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Lesson

Training Future Faculty in 30 Minutes a Week: A Modular Framework to Provide Just-in-time Professional Development to Graduate Teaching Assistants

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Abstract

Despite increasing recognition of the need to train the teaching assistants (TAs) teaching the majority of STEM lab sections, very few programs report offering sustained teaching professional development opportunities. Here we present a year-long, modular framework and professional development materials designed to take 15-30 minutes during regularly scheduled lab preparation meetings. We use the concept of "Just-in-Time Teaching," adapted to "Just-in-Time Professional Development," to provide sustained professional development and to gain continuous feedback from TAs to ensure that modules are timely and relevant to the TAs' needs. Modules include sessions on interacting with students, designing and grading assignments, and time management. The framework and modules were designed, tested, and modified over the course of six semesters. We also offer suggestions for implementation and how the modules could be modified for use in other contexts.

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Learning Goal(s)

Teaching Assistants will learn:

- to develop, grade and provide feedback on a variety of assessment types.
- to design small classroom activities.
- strategies for handling various types of interactions with students including ways to promote inclusion in the classroom.
- strategies for time management in the classroom and in graduate school.
- to summarize their teaching experience in their professional application material.
- to reflect on their teaching practice.

Learning Objective(s)

Teaching Assistants will be able to:

- design small classroom activities.
- design fair quiz and exam questions.
- use rubrics to grade assignments fairly and in a timely manner.
- offer constructive, actionable feedback on student written work.
- compare and contrast context-specific strategies for dealing with student problems.
- compare and contrast context-specific time management strategies.
- discuss the importance of diversity, evaluate their own implicit biases, and discuss how these could impact their teaching.
- compare and contrast different methods of summarizing teaching experience on job application materials.
- evaluate their teaching in a reflective manner to develop future teaching goals.

INTRODUCTION

Teaching assistants (TAs), whether graduate or undergraduate students, teach the majority of science, technology, engineering, and math (STEM) lab courses at both large research universities and comprehensive universities (1,2). TAs often teach introductory or "gateway" courses (1–3), which can greatly influence the long-term trajectories of the students they teach. For example, students taking an introductory course taught by a graduate TA were almost twice as likely to continue in that major compared to students who took the same course taught by a faculty instructor (4). This finding highlights the crucial role TAs play in the retention of students in STEM majors. Despite TAs' impacts on their students, most efforts to improve undergraduate education have focused on training faculty to integrate evidence-based teaching practices (5,6) into their courses and curricula (7,8). Until recently, relatively little work has focused on providing – never mind improving – professional development (PD) for TAs.

Fortunately, only 4% of respondents to a recent survey on biology TA PD reported not providing any training for their TAs, down from 49% reported in a previous study (1). Workshops are the most prevalent form of TA PD (1), and can range from a few hours to a week of training, often held prior to the start of the academic term (9–11). Courses offering TA PD appear to vary greatly with regard to length, content (general vs. discipline specific), and whether they are required or optional (1,12–14). Although there is evidence suggesting these modes of PD are effective (9,11,15), they also have potential drawbacks. One possible limitation is that courses and workshops often target a general graduate student audience because they are attended by large groups of TAs from a wide variety of disciplines; thus, TAs might not see how the PD content can be implemented in the course they are teaching (12). Another potential drawback is that TA programs vary in their training expectations of TAs (1) and must balance teaching expectations with research realities. If PD in teaching is not required of TAs, and departmental norms are such that TAs are not expected to participate in non-required PD, coordinators of undergraduate courses need some other means of ensuring TAs learn, and hopefully use, evidence-based teaching practices in their lab sections.

One strategy to ensure TAs are exposed to PD is to offer sessions during weekly lab prep meetings. These weekly prep meetings—typically covering course content, lab procedures, and upcoming assignments—are essentially ubiquitous, TAs are typically required to attend, and they usually last 1-3 hours. These attributes can make prep meetings an ideal venue for short PD sessions that target course/activity specific issues without requiring an additional time commitment from TAs. Previous work details how PD focusing on specific aspects of scientific teaching (such as active learning) has been integrated into specific courses (16,17).

While these previous studies provide useful examples and were effective in their specific settings, our needs were somewhat different. The Introductory Biology Program (Intro Bio) at Louisiana State University (LSU) coordinates several introductory level biology labs for STEM majors and non-STEM majors. Biology 1208 and 1209 comprise a sequence of traditional lab courses (each offered every semester) with 10-52 sections each. Some sections of these courses, as well as Biology Honors 1207 and 1503, are offered as course-based undergraduate research experiences (18,19), but they are beyond the scope of this paper. Biology 1005 is an inquiry-based lab for non-STEM majors; 8-12 sections are offered every semester. All Intro Bio TAs are graduate students in the Department of Biological Sciences and typically teach two sections of the same course. All biology graduate students without prior teaching experience, regardless of their teaching assignment, are required to take a one credit course on science laboratory pedagogy during their first-year.

Previous published work (12) and the authors' own experiences as a former TA and coordinator of LSU's Intro Bio labs (LEP and EWW, respectively) revealed that TAs prefer PD that is practical, immediately useful, and specific to the lab course they are currently teaching, "Just-in-Time PD." We are aware of the more formalized Just-in-Time Teaching (JiTT) pedagogical strategy: its principle of using student feedback to direct the focus of class discussions inspired the design of our PD sessions (20). We are using the term "Just-in-Time PD" to indicate that we plan sessions that are specific to and immediately useful for the unique combinations of courses and TAs in any given semester, not to suggest that we adhered to all the formalized JiTT principles. Therefore, we developed this framework and individual lessons with the following features

- Low time commitment: The PD sessions take 15-30 minutes and are meant to be completed within the scheduled prep meeting time.
- Modular: Most sessions can be done in any order so they can be presented when applicable to the structure and schedule of a given course.
- Responsive: Session structure and topics are modified during the semester to reflect course structure, TA needs, and feedback from TAs.
- Active: Facilitator models active learning teaching practices during each session.
- No self-selection: Because the PD sessions are during the required lab prep meetings, all TAs are exposed to scientific teaching practices and cannot opt out.
- Continuous: Unlike one-off workshops and pedagogy courses, these PD sessions offer training and support throughout the semester.

This framework is meant to supplement, not replace, existing pedagogy courses and workshops. As outlined above, it is designed to be easily modified in response to the needs of TAs and lab coordinators in a variety of different contexts.

Intended Audience

This PD session framework is intended for TAs who are teaching biology labs. In the original implementation, the sessions were used during lab prep meetings for graduate students teaching major and non-major introductory biology at a research-intensive university, but the methods are applicable for undergraduate TAs, other biology courses, and other college/university settings.

Required Learning Time

The PD sessions in the framework take 15-30 minutes of each of the weekly lab preparation meetings for 13 weeks. The framework is designed to be modular and responsive to the needs of the TAs, course coordinator, and course.

Prerequisite Student Knowledge

We assume that the TAs have the appropriate content knowledge to teach the course. The training modules in this framework are modular and not contingent upon each other or on prior pedagogical knowledge.

Prerequisite Teacher Knowledge

The instructor should minimally have working knowledge of evidence-based teaching practices and pedagogy, but preferably have participated in workshops such as the Summer Institutes on Scientific Teaching (summerinstitutes.org), Center for the Integration of Research, Teaching, and Learning (cirtl.net), or other similar training. Experience teaching individual sections of a multi-section lab course is essential. Knowledge of the course structure, common student misconceptions and errors, and grading policies are also necessary. We found it useful to have a postdoctoral researcher (LEP) run these PD sessions because she was not in a supervisory role over the TAs

and had served as a TA in the department herself, so earned the trust of the TAs more readily.

SCIENTIFIC TEACHING THEMES

Active learning

Each module was designed to actively engage participants through at least one active teaching technique; these techniques include think-pair-share, clicker questions, brainstorming, and small and large group discussions.

Assessment

Because this training framework was not part of a graded course, assessment of TA learning gains during the semester was informal and consisted of formative assessments like think-pair-shares, clicker questions, and discussions. The instructor used the responses to these activities to gauge TA understanding of the topic in question. We sought TA feedback on the modules and training topics throughout each semester via anonymous comments on notecards and then modified topics and teaching techniques based on these comments.

In addition, we examined TA self-efficacy and confidence using surveys administered before the semester started and after the semester concluded. These data will be included in a forthcoming publication.

Inclusive teaching

The modules are designed to ensure that all TA voices are heard using a variety of activities. In addition, several of the modules explore and discuss how to create an inclusive classroom, how bias can affect teaching, and how to avoid bias when assessing student work.

LESSON PLAN

Modular PD Plan

We have organized our PD sessions into three broad categories: Interacting with Students; Writing, Grading, and Critiquing Assignments; and Other Professional Development and Support. We used TA feedback and our prior knowledge of course structure and experiences with TAs to inform our Just-in-Time-PD approach to the module topics and schedule. Table 1 offers suggestions for when to offer the PD sessions so they are most useful for TAs; however, because these sessions are designed to be modular, we recommend that facilitators modify our suggestions in a way that makes the most sense for their TAs and courses.

Pre-Semester Preparation

Prior to the start of the semester, we found it helpful to do the following:

- Compile and redact prior student work: Several of the PD sessions involve grading student work and critiquing feedback. These activities are most useful if they are based on assignments turned in by actual students with feedback from actual TAs, if possible. We recommend that the lab coordinator collect some examples of these assignments (minimally, one very good and one mediocre example) from past semesters and remove any information identifying the students and TA.
- Form teaching teams: For courses with more than 4-5 TAs, we formed teaching teams of 3-6 TAs. We tried various strategies to form groups in different semesters, including: 1) attempting to have genders, new TAs, and PI lab members evenly distributed among groups; 2) having TAs self-assort into groups; 3) forming groups based on where TAs decided to sit during the meeting. We also tried maintaining teaching teams throughout the semester and forming new groups every few weeks. There was considerable variation in TA's opinions of all these strategies, within and among semesters, regardless of the type of PD session so we refrain from offering advice on which strategy lab coordinators should choose.
- If lab coordinators want to assess the PD sessions, collecting pre-semester survey data from TAs may be helpful. Reeves and coauthors (3) offer a framework with suggestions for which kinds of data to collect and how to collect them.

Interacting with Students

Icebreakers, purpose of labs, setting the tone, set a teaching goal

We typically demonstrate two icebreaker activities to help the TAs get to know each other and feel more comfortable around each other during the first prep meeting of the semester (held the week before TAs met with students for the first time; Supporting File S1: Interacting with Students – Icebreakers, purpose of labs, setting the tone, set a teaching goal). One of these activities involves TAs writing what the instructor did in the best class they ever took and what happened in the worst class they ever took. The TA responses serve as a starting point of a discussion on how they can use these elements to set the appropriate tone for their first day with their students. This also leads into a discussion of why we teach labs in the first place and how this should dictate their approach to teaching. In addition to the icebreakers, during the first prep meeting of the semester, we also ask TAs to make a teaching resolution. We ask them to think of some tangible aspect of their teaching they want to work on during the coming semester. We hand out notecards and ask the TAs to write their resolution on the cards. TAs are welcome to share their resolution with the whole group if they are comfortable doing so. The TAs are asked to keep these cards with their teaching notebook and to refer back to them periodically.

Backward design and Tiny Teaching Tidbit demonstration

The tangible end product of the Summer Institutes on Scientific Teaching is a Teaching Tidbit, or a teaching activity that can be used to present material in an engaging manner (7,8). Participants in the SI use backward design during the creation process such that the learning goals and assessments are designed before the activity itself (5). These teaching tidbits are then presented to the other SI participants for feedback, revised, and made freely available to the SI participants. We used this approach in an effort to help TAs teach in a more engaging manner (Supporting File S1: Interacting with Students – Backward design and Tiny Teaching Tidbit demonstration and Supporting File S2: Interacting with Students slide decks – Tiny Teaching Tidbit demonstration). We start by discussing the idea of backward design and how it can be used by TAs when they are planning and preparing their teaching materials. We then demonstrate what we call a Tiny Teaching Tidbit (TTT), an

activity lasting 5-10 minutes, for each lab course during the second or third prep meeting of the semester. Teaching teams sign up to create and present their own TTT 1-3 times during the semester. The facilitator emails teams to remind them of the dates they signed up to present and encouraged teams to meet with her for guidance on creating their TTT. Teaching teams present their TTT at the start of their designated prep meeting, receive feedback from their peers and the facilitators, revise their TTT based on this feedback, then email the TTT materials to their fellow TAs so they can use it in their labs if they choose.

Student interactions

Our TAs often struggle with how to appropriately handle discussions about student problems and/or with problem students. We initially tried to facilitate a group discussion of problems experienced by TAs in the group, but found that most TAs didn't want to share their own experiences and those who did mostly used the opportunity to bad-mouth the student(s) involved. A better approach, which we used for subsequent PD sessions, was to write several scenarios based on actual, but anonymized interactions we had experienced (Supporting File S1: Interacting with Students – Student interactions). In the prep meeting, teams of TAs are asked to read 1-3 scenarios and decide how they would deal with the situation. Then the teams summarize the scenario for the whole group and tell us how they would handle the scenario. The facilitator and other TAs then give the group feedback on their solution, advice on other ways the situation might appropriately be dealt with, and any applicable policies TAs should take into consideration. This session seems to work best when offered a few weeks into the semester, which is when many student problems start to arise.

Using the student response system

Student response systems ("clickers") are a well-documented way to easily and anonymously encourage active student participation in classes (e.g., 21,22). Most students at LSU are required to use clickers in their courses so they are an easy way for TAs to increase student engagement when presenting the introductory materials for the labs. Early in the semester, we devote a PD session to giving TAs a "crash course" in creating clicker questions in the software used by LSU at the time. We recommend PD facilitators make materials specific to the platform used at their institutions using our materials as a guide (Supporting File S2: Interacting with Students slide decks – Using the student response system).

Email etiquette and keeping up with emails

We find it helpful to periodically remind TAs that their email correspondence with students (and colleagues) should be professional, what professional emails look like, and strategies for keeping up with email (Supporting File S2: Interacting with Students slide decks – Email etiquette and keeping up with emails). These sessions employ student response system clickers and small and large group discussions. They can be presented singly or combined depending on the needs of the TAs in a given semester.

Diversity and inclusion

We only briefly touch on these important topics (e.g.,23) in this PD session. We ask TAs to take the gender implicit association test (https://implicit.harvard.edu/implicit/) and write down their results. During the prep meeting the facilitator leads group discussions of implicit bias in general; how implicit biases can affect their interactions with students, mentors, and peers; how to avoid implicit bias when grading; and strategies for making their teaching more inclusive (Supporting File S2: Interacting with Students slide decks – Diversity and inclusion).

Mindset

We feel that giving TAs information on fixed and growth mindsets can help them improve their teaching and their interactions with students (e.g.,24). We first have TAs complete a fixed versus growth mindset quiz individually. We then briefly introduce the idea of mindset before facilitating a group discussion about how mindset can influence the way they approach graduate school and teaching (Supporting File S1: Interacting with Students – Mindset and Supporting File S2: Interacting with Students slide decks – Mindset). We then move into a discussion of how mindset might influence their students' approaches to the course and strategies for fostering a growth mindset in their students.

Learning styles

Although research has shown people are capable of learning material presented in their non-preferred learning style (e.g., 25,26), it can still be helpful for TAs to think about using multiple modalities to present information. To explore learning styles, we ask TAs to complete a quiz before the prep meeting and bring their results. In small groups, TAs discuss several questions about their learning style and how they think this might have affected their academic career so far and the teaching strategies they use (Supporting File S1: Interacting with Students – Learning styles). These small groups report out to the large group, then discuss how they might present information in multiple ways during their lab or when meeting students during office hours.

Teaching styles

Understanding their preferred teaching style can help TAs identify ways that they can teach their students in a more engaging manner (27). To do this, we again ask TAs to complete a quiz before the meeting and bring their results. In small groups, TAs discuss their results, determine if all TAs in a group had the same teaching style, and whether their teaching style had changed over time (Supporting File S1: Interacting with Students – Teaching styles). After the small groups report out to the larger group, the facilitator discusses the importance of engaging students and gives concrete examples of how to do so during their lab in the upcoming week.

Engaging students

Toward the middle or end of the semester it can be helpful to remind TAs about the importance of engaging students and the point of teaching labs. This session varies depending on the semester and the problems TAs encounter (Supporting File S1: Interacting with Students – Engaging students). Usually, though, it consists of TAs brainstorming the ways lab courses differ from content ("lecture") courses, then discussing their roles as facilitators. TAs then brainstorm and discuss strategies to engage all students in the lab, particularly during the introductory portion of the lab.

Facilitating brainstorming

Students in our non-STEM majors lab (Biology 1005) spend the last third of the semester designing, implementing, and presenting the results of an experiment to answer a biologically

relevant question of their choosing. Because there are so few constraints, it can be difficult for students to come up with a testable question and it can be similarly challenging for TAs to facilitate this process. During semesters when we have inexperienced TAs teaching this lab, we find it helpful to guide a whole group discussion of facilitation strategies that worked for the more experienced TAs in the course (Supporting File S1: Interacting with Students – Facilitating brainstorming). As a group, we also develop alternative approaches for helping students come up with, then choose, project ideas.

Writing, grading, and critiquing assignments

Quizzes

TAs in our courses are expected to write and give in-class quizzes nearly weekly. New TAs often struggle to write quiz questions that adequately and appropriately assess student knowledge and yet are easy for the TA to grade. We ask TAs to write and print their second quiz prior to the prep meeting (the first quiz typically covers safety training and the syllabus so is not the most useful quiz for this activity). TAs are broken into groups, each containing at least one experienced TA (Supporting File S3: Writing, grading, and critiquing assignments – Quizzes). Quiz drafts are exchanged between groups and taken and critiqued by group members. We find that exchanging between groups instead of within groups helps TAs feel better about providing constructive criticism this early in the semester. After the groups provide a brief written critique of the quizzes they've been given, the facilitator leads a large group discussion of more and less useful question types and topics. New TAs get to see the level of questions they should be aiming for and are provided with an opportunity for feedback in a low-stakes environment. Experienced TAs are usually willing to offer useful feedback and advice. The critiqued quizzes are returned to the original author for revisions. We usually only offer this module in the fall semester unless there happen to be a lot of new TAs in a given spring semester.

Rubric norming and setting expectations

One of the most important sessions is rubric norming, in which all TAs grade the same written report(s) using the rubric for the assignment (Supporting File S3: Writing, grading, and critiquing assignments – Setting expectations and rubric norming). The timing of this session is important; we recommend 1-2 weeks prior to the due date of the first major writing assignment. This ensures that TAs have time to make their expectations on the upcoming assignment clear to their students. We use actual assignments students turned in during previous semesters, after removing any identifying information. It is important for TAs to get an idea of the range of quality of student work they are likely to see, so we chose a very good report (90-100%) and a mediocre report (~70%) for this activity. TAs are asked to individually grade these using the rubric, then write their scores on the board. Typically, there is wide disagreement in the scores assigned to each report; we often observe a 50% spread in points. TAs are then divided into teams to reach consensus scores for each report, which are then written on the board. At this point, the scores are usually much closer, so the facilitator leads a whole group discussion focusing on the areas with the greatest score disagreement. This discussion usually results in scores that are only ~5% different between teams, a level we find acceptable. We then segue to a discussion of differences in writing expectations among TAs, how TAs can make these expectations clear to their students, and provide some examples of strategies used by TAs in the past.

Providing useful feedback

TAs often have difficulty providing useful feedback, using an appropriate tone, and doing so in a timely manner. In this session, we give TAs the reports from the previous session (rubric norming and setting expectations), this time including the feedback from the de-identified TA who originally graded the report (if they were no longer teaching with us) or feedback we wrote ourselves (although we did not tell the TAs this). The TAs are then asked to work in groups to use a worksheet to provide feedback on the feedback (Supporting File S3: Writing, grading, and critiquing assignments – Providing useful feedback). The facilitator then leads a whole group discussion of strengths and weaknesses of the feedback provided by the original TA and strategies for grading and giving meaningful feedback in a timely manner.

Final report rubric norming

The final lab report in these courses is longer, uses a different rubric, and is worth a larger proportion of points than the previous written reports, so another rubric norming session is important. This session runs in the same manner as the norming session earlier in the semester but tends to take longer due to the length of the final report (Supporting File S3: Writing, grading, and critiquing assignments – Final report rubric norming).

Final exam

All of the Intro Bio labs at LSU have cumulative final exams consisting of written and practical sections; both sections are written and administered by each TA. Like the quiz-writing module, we ask TAs to bring their final exam drafts to the prep meeting. At the meeting, we again break the TAs into groups, but now we have TAs exchange their exams within their group (Supporting File S3: Writing, grading, and critiquing assignments – Final exam). TAs take and critique the exam they are given and talk though their feedback with the author of the exam. By this point of the semester, TAs are typically comfortable enough with each other to give and take constructive criticism face-to-face. The facilitator then leads a large group discussion of some of the good and not as good questions on the draft exams and provides tips and tricks for setting up and administering a practical exam. TAs have 2-4 days to revise their exam and send it to the lab coordinator for proofreading. We used this module every semester because it helped ensure TAs sent their updated finals to the lab coordinator in a timely manner.

Other professional development and support

Soliciting TA feedback

We ask TAs for informal, anonymous feedback at least twice during the semester. Typically, we devote a PD session in the middle of a semester to gathering this feedback, usually during a week when the prep meeting is long enough that there isn't time for a full PD session, and again at the end of the semester (Supporting File S4: Other professional development and support – Soliciting TA feedback). TAs are given notecards on which to write their responses to 1-2 of the following prompts.

A) What training topic do you think should be covered? B) How do you think the training sessions are going so far? C) How could the training sessions be improved? D) What was the most helpful training session? E) What was the least helpful training session? TAs are given 5-10 minutes to write, then are asked to leave the cards near the door as they leave the meeting.

Time management 1

The first session on time management focuses on strategies to manage time while teaching a lab and is usually offered during the prep meeting immediately prior to the first very busy lab of the semester (Supporting File S4: Other professional development and support – Time management 1 and 2). TAs are broken into teams (each preferably containing an experienced TA) to prepare a time budget for the upcoming week's activities. Each team then shares their time budget on the board. The facilitator leads a whole group discussion of these time budgets and strategies to manage time during labs.

Time management 2

The second time management session is more of an informal discussion of strategies to help TAs find and maintain a balance between the time they spend teaching and doing research (Supporting File S4: Other professional development and support – Time management 1 and 2 and Supporting File S5: Other professional development and support slide decks – Time management 2). This discussion also extends to advice on ways TAs might find and maintain work-life balance while in graduate school. This session seems to be most useful for TAs when implemented during the middle of the semester.

What to do with student evaluations

Students in all of the Intro Bio lab courses at LSU are asked to complete evaluations of the course and their TA. Eventually, TAs receive these student evaluations but receive no instruction regarding what to do with them. In this PD session we discuss as a large group how student evaluations can be used to improve TA teaching (Supporting File S4: Other professional development and support – What to do with student evaluations). We also discuss ways that student perceptions can be biased and encourage TAs to observe each other's teaching to get less biased opinions. We then show TAs examples of how student and peer evaluation data can be summarized for academic job applications.

How to summarize teaching on a resume or curriculum vitae (CV)

We started offering this PD session because many TAs planning to graduate soon asked how they should summarize their teaching experience on their resumes and CVs. TAs are instructed to bring their CV to the prep meeting; the facilitator also brings in copies of their CV for TAs to look at (Supporting File S4: Other professional development and support – How to summarize teaching on a resume or curriculum vitae (CV)). We break TAs into groups to look at each other's CVs to get ideas for organizing information and to see what kinds of information should be on a CV and discuss how one can tailor a CV for different jobs. We then ask the groups to decide on a job that they think they want (usually they choose a postdoctoral researcher, industry researcher, or tenure-track faculty), then outline the appropriate sections on the board. As a large group, we discuss any pros and cons of the mock CVs for their intended jobs. The facilitator then discusses some of the education jargon that TAs might want to use in the teaching section of their CV, such as "inquiry-based" and "course-based undergraduate research," and how this section might be tailored for various jobs. One interesting aside mentioned by TAs, particularly new graduate students, during our first CV PD session was feeling overwhelmed and anxious that their CVs very short and not very professional compared to the facilitator's and those of more advanced graduate students. Subsequently, the facilitator also started bringing her CV from when she applied to graduate school and compared it to her current CV. TAs seemed to appreciate seeing how her career had progressed and how this was represented "on paper."

End of semester reflection

It is important for TAs to reflect on their teaching. We end the semester by having TAs reflect on what they think they did well when teaching and what they want to improve the next time they teach (Supporting File S4: Other professional development and support – End of semester reflection). We also ask TAs to give us anonymous feedback on the PD sessions on notecards.

TEACHING DISCUSSION

We developed and implemented this PD framework over six semesters, from Fall 2014 to Spring 2017. More formal types of training, such as teaching workshops and courses in pedagogy, can spend more time on individual topics and go into much greater depth than the PD sessions we present here. Our framework and modules are intended to supplement, not replace, such workshops and courses. Additionally, we use the Just-in-Time-PD approach to meet the immediate instructional needs of the TAs each week. We reiterate that the suggested modules and their order are based on our experiences but are meant to be modified based on the needs and concerns of TAs in a given course.

At LSU, most biology graduate students enter the program during the fall semester and start teaching their first semester. Based on our experience, these new TAs are primarily concerned with their own teaching ability and content knowledge, so they want to know how to deal with the practical aspects of teaching the course to which they are assigned. Therefore, the fall semester PD sessions focus mostly on applying course-specific skills the TAs need and want for the lab activities in the upcoming week or two (Table 1). In the spring semester, we have very few new TAs, but many TAs switch to teaching a different course. This means that TAs still have some course specific concerns (hence we repeat some PD sessions), but they tend to have fewer teacher-centered concerns and more learner-centered concerns. Therefore, the PD sessions also shift to more pedagogical topics, as well as how to present material in a more active and inclusive manner, and how to highlight their teaching experience in job application materials. Throughout the six semesters we used the framework, we modified the PD topics and the order in which they were presented based on the needs and wants of the TAs teaching with us in a given semester. Consequently, we developed PD modules that do not appear in Table 1, but were nonetheless useful to TAs when we used them.

TA feedback was generally positive, particularly from less experienced TAs; a thorough analysis of our survey data will be included in a forthcoming publication. One issue we

encountered in the first year of offering TA PD was resistance from a small but vocal group of experienced TAs in their last year of graduate school. Based on written and verbal comments, these TAs disliked the time our training sessions added to the weekly prep meetings (albeit minimal) and the small "homework" assignments we asked TAs to do prior to the prep meetings. This feedback helped us decide how to frame and streamline the PD sessions to increase TA buy-in. Facilitators implementing a professional development program should be aware there could be pushback from TAs if participation is mandatory.

TAs in the Intro Bio series at LSU, as in most introductory STEM lab courses, have no control over the content and experiments that must be covered in each lab session; they do, however, have control over how they present the content to their students. The Tiny Teaching Tidbits (TTTs) were a strategy to encourage TAs to think of how they could present the introductory material to their students using evidence-based approaches. Some TAs were resistant to these TTTs while other TAs consistently impressed us with their creative and insightful activities. Whether these differences were because of the individual TAs or the course structure, we are unable to say with certainty, but facilitators should be aware that groups of TAs may differ in their receptiveness to the TTTs.

We made a point in our modules to model the scientific teaching practices we were asking the TAs to use, especially using a variety of evidence-based techniques to engage TAs with the PD material each week. During the first 3-4 semesters we did not point out to the TAs that the methods we were modeling could and should be used in their own lab courses. We discovered through conversations with the TAs that they had not noticed we were using evidence-based approaches, nor had they realized we were doing so deliberately and that they could use the same techniques in their TTTs specifically, or their labs generally. Based on this experience, we suggest that PD facilitators explicitly point out the types of techniques they are using and how they might be adapted to a laboratory setting.

As mentioned previously, a postdoc (LEP) familiar with the labs designed and implemented the PD modules. Although lab coordinators or lab prep staff could easily take on this role, we suggest using a postdoc for the following reasons: 1) Although the postdoc had slightly more authority in the meetings than the TAs, she did not have the authority to hire, fire, or discipline TAs. Most TAs viewed the facilitator as a "safer" person to confide teaching troubles in than the coordinator or prep person. 2) The postdoc was much closer in age and experience to the TAs and had taught the lab courses very recently. In many cases, faculty and staff have not taught multi-section lab courses for years and forget the challenges of teaching a course over which they have little or no control of the content. 3) Having the postdoc facilitator organize the PD meant that these tasks were not added to the workload of the existing staff.

Conclusions

This framework and PD materials provide a scaffold with which to provide TAs with timely, relevant pedagogical training based on the principles of Scientific Teaching. These principles, particularly active learning and inclusive teaching, were used by the facilitator throughout the sessions so that TAs could see these teaching methods in action. This approach to PD, especially when combined with workshops and/or coursework in teaching, offers a powerful, responsive, and time-conscious method of training future faculty members.

SUPPORTING MATERIALS

- S1. Training Future Faculty - Interacting with Students
  - Icebreakers, purpose of labs, setting the tone, set a teaching goal
  - Backward design and Tiny Teaching Tidbit demonstration
  - Student interactions
  - Mindset
  - Learning styles
  - Teaching styles
  - Engaging students
  - Facilitating brainstorming
- S2. Training Future Faculty - Interacting with Students Slide Decks
  - Tiny Teaching Tidbit demonstration
  - Using the student response system
  - Email etiquette and keeping up with emails
  - Diversity and inclusion
  - Mindset
- S3. Training Future Faculty - Writing, Grading, and Critiquing Assignments
  - Quizzes
  - Setting expectations and rubric norming
  - Providing useful feedback
  - Final report rubric norming
  - Final exam
- S4. Training Future Faculty - Other Professional Development and Support
  - Soliciting TA feedback
  - Time management 1 and 2
  - What to do with student evaluations
  - How to summarize teaching on a resume or curriculum vitae (CV)
  - End of semester reflection
- S5. Training Future Faculty - Other Professional Development and Support Slide Decks
  - Time management 2

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Table 1. Training Future Faculty - Teaching Timeline. Two-semester training sequence includes focus on surviving teaching the first semester and more philosophical sessions the second semester. Each week includes a professional development (PD) topic and a lab topic.

Week	PD Topic	Lab Topic
Fall Semester		
1	**Ice breakers, why are we here?, setting the tone**[a,b]	Meet and greet
2	**Backward design and TTT demo**	*Lab techniques; quiz*
3	Critique quizzes	Experiment I; quiz
4	Time management 1: allotting time for class activities	Experiment II
5	Setting expectations for writing assignments and **Rubric norming**	Experiment III; quiz
6	Providing useful feedback	Experiment IV; quiz, formal writing assignment 1 due
7	Student interactions	Experiment V; quiz
8	**Get TA feedback**	Experiment VI
9	Time management 2: grad school and life	Experiment VII; quiz; formal writing assignment 2 due
10	No PD	Experiment VIII; quiz
11	**Lab report rubric norming**	Experiment IX; quiz
12	**Final exam feedback**	Experiment X; quiz, lab report due
13	**Teaching reflection**	Final: written and practical
Spring Semester		
1	**Ice breakers, why are we here?, setting the tone, make teaching goal**	Meet and greet
2	**Backward design and TTT demo**	Lab techniques; quiz
3	Clicker tutorial and tidbit sign up	Experiment I; quiz
4	Email etiquette	Experiment II
5	**Rubric norming**	Experiment III; quiz
6	Diversity and inclusion	Experiment IV; quiz, formal writing assignment 1 due
7	**Get TA feedback**	Experiment V; quiz
8	What to do with student evaluations (for teaching and getting a job)	Experiment VI
9	CVs	Experiment VII; quiz; formal writing assignment 2 due
10	No PD	Experiment VIII; quiz
11	**Lab report rubric norming**	Experiment IX; quiz
12	**Final exam feedback**	Experiment X; quiz, lab report due
13	**Teaching reflection**	Final: written and practical

[a]Sessions in bold are shared between both semesters.
[b]The materials for the PD sessions are available in the supporting materials.