smith 1996 reading and the discussion on implementing POGIL) when they had more experience to reflect on and were better able to connect with the material. In this manner, the early emphasis on Scientific Teaching principles caused a disconnect between content and context because assigned readings did not relate to TA experiences (or preempted experiences).

We also identified a strong preference by TAs to participating in professional development in person rather than through online activities. For example, TAs found in-person discussions with their teaching mentor much more helpful than reflective writings. One TA commented, “When you give us a reading and have us submit a reflection, I think I forget it right after submitting.” All TAs expressed a strong desire

to meet more often with their teaching mentor than the once a month that we offered in our first implementation of BEST. This has important design and logistical implications as scheduling in-person meetings with TAs can be challenging if the schedule for those meetings is not set early on. However, if the logistical barriers can be overcome, our experience suggests TAs benefit more from in-person meetings.

## CONCLUSIONS AND NEXT STEPS

### Scaffolding material to meet TA needs

Perhaps the most important lesson learned from the initial implementation of the BEST program was that TA support needs are dynamic over time, and professional development opportunities must be closely aligned to fill those needs. Our group of new TAs started out primarily needing support in the logistical aspects of running a lab and performing their day to day duties (such as taking attendance and grading in the course management software program). After three-five weeks, TAs seemed more comfortable in the teaching labs and confident in testing new teaching strategies. At this point, they were more engaged with materials examining the theory behind Scientific Teaching strategies. Future training programs should focus primarily on logistical support and building TA confidence in their classrooms early on in the first semester of teaching. After TAs have gained confidence and feel that they have their classrooms under control, then they should begin receiving coaching and training on the fundamentals of scientific teaching. This scaffolded approach to TA development would improve future design processes by creating a program that was more strongly aligned to the instructional needs of the participants, which should maximize the benefit for them.

### Opportunities for peer observations to learn from colleagues

TAs all had a positive experience reviewing their own video-recorded lab sections to do self-evaluations of their teachings, but all of the TAs felt it would have been helpful if they had also been given the opportunity to observe and learn from their colleagues. By having the video-recorded observations occur in the middle of the first semester, TAs had already built a strong sense of supportive community with their fellow TAs. This community-building would be pivotal for being able to facilitate a constructive peer observation system. Incorporating this opportunity for peer feedback could also have an additional positive impact on the feelings of support from colleagues. This type of opportunity could be facilitated in a group setting at first, with the teaching mentor leading a group observation session on videos from each TA's lab section. That would help promote a positive and constructive atmosphere. Once this has occurred, it would then be possible to set up live observations

for TAs that wanted to continue learning from their peers. By building in opportunities for peer observation into TA professional development, future designs would benefit not only from the observational experience itself (i.e., TAs giving and receiving feedback) but also because this type of interaction helps professionalize the TA position and promotes a culture of continued growth for TAs.

### TAs benefit from a shift in culture around training and expectations

Working with our departments to shift the culture around the value of teaching experience was paramount for the success of this TA training experience. In order for our TAs to invest enough time in improving their teaching practice, they needed to feel like teaching was a valuable skill. Having the academic department of Biology Teaching and Learning allowed us to highlight the importance of teaching, even a large research university, where many programs have been designed to get students involved in research experiences. While institutional investment into undergraduate research is an important endeavor, our context also highlighted undergraduate teaching opportunities as important professional development. By shifting the culture around teaching towards a more professional and supportive community, where TAs are expected to work hard to improve their teaching but also given the support system they need to meet these expectations, our TAs reported a strong sense of ownership over their experience. In this manner, creating a culture focused on providing excellent teaching and learning opportunities were imperative for helping our institution fulfill mission of educating its students.

## ACKNOWLEDGMENTS

We would like to thank the four teaching assistants that participated in this study for their commitment to their roles and their willingness to learn alongside us. This study was made possible by National Science Foundation Grants #1540789, #1712033, and #1904102. The findings, conclusions, and opinions herein represent the views of the authors and do not necessarily represent the views of personnel affiliated with the National Science Foundation.

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