TA Training Workshops

Morning Workshop:
Teaching the Teacher: Introducing and Training TAs in
Inquiry–Based Learning Methods

Afternoon Workshop:
Breakout: Identifying effective and innovative solutions to common TA
issues

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Abstract: In this these workshops, participants learned methods, tools, and resources used for training teaching assistants (TAs) to be more effective teachers. **In the morning,** training strategies were demonstrated which help TAs conceptualize and experience inquiry, develop and deconstruct inquiry-based labs, practice using inquiry-based learning strategies in lab, and reflect upon outcomes of an inquiry lab experience. **In the afternoon**, facilitators led focus groups to develop strategic plans for a specific TA training topic or issue. Topics were 1) teaching professional ethics and responsible conduct, 2) evaluating TAs, 3) international TAs, and 4) increasing TA and student engagement in labs.

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Session 1: Teaching the Teacher: Introducing and Training TAs in Inquiry–Based Learning Methods

Introduction (Summary of Session)

For many teaching assistants (both graduate (GTA) and undergraduate (UG)), the primary method of lab instruction that they have experienced is a traditional (didactic), passive approach to learning. These labs are commonly presented in a "cookbook" approach in which the students are told exactly what to do, how to do it, and what results will be achieved if they do the procedures correctly. In order for the inquiry approach to learning to be embraced by these TAs, one must overcome the barriers that exist because of these past experiences. First one must identify the barriers, provide the tools and the means to overcome the barriers, and provide encouragement and support to reinforce the need for change. As with any attempt to foster change, one also must instill in the TA that the change is justified, valued, and is an improvement over past experiences.

This workshop's aim was to help TA trainers foster the understanding and the belief in the IBL approach so their TAs can overcome barriers in making the change from "cookbook" labs to inquiry-based labs. The workshop was geared towards individuals who were already familiar with basic principles of inquiry-based instruction in lecture and laboratory environments, and the presenters focused mostly on specific methods for training TAs to use this pedagogical strategy with students. The following summary outlines the general flow of activities in the first workshop. Subsequent sections detail specific tools and materials that were provided to the participants.

The workshop began with a general introduction to IBL as a teaching method. Participants were shown a PowerPoint presentation, developed by Jeff Osborn at the University of Kentucky, used to introduce TAs and undergraduates to inquiry as a teaching method. Briefly, inquiry-based labs (IBL) allow for student-centered exploration of a topic. In IBL, students answer questions by designing and performing their own investigations, collecting and analyzing their results to make evidence-based conclusions, and sharing their conclusions with others. Effective IBL requires instructors that are familiar with its basic principles and utilize teaching methods that foster active learning. Thus, implementing IBL in multi–section laboratory courses requires more extensive TA training and monitoring than traditional confirmation and demonstration-type laboratories.

After introducing inquiry, the presenters presented a summary of results from a pre–workshop survey they and several participants had completed. The survey (reproduced in Appendices B and C), loosely modeled after the Teaching Goals Inventory of Angelo and Cross (Angelo, 1993), was designed to assess the attitudes towards and use of inquiry-based learning by TAs. Participants were encouraged to use the two instruments in Appendices B & C as a means to evaluate their program status, assess their TAs' preconceptions about IBL, and estimate the level to which their TAs use inquiry-based learning strategies in their classes. Initial results of this survey were shared at the workshop. The discussion of these results helped describe how identifying TAs' prior knowledge and possible misconceptions about inquiry and student learning can help coordinators identify barriers to TAs' effectiveness in employing IBL in laboratory environments.

Next, participants learned to recognize and identify teaching practices and behaviors that foster IBL versus more passive learning by viewing video clips of traditional lab instruction and inquiry-based lab instruction. Participants took notes on differences and similarities between the lab

video clips in terms of teaching roles and strategies and student behaviors and level of engagement. While viewing the clips, participants were introduced to an observation protocol that can be used for either direct observation or for reviewing videotapes of TAs teaching (Appendix C).

The next topic of discussion was specific techniques that participants can use to train TAs to be effective facilitators of established inquiry-based labs. TA training methods that were highlighted include having TAs:

- Conceptualize inquiry
- Experience inquiry
- Assess and reflect upon the outcomes of an inquiry experience
- Develop and deconstruct inquiry-based labs

Methods that facilitators demonstrated included:

- Modeling inquiry-based teaching using two lab demonstrations
- Using a curricular development model to identify key components of inquiry-based labs
- Using the 5E instructional model (conceived by Roger Bybee at BSCS) to structure inquiry-based learning experiences
- Using constructivist learning strategies to introduce inquiry to TAs, bringing attention to effective questions for IBL, and performing TA observations using a standardized observation protocol.

During the final part of this workshop, the participants were given time to develop a plan for implementing one or more of the presented strategies into their TA training program. Before forming groups, the presenters shared common barriers and timeline issues that are important to consider when implementing IBL training for TA's (Appendix D). The participants first prioritized the barriers they may experience at their home institutions before identifying which TA training strategies were appropriate for them. They also considered their timeline for implementing IBL training for TAs since some methods take more time than others.

Throughout the workshop, participants were asked to add to several running lists. These lists are in Appendix D and include:

- Instructional behaviors and skills that foster IBL in the classroom
- Common barriers in training TAs on IBL and in implementing IBL into the classroom
- Recommendations for TA training and management, in general
- IBL related topics for future ABLE workshops

Summary of Workshop's Survey Findings

Each presenter for this workshop coordinates multi–section, introductory biology laboratories for biology majors. The labs are taught by TAs with a myriad of background experiences. All four presenters have used IBL in their introductory biology labs, but how they use IBL differs in: 1) the extent to which the lab is guided versus open-ended and 2) the number of IBL investigations used in a course. Each presenter completed the surveys in Appendices B and C; Tables 1 & 2 summarize their responses. Their summary data are meant to give faculty who have not yet adopted IBL some guidelines and strategies to consider as they develop their own TA training programs.

Coordinators who are moving towards IBL or making substantial changes in their TA training program were STRONGLY encouraged to complete the surveys in Appendices B & C before implementing any changes. Comparisons of pre– versus post– implementation survey data are

invaluable in assessing whether new TA training is achieving its intended goals. Results from the Program Summary (Appendix A) for each of the four presenters' are summarized in Tables 1 and 2.

Each of the four presenters uses a multi–pronged approach for training TAs to teach biology laboratories in an IBL format. Methods used are summarized in Table 2. Narrative descriptions of how each program trains TAs on IBL skills can be found after the table.

Table 1. Profile of introductory biology lab populations at presenters' institutions.

	University of Kentucky	University of Dayton	Wake Forest University	University of Georgia
#students/semester	~600	~400	~500	~900 – 1300
#sections taught per semester (max #students per lab section)	18 (35)	~25 (20)	~ 35 (16–18)	Between 44 and 66 (20)
Length of Lab Period (hours)	2 (twice a week)	Non-majors 2; Majors 3	3	2
# TAs working in intro labs (# TAs per section)	18 (2)	14 (1)	18 (1)	40 (1)
TA diversity	International and domestic	International and domestic	Primarily domestic	International and domestic
IBL introduced to the intro labs	2 years ago	3 years ago	9 years ago	2-5 years ago
# IBL lab exercises	Several	Several	21 of 26	All
IBL "buy–in" by TAs	Nascent	Evolving	~50% fully invested	Most

Table 2. TA training at presenters' institutions.

	University of Kentucky	University of Dayton	Wake Forest University	University of Georgia
Pre-semester TA Orientation	2 days	3 days	1 day	1.5 days
Weekly Lab Meetings	2 hours per week	2 hours per week	2 hours per week	1.5 – 2 hours per week
College Teaching Seminar/Course	N/A	Yes – required first semester	Available as separate course	Yes
Mentoring Program (How long in place?)	IBL specific (2 years)	Just for ITAs (1 year)	None	New – in revision stages

University of Dayton

At the University of Dayton IBL objectives for TA training are to increase awareness of IBL and enhance IBL related skills through a pre-semester TA orientation, weekly TA lab meetings, and a College Teaching Seminar. Briefly, these programs include the following IBL components:

Pre-semester Orientation:
- New TAs are introduced to the article, "Seven principles for good practice in undergraduate education" (Chickering and Gamson, 1987) during the university graduate TA orientation.
- New TAs further the discussion on this article during the discipline-specific orientation. TAs also discuss how to effectively facilitate student investigations and other basic effective pedagogical techniques (being attentive, encouraging critical thinking, asking open ended and probing questions, etc).
- TAs practice their pre-lab presentations for the first lab, which is a guided inquiry lab (scientific process lab using termites as the model organism). All new TAs watch each other and give constructive criticism to each other regarding these presentations.

Weekly TA Lab Meetings (course specific):
- All TAs attend these meetings to discuss administrative issues as well as to run through the investigation for the week.
- Either an experienced TA or the lab coordinator will model how to present the IBL labs and will review possible experiments students will choose to do.
- Experienced TAs help the new TAs with techniques, learning equipment, and tips for dealing with student problems.

College Teaching Seminar (semester long course taken by all new TAs):
- The goals of this course include, among other things, enhancing basic pedagogical skills of TAs, introducing TAs to learning theories (including constructivism and IBL); practicing effective teaching techniques (including IBL); helping TAs to become reflective practitioners; and training TAs on authentic assessment techniques.
- During this course, the instructor and the graduate students take turns leading discussions on pedagogical topics. Graduate students have several other assignments including developing midterm student evaluations, developing active learning experiences, observing and reflecting upon their own teaching, and developing a teaching portfolio.
- Before introducing IBL, TAs read and discuss articles and chapters about constructivism, pedagogical content knowledge, student-centered learning, and learning styles.
- Before discussing IBL, TAs have taught both an inquiry based lab (the first lab on the scientific process) and a relatively traditional (cookbook) lab on biological instrumentation.
- IBL is introduced by using the 5E learning cycle (Appendix E), which was originally conceived by Roger Bybee at BSCS (1989). This format is used for structuring the IBL lesson since the TAs will later be expected to use the 5E learning cycle to convert a cookbook investigation into an inquiry-based investigation. For more information, refer to below descriptions of training techniques demonstrated at the workshop.

University of Kentucky

TA training at the University of Kentucky is similar to the University of Dayton with regards to pre-semester orientation and the weekly lab meeting format. They differ with respect to continuing education of TAs on the IBL approach. At the University of Kentucky a mentor/mentee program is utilized to reinforce best teaching practices, while the UD includes a College Teaching Seminar.

Pre-semester Orientation:
- New TAs are introduced to the VARK inventory styles of learning (http://www.vark-learn.com/english/index.asp). The TAs take the inventory to gain an appreciation of their particular learning styles, followed by a group discussion of ways to address the various learning style preferences in a laboratory teaching environment. TAs will ask students to take the VARK inventory during the first day of class in order to gain an appreciation of their student's learning preferences.
- TAs discuss readings from Gregory and Chapman's (2002) instructional strategies book about knowing and assessing the learner and instructional strategies for student success.
- New TAs are introduced to constructivism and the 5E instructional model. This provides a framework for TAs to deconstruct the traditional cookbook approach to teaching labs and re-structure their instruction towards a more student driven approach to learning.
- During orientation, inquiry-based teaching is introduced to TAs via a power point presentation and followed with hands-on experience. In an effort to set student expectations, the TAs will present this same power point presentation to the students prior to students engaging in their first inquiry based lab.
- TAs perform an inquiry-based lab. Afterwards, TAs are asked to break out into pairs or small groups and devise a teaching plan for this particular lab.

Weekly Lab Meeting:
- All TAs attend the weekly lab meetings. A small group of senior TAs are selected as mentors to assist during lab meetings for more individualized training of their mentees.
- Lab meetings begin with administrative information and a detailed lesson plan for the week.
- TAs organize into their assigned mentoring groups to perform the upcoming labs. They discuss laboratory techniques as well as concepts and common student misconceptions.

Mentoring Program - this has been implemented in two ways:
1. A specific mentor (i.e. an independent experienced TA) selects up to four inexperienced TAs with whom they will meet to discuss the upcoming laboratory and best teaching strategies and practices. This is accomplished through either one on one interaction or through a group mentor/mentee meeting, depending on the needs of the newer TAs. In addition, the lab coordinator meets with all the mentors once a week to coordinate the upcoming information, in order to relay and to discuss mentoring related issues.

2. Additionally, mentor/mentee relationships are established through the weekly TA lab meetings, by establishing work groups of no more than four TAs per group. The group will be comprised of at least one experienced TA who will function as a mentor to the other members in their group during the TA lab meeting.

Wake Forest University

Before teaching for the first time in our department, all TAs must attend a one–day training session. Fundamental skills introduced at this session are reinforced during weekly laboratory prep meetings for each course. TAs seeking more in–depth training in pedagogy and teaching methods may elect to take a graduate level course, "BIO783: Teaching Skills & Instructional Development."

New TA Training:
- During this general training and orientation session, the lab coordinator meets with all new TAs, and determines their background, specialty, and prior teaching experience. This information is used to make initial teaching assignments. General departmental and institutional teaching policies that will affect the new TAs are explained, as well as the following pedagogical topics:
  - Basic principles of learning and instruction (Perry model, constructivism, Bloom's taxonomy, inquiry-based instruction).
  - General format of department's lab courses (outcomes centered).
  - Pedagogical goals and structure of lab courses (fostering inquiry and best practices).
  - Assessment principles and strategies

Weekly TA Lab Meetings (course specific):
- Both new and experience TA's must attend meetings.
- If a new lab unit is starting in the upcoming week, the lab coordinator leads the TAs in deconstructing the laboratory. We use Diamond's strategy for course development as a guide to identify and discuss outcome objectives, content and performance goals, effective micro–teaching methods, and formative and summative assessment techniques.
- Assessment methods are discussed and, if necessary, scoring rubrics are developed.

Formal Graduate Course in College Instruction:
- The first half of the course is a seminar. We discuss selected reviews of learning theory and instructional practices. Students also are introduced to Diamond's outcomes-centered approach to course development. The goal in this stage of the course is for graduate students to develop a set of shared, practical guidelines for how to design and assess an engaging, instructionally effective college course.
- In the second part of the course, the students put these guidelines to work. They are given a hypothetical group of undergraduates for their target audience. As a group, they must design a learner–centered undergraduate biology survey course for this group. They are encouraged to abandon preconceived ideas about course structure and content, and to think creatively, using the guidelines and theory they learned in the first part of the course.

- Next, graduate students test key components from the course they have designed, by conducting short class sessions in the same manner as they would for students. Based on feedback, the graduate students revise and improve their original course design.
- For final projects, participants develop an outline for a course in their subspecialty. Two other participants and I then review their course using a standardized rubric, and make suggestions for improvements.

University of Georgia

TA training in IBL has not had a formal format prior to a field-tested IBL TA training program in the fall of 2006 (6 Graduate Laboratory Assistants: GLAs; see details below under "Other"). IBL training has primarily taken place as a component of weekly preparatory meetings.

Weekly Prep Meeting:
- All GLA's meet with lab coordinator each week.
- In the first prep session of each semester the LC introduces the pedagogy of inquiry-based instruction, focusing specifically on differences between traditional "cookbook" means of carrying students through a laboratory course versus IB laboratory experiences.
  – GLAs' perceived benefits of using IBL versus "cookbook" methods are shared.
  – GLAs read about IBL instruction and its benefits before their first lab meeting. GLAs are encouraged to spend at least 10-15 minutes in their first lab session leading discussions on IBL instruction with their students.
- GLAs perform the lab for the upcoming week, exactly as students would undertake the lab.
- The environment of these meetings generate a form of "peer mentoring" where GLAs lend advice to one another on teaching and classroom management strategies.
- Often times the LC incorporates suggestions as to how to focus teaching efforts towards maintaining an inquiry-learning atmosphere during lab sessions (as opposed to just giving students the answers to questions).

Specific Training for GLA's Leading IBL Sections of Lab:
- **Introduction** to IBL and statistics on the likelihood of having to teach upon graduating with a post-baccalaureate degree.
- **Video clips** of how GLAs taught the traditional cookbook labs and how GLAs taught the same labs in inquiry format.
- **Observation sessions**: GLAs are observed two different times during the semester. An interview/debriefing session took place immediately following each observation session; all observations made were shared with GLAs. Each GLA also observed three other GLAs at least once during the semester using the same observation protocol. The same interview/debriefing process took place immediately following the observation sessions.
- **Questionnaires**: A questionnaire was given to all GLAs who were teaching an introductory biology lab at the beginning of the semester in attempt to ascertain the GLAs' prior knowledge of inquiry, experience with inquiry, self-efficacy towards teaching introductory biology labs, demographic information, career goals, etc. This same questionnaire will be given again at the end of spring semester, 2007.

- **Interviews**: The six GLAs were interviewed by an unbiased interviewer at the end of the semester. These ascertained the GLAs' experiences teaching inquiry labs as well as how the IBL training they were given helped them throughout the semester.
- **Feedback sessions**: GLAs were given ample opportunities in prep sessions and in a separate "feedback" session at the end of the semester to provide input into what did and did not work in the inquiry labs, and why. This input was directly implemented into an updated version of the inquiry-based lab manual and the lab course syllabus (spring 2007).

Summary of Results from Laboratory Methods Inventory

Appendix B contains the Lab Methods Inventory, the second instrument the presenters developed for coordinators to gauge the effectiveness of their TA training. To provide comparison data, three of the presenters asked TAs in their respective programs to complete the Inventory. The compiled data for each presenter's program are shown in Figure 1, panels A–C. Several participants at the workshop had also conducted this survey with their TAs, and submitted the forms for analysis. To preserve confidentiality, no individual participant's data are presented here. Only aggregated data for participants are shown in Figure 1D.
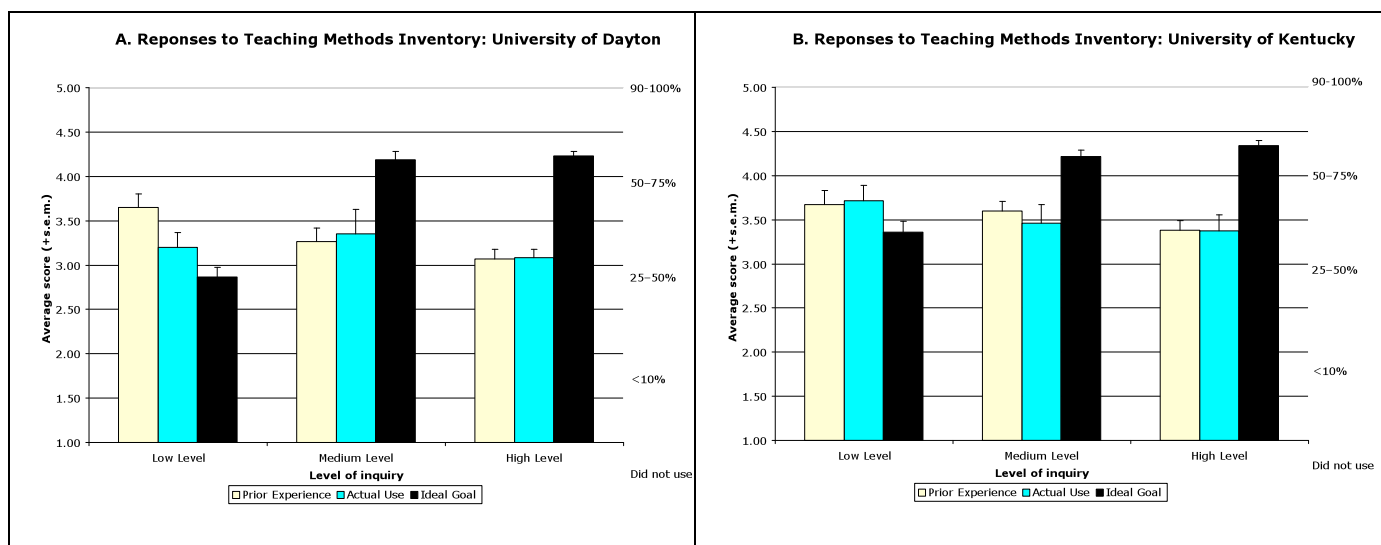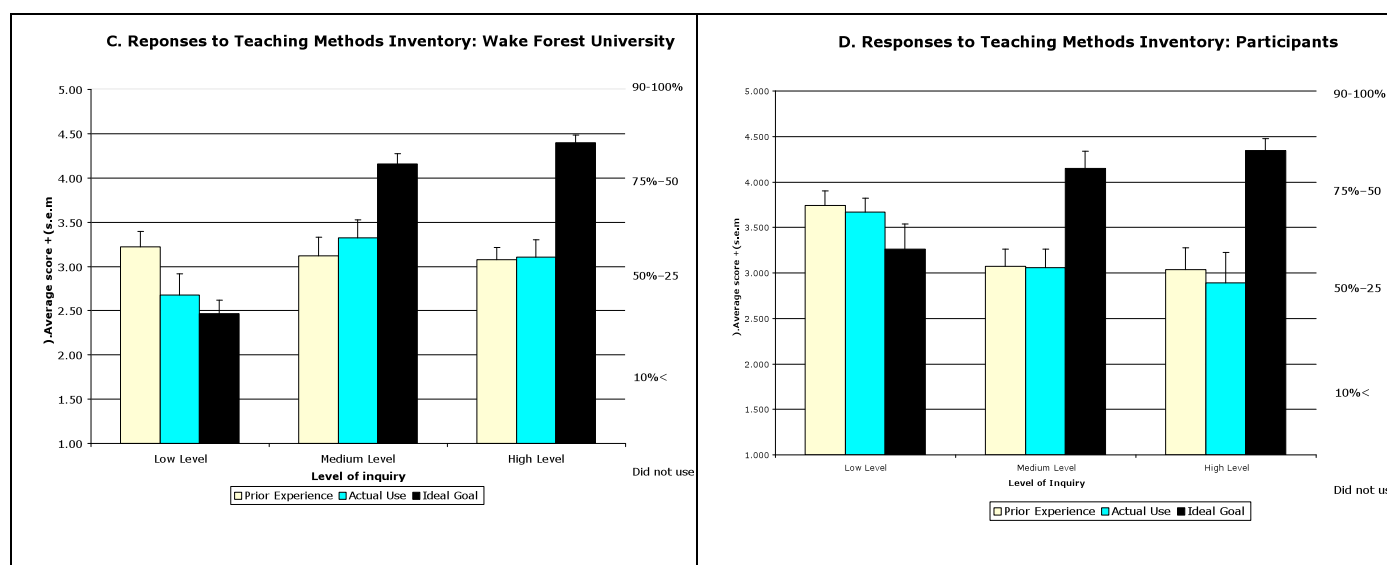
Figure 1A-D. TA responses on Teaching Methods Inventory according to institution. Level of inquiry is categorized according to how well the teaching method correlates with inquiry-based learning practices (low level similar to traditional lab methods, medium level methods are often used in inquiry-based labs but are not indicative, high level methods are tell-tale signs of inquiry-based learning).

When the results from presenters' and participants' TAs were compared, there was no difference in how much inquiry–based teaching either group had previously experienced when they were undergraduate students. This suggests that TAs at both the presenters' and participants' institutions start their teaching careers with the same general level of limited experience with inquiry as an instructional model. If this conclusion is correct, then changes in a TA's use of inquiry during their graduate career are most likely due to specific training or exposure to particular expectations and attitudes about inquiry that they encounter during their graduate teaching experiences.

So is there any difference in the TAs use of inquiry methods between the presenters and the participants? Figure 2 shows a direct comparison between the average scores on the Inventory for the two groups; panel A compares current use of inquiry by TAs in each program, and panel B compares idealized goals. On average, TAs at the presenters' institutions use low, medium, and high–level instructional methods with about equal frequency. In contrast, TAs at participants' institutions use low level methods (which do not promote inquiry) nearly twice as often as high–level methods (that strongly promote inquiry). These results suggest that TAs who are specifically trained to use inquiry (or at least are teaching in an institutional setting that actively promotes it) employ a wider range of teaching methods and tend to use methods that promote inquiry more often than TAs who are not.
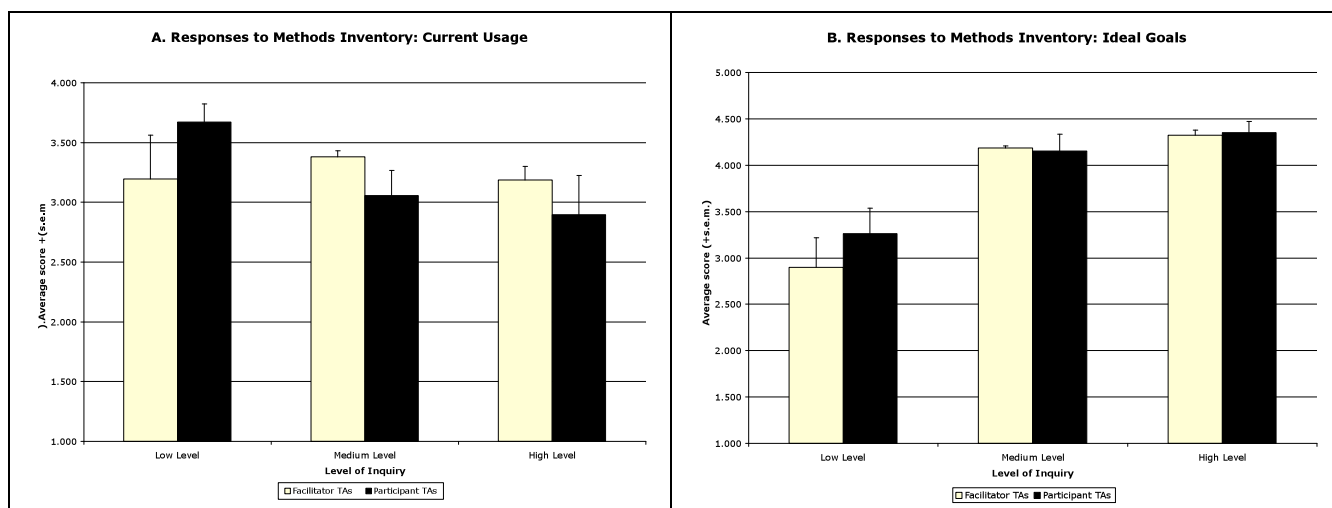
Figure 2. TA responses to lab methods inventory comparing presenters' TA responses to participants' TA responses. A) TAs current usage of low, medium, and high-level inquiry-based methods in their classrooms. B) TAs rate which methods would ideally be used in an inquiry-based learning classroom.

Ironically, when asked what was the *ideal* ratio of instructional methods to use, TAs at both the presenters' and participants' institutions answered identically: mostly high–level methods that strongly encourage inquiry, and significantly fewer low–level methods that do not encourage inquiry (Figure 2B). Moreover, both groups of TAs said that, ideally, they would use low–level methods LESS often than they do currently. From this, it seems clear that TAs recognize which methods of instruction are more effective, but 1) do not know how to actually implement teaching methods that promote inquiry, and/or 2) do not feel supported in their attempts to use inquiry methods. The Inventory cannot distinguish between these two possibilities; course coordinators are urged to follow up and discuss this specific issue with the TAs in their program, then tailor their training program accordingly.

Specific TA Training Protocols and Tools

Modeling Inquiry-Based Teaching Using Lab Demonstrations

Termite Lab – University of Kentucky
     TA*s* perform an inquiry-based lab using termites. Afterwards, TAs are asked to break out into pairs or small groups and devise a teaching plan for this particular lab. The lab exercise used is in Appendix F.

Static Electricity Lab – University of Georgia
     During the first prep session, an inquiry activity on static electricity is distributed to TAs. This exercise introduces TAs to an inquiry lab and also serves as in ice breaker activity where the TAs can begin to get to know one another. Working in pairs, the TAs complete as much of the exercise as they can in approximately 30 minutes. After the 30 minutes, the TAs and Lab Coordinator regroup and discuss overall impressions of the exercise. Specifically, the Lab Coordinator has TAs reflect upon what makes the exercise different from one they might normally

complete in lab. For example, the TAs discuss any differences in how directions are given, the types of questions asked, the amount of thought that it takes to answer questions, and the perceived difficulty and/or benefits of completing the exercise the way it is presented. This exercise is presented in Appendix G.

Questions for Post–Lab Analysis
- What specific behaviors did you notice all of the facilitators doing? What do you think is the purpose of each of these behaviors?
- We've spent a lot of time writing ideas up on paper and boards? What do you see as the advantages of that behavior?
- What did we do as facilitators that prevented you from learning?
- What kinds of questions did we ask of you as lab participants? How did we respond when you were asking questions? Why do you think this is important?
- Fred, you were talking about the dinner last night, rather than engaging in the lab. Do you remember what I did to get you to come back to the task at hand? Was that a positive or negative experience?

Helping TAs Conceptualize Inquiry-Based Learning (IBL)

As demonstrated by the survey results, many TAs have little previous exposure to IBL. To be effective in implementation of IBL in the labs they will teach, TAs need exposure to IBL and need to conceptualize for themselves exactly what it is. It is possible to start meeting both of these needs at the same time: instead of *telling* TAs what IBL is and what it looks like, have TAs experience IBL as they construct their own knowledge about what IBL is.

The technique demonstrated during this workshop to introduce TAs to the concept of IBL is structured with two learning cycles. The learning cycle is a model of instruction based on inquiry-based learning that was first conceived by Robert Karplus in the 1960s. It includes having students first explore a concept on their own, then having them develop the concept in their own words, and lastly having them apply the concept to a new situation. Roger Bybee, at BSCS, has since developed this cycle into the "5E cycle," which expands the learning cycle by engaging the student before they explore the concept and evaluating the student throughout the learning cycle (Appendix E).

The TAs begin this training session with no information about IBL. They are asked to read several of the following articles about learning (explore stage of learning cycle #1):
- "Seven principles for good practice in undergraduate education" (Chickering and Gamson, 1987).
- "Mind and Brain" (NRC, 2000).
- Selected readings in How Students Learn: Science in The Classroom (NRC, 2005).
- Selected readings in Brain-Based Learning (Jensen, 2000).

As a group, the TAs discuss learning based on what they have read and generate a list of "what do we know about effective learning" (explain stage of learning cycle #1). Then the TAs are asked, "based on what we know about how students learn, how should we teach?" (extend/elaborate stage of learning cycle #1). To further this stage of the learning cycle, they are also asked, "How would your new knowledge about facilitating learning apply to teaching lab investigations?"

The second learning cycle begins with providing the TAs with a list of teaching behaviors, some being traditional and some being inquiry based (the list in our TA survey is used). They are

asked to rank these behaviors based on their previous experience in labrooms. Then they are asked to define the word inquiry. These two activities are the engage stage of the second learning cycle. For the explore stage of learning cycle #2, each TA is given a short excerpt on what inquiry-based learning is (each excerpt is different). They are asked to read these and then to share what they read with a partner. As a group, they are asked to define "inquiry-based learning" in their own words. For the explain stage of this second learning cycle, the TAs are asked to revisit the list of teaching behaviors and prioritize them for an inquiry-based classroom experience. After this they are asked, "how does this differ from your previous experiences?" For the extend/elaborate/apply stage, the TAs are then asked how a traditional lab ("cookbook" lab) investigation would need to be changed in order to be inquiry-based. Here, with the facilitator, the TAs discuss what skills will be needed, what teacher behaviors will have to change, and what in a lab write-up would have to change to make a lab experience more inquiry-based for their students.

To finish this lesson, the TAs also discuss how inquiry-based experiences do not all look alike and are not all completely open ended as some might think. The TAs are taught to visualize the extent of inquiry in a lab investigation as a continuum. At one end of this continuum are "cookbook" labs and at the other end are open inquiry labs. In some instances it may be more appropriate to be at the open inquiry end, in other cases it is more appropriate to give the students the question to be investigated and the material to use, but allow the students to design the procedures (more guided).

Using 5E Instructional Model to Structure IBL Experiences

The 5E instructional model can be used in several ways for training TAs about IBL. First, it can be used to structure the actual lab investigations that the TAs will be teaching. Second, it can be used to structure TA training lessons (as done above). And third, the TA trainer can request that their TAs revise a "cookbook" lab into an inquiry-based lab by using the 5E instructional model.

In the above training strategy ("helping TAs conceptualize IBL"), the 5E model was used to help the TAs explore, define, and apply IBL for themselves. After going through that lesson with the TAs, a TA trainer can have the TAs reflect on how the lesson was structured. Start by asking, "what strategies and ways of structuring the lesson did I just use?" Use the following series of questions to aid the TAs through the reflection:

1. What initiated the learning process and exposed your current conceptions and/or situation?
   Or, what engaged you – helped you get interested enough to invest yourself?
2. What helped you become more aware of and explore/experience the concept?
3. What helped you examine/think in-depth about/come to a better understanding of the concept?
4. How did you assess that you learned something and can apply it?

After asking these questions, show a slide or a handout of the 5E instructional model and have the TAs decipher how you used the model to teach them about IBL. Then, ask the TAs to pick a "cookbook" lab and change it according to the 5E learning cycle. The product they make from this assignment can be used for the "evaluate" stage (for you to evaluate the TAs).

Using an Observation Protocol to Assess TAs' Use of IBL Instructional Methods

The TA Observation Protocol (Appendix C) is one means for providing TAs with direct feedback about their abilities to promote IBL in the laboratory teaching skills. A key to successfully using this protocol is not only to rate the TA on each category but especially to provide as many comments and examples as possible. The written notations are critical to fostering a dynamic 30-minute interview that takes place immediately following the observation session. A copy of all comments and responses should be provided to the TA so that s/he can leave their observation session with feedback in hand to review and prepare for future labs. This observation protocol also can be used for peer mentoring and supervisor mentoring.

During the workshop, the TA Observation Protocol was shared and details were provided as to how the protocol was developed and modified as well as its relative success in achieving its goals.

Deconstructing a Lab Unit

When developing courses and curriculum sequences, Robert Diamond and other authors advocate using an outcomes–centered approach. Courses developed this way tend to be highly learner–oriented, and in the case of laboratory courses, use several inquiry–based learning exercises or teaching methods. The outcomes–centered approach is a very effective way to familiarize new TAs quickly and efficiently with existing lab curriculum. The process requires around 30–45 minutes, depending upon the number of TAs and how ready they are to talk.

- First, a two to three–minute outline of this method of course development is given.
- Next, the group is asked to discuss and decide upon outcome objectives they think reflect successful biology lab instruction. New TAs usually can develop a list that is close to the department's objectives for core lab courses.
- TAs work in pairs or as a group (both methods work well) for 10 minutes to devise specific content and performance goals for a single topic in a non–majors' lab (a simple topic that most new TAs will know is the best choice, such as principles of enzyme function). Like faculty, TAs usually struggle as they attempt to define the specific course goals in measurable terms.
- At this point, the group reconvenes and the trainer explains the current performance and content goals for the model lab. The TAs are then shown the corresponding laboratory exercise from the non–majors' course, and explain how its structure leads students to achieve the content and performance goals.
- At the end of this exercise, the role of assessment in a course is initially discussed. This leads into the next topic in the training program, which is how to develop and use formative and summative assessments.

Session 2: Finding Effective and Innovative Solutions to Common TA Training Issues

Introduction (Summary of Session)

In this workshop, participants divided into focus groups, each led by a facilitator that directed the discussion of a different topic. To stimulate conversation, each facilitator began their session by sharing a method that s/he uses to address the topic at her/his institution. Subsequently each group developed a short presentation for the rest of the workshop participants in which they:
- Described common problems or issues associated with topic.
- Outlined general approaches or strategies for dealing with the issues.
- Described one specific tool or method for dealing with the training issue.
- Briefly explained other approaches to solving the problem.
- Briefly described methods by which progress in training can be assessed.

Four summaries follow, one for each focus group. Supplemental materials developed or used by a focus group are in Appendices. In discussing topics and developing the presentations, several participants suggested ideas for future ABLE workshops. These were collected and posted for participants (Appendix D).

Focus Groups

Focus Group One: Problem-Based Learning (PBL) & Other Techniques for Teaching Professional Conduct

Faculty often face professional ethical dilemmas. Some have to do with teaching practices while others relate to research or professional interactions. How do we teach TAs to solve these dilemmas effectively? The facilitator began by outlining one possible strategy: using a problem-based learning approach to teach TAs how to deal with issues of proper professional conduct. This strategy was developed originally as part of a graduate bioethics course, but has proven equally useful for teaching TAs how to handle a variety of professionally challenging situations.

Working in groups of 5–6, graduate students analyze and discuss a case that highlights a particular professional issue or problem. TAs identify learning issues that they need to research further on their own, then in subsequent meetings, share information and reassess the case in light of their new knowledge. This problem–based learning approach allows students to construct professional decision making models for themselves through directed experience, rather than simply hearing them in a lecture.

Participants worked through the steps of a short case (Appendix H) written specifically for this workshop, in which they had to handle a possible case of plagiarism by a student. The case served as the springboard for the group to discuss and develop their own list of ethical issues related to teaching, and strategies for resolving these issues. They also received a copy of the course syllabus and grading guidelines.
- Introduced PBL as a teaching format (10 min).
- Participants read, worked thru Part 1 of demo case (20 min).

- Explained how students use learning issues in intervening week to gain knowledge. (5 min).
- Participants read and worked thru Part 2 of demo case (10 min).
- Group discussion focused on identifying other ethical issues related to teaching training and professionalism that could be addressed using PBL.
- Presented some practical issues associated with using PBL as a training tool, including:
    – Strategies and methods for writing cases
    – Learning to facilitate cases
    – References on the PBL method, and on case writing
    – Sources for more information

The group developed a list of learning issues and problems that are likely to need resolution when teaching professional conduct; these were added to the lists in Appendix D. The outcome of the discussion was presented to the PBL focus group during the next session.

Focus Group Two: International Teaching Assistants

Being a teaching assistant (TA) for the first time can be an overwhelming experience in itself. For the domestic graduate student, the challenges are basically related to curriculum differences and/or teaching style preferences that are different from the TA's previous undergraduate experience. For an international TA (ITA), they are faced; not only with the differences mentioned above, but in addition, language and cultural differences have a significant impact on the quality of the teaching experience. In order to prepare ITAs for teaching, they are trained on the curriculum during orientation and weekly meetings. In an effort to make the transition easier, both new TAS whether domestic or international, are assigned a mentor. The role of the mentor is to observe their mentees in the classroom on a weekly basis and to work with them one on one or in small groups to improve communication skills, discuss curricular content, and best teaching practices. This focus group began with a description of the mentoring program and ways to tailor ITA training to particular needs. An article, "A Failure To Communicate"(see Inquiry Talk for Students PowerPoint) was provided to participants to read.

After reading the article, the following common issues were identified in regards to working with ITAs:
- Pronunciation, projection, intonation problems
- Cultural differences, especially the role of the teacher in other countries (commonly very didactic, strict, non-interactive)
- Students never speak when teacher or anyone else is speaking
- Only one person in a lab group actually does the experiment
- Labs are all "cookbook"
- "Not my job" attitude in cleaning up, setting up, maintaining equipment, etc.
- Grading difficulties
- ITAs misunderstand policies and procedures
- ITAs perception of US students: lazy, impolite, don't accept international cultures
- ITAs come across to their students as condescending, unapproachable, strict, etc.

Possible solutions identified:
- Deal with the most serious issues first.

- Provide routine, out–of–class experiences where ITAs must use English.
- Provide introduction to common cultural idioms and differences.
- Create a book of language idioms.
- Ask Drama Deptartment or students to help train ITAs to project and speak distinctly.
- Provide ITAs opportunities for positive cross–cultural exchanges with students. What is THEIR educational history, personal life like at home?
- Screen international students before offering them a TA. Perhaps a cut-off score on TOEFL or a face to face interview first?
- Provide a graduate or undergraduate mentor for first semester/year to help them prepare for class and to be in the class with them.
- Take a one semester course on giving good presentations and on different presenting styles
- Be explicit in discussing the differences between their culture and ours – ask them what their experience is and tell them how it will be different.
- Rent "Teaching in America" (out of Harvard) and hold discussions about the video.
- Practice asking leading questions instead of telling facts.
- Speech pathology clinic visits.
- Video tape them and make them watch it as well.
- Use humor. Tell them to actively learn to be less polite.
- Be clear about expectations on how they should interact with you and their students.

Focus Group Three: Evaluating Teaching Assistants

As university employees, TAs are expected to provide high-quality instruction to students. This requires a great deal of time and effort on the part of TAs as well as their faculty mentors. Providing TAs with meaningful feedback on their teaching methodologies is critical for improving teaching methods and attitudes towards teaching. How can we evaluate our TAs in ways that encourage them to teach to the best of their abilities and to strive for academic excellence in the midst of their numerous time constraints?

Copies of a recently field-tested TA observation protocol (see Appendix C) were shared with participants. This protocol was used by a biology lab coordinator and a faculty instructor to evaluate TAs teaching inquiry-based introductory biology labs in the following areas: pedagogical skills, classroom management skills, content knowledge, and preparation. Student behaviors during lab were also assessed. A post-observation interview between the observer and the observee was conducted immediately following the lab session. TAs used the same protocol to evaluate each other.

The first part of this second session was spent discussing how the protocol was constructed, the difficulties in reaching this product, and its perceived usefulness by TAs, the lab coordinator, and the involved faculty member. Participants practiced using this protocol on video clips of TAs teaching inquiry labs. The participants were particularly interested in discussing barriers to video-taping TAs and students as some group participants noted that in their past attempts to video-tape labs, both TAs and students have refused to participate for such reasons as being uncomfortable, privacy issues, and modeling contracts.

The goal for the second part of the session was for participants to build a loose observation protocol "skeleton" that they could leave with and then work on at their home institution. A handout was given on how to develop this skeleton (see Appendix I). Discussion centered around how to build observation categories for their protocols. We focused on the themes of goals/outcomes for

labs and TAs, TA feedback needed, and barriers to reaching the established goals and desired feedback.

As a final product, participants created summary points of what should be considered when creating TA evaluation (feedback) instrument categories. These points fell into the three areas:

1. Categories should attempt to address what instructors and TAs both express is needed in terms of feedback:
    a. Classroom management skills
    b. Content knowledge (or lack thereof)
    c. Attention/time equity amongst student

2. Categories should attempt to address what barriers that TAs might face when adequately attempting to teach IBL labs:
    a. Achieving professional distance from students
    b. Questioning and answering skills
    c. Abilities to successfully foster discussions
    d. Abilities to troubleshoot and solve problems (often quickly)
    e. Cultural differences (language, behavior, ego)
    f. Knowing about to be critical of student work while being supportive

3. Categories should attempt to address the goals of the IBL labs, specifically in relation to goals that instructors/TAs wish for students to achieve:
    a. Be able to describe experimental design
    b. Decrease neediness of students on TA
    c. Increase comprehension of basic concepts
    d. Increase critical thinking skills
    e. Increase writing skills
    f. How to handle data analysis (e.g. use of statistics)
    g. How to use scientific process: question, hypothesis, justification

Focus Group Four: Increasing Student and TA Engagement in Labs

How often have you heard your TA's tell you that they ask questions, but to no avail, their students simply don't respond? And they say their students never ask questions themselves or just ask procedural/verification questions. There are so many reasons that students remain unresponsive and disengaged, ranging from boredom and lack of sleep to confusion and fear. Other reasons students are disengaged could include the TA using too many closed questions, only looking for the right answer, asking questions that are too broad or too vague, or doing activities that require no "action" from the students.

How often have you noticed your TAs grumbling about teaching, just going through the motions, and doing the bare minimum? How do you get your TAs to buy-in to teaching, be excited about teaching, and effectively use inquiry-based learning strategies? There are many reasons why TAs are disengaged - fear, lack of preparation, too little time, too much pressure to do research, etc.

During this focus group, participants shared the largest problems they have experienced with TA and/or student engagement. After sharing, the group chose the most common problems and

discussed ways that these problems could be solved at their institutions. Below is a list of the common problems cited and the solutions that were suggested.

Common concerns regarding TAs:
- TAs are overwhelmed with teaching for the first time (with little training in advance).
- TAs do not know the content very well and are reluctant to be wrong.
- TAs are not familiar with and/or comfortable with sound scientific investigation design.
- Supervisor has little knowledge of what is happening in the classroom each week (lack of time) – TA and student feedback greatly differ and not sure why.
- TA thinks they are guiding students just fine, but upon observation and/or asking students, they are misguiding the students.
- TAs have problems trying to get the students hooked - good TAs can foster excitement but new TAs do not pick up on how to get the students attention.
- Many TAs do not want to teach and find the quickest way to run through a lab.
- Many TAs take a traditional approach by over explaining the material.
- TAs are overly interested in making students happy, resulting in easy grading, shortened labs, answers given out before hand, etc.
- TAs do not have the skills to foster discussion.
- Poorly qualified graduate students that are not that interested in the subject.
- TAs often do not take the responsibility to prepare themselves for teaching (both content and pedagogy).
- TAs have little experience in pedagogy – not enough time to train beyond lab content.
- Some graduate students only teaching for $$$, so not motivated.
- TAs lacking questioning skills – often ask only closed questions and questions are often confusing.
- TAs give out the answers.

How do we get the TAs to be engaged with the labs, have students perform decent experiments?
- Require TAs to observe each other.
- Have individual meetings with the TAs.
- Videotape TAs: may see elements of being too didactic, too traditional, lack of scientific method knowledge. ('I see that you are telling them…').
- Ask for random collections of student work.
- Require students approve their investigation design with the TA before proceeding. TA should consider if the experimental design answers the question being asked and makes sure the students have planned what they will do.
- Start collecting 'mushy' experimental designs from students and use them in training TAs. Ask TAs, "what questions would you ask to lead them to design the experiment better?"
- Teach TAs (coach them) about how to judge whether the experiment is good or bad.
- TA's need to attend labs and spend time practicing to become familiar enough with the equipment.
- During weekly TA meetings, discuss not only the previous lab and the upcoming lab, but also appropriate pedagogical tools to use for the labs.

How do we get buy in from the TAs?

- Provide explanations of best practices in teaching and the level of expectation the TAs should have for their students.
- At TA meetings each week, have a debriefing of how the week went, solicit questions to use in discussions, and clarify parts of text that caused confusion.
- Allow TAs to write their own prelab questions/quizzes.
- Let TAs have input on improving labs.
- Ask TAs why they went into biology – what inspired them?
- Show TAs what research says about effective teaching.
- Involve experienced TAs as role models in TA training and have them explain the benefits of being a TA.
- Pair up novice with experienced TAs.
- Coordinator/supervisor must also be enthusiastic about labs.
- Set up "safe" environment and let it be OK for TAs not to know everything.
- Take TAs out for lunch and discuss issues/improvements.
- Tell TAs that you expect best practices in regards to teaching with threat of not being rehired.
- Have Department chair come and speak with TAs about the value the dept places on undergrad curriculum and education.
- Explain how teaching labs will help TAs in their future careers eg. teaching portfolios, teaching pedagogy for grants, improving research skills. See "Why TA Training Powerpoint presentation" developed and used by Peggy Brickman at the University of Georgia.

Problems with student engagement:
- Non-majors taking biology as just a science credit.
- Students with specialized knowledge/enthusiasm not interested in other subject areas.
- Students "zone out" when TA's are talking.
- Students only want the answers.
- Students do not see how labs are relevant to them.

How to hook students:
- Use the 5E instructional model when designing lab investigations.
- Use active learning.
- Use the 'what's in the box' session presented at ABLE a few years ago. There is an unknown object in the lab and the students can only use available evidence to figure out what it is. Stress "this is what we know at this time."
- Have TAs share ideas on hooking their students into the lab topic and in finding interesting ways that the topic is relevant to their students' lives.
- Have lecturers talk to students during lecture about the benefits of IBL, keeping a lab notebook, etc.

Acknowledgements

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Kelly Bohrer received a B.S. in Environmental Biology and an M.S. in Biology from The University of Dayton, where she is currently the Biology Lab Coordinator. As such, she coordinates five introductory lab courses, supervises and mentors TAs and prep assistants; and develops lab curricula. She also teaches an environmental instrumentation lab, ecology lab, biology lab for pre-service teachers, introductory courses, and a graduate course on pedagogy and professional development. Her research interests include innovative laboratory pedagogy and training/mentoring TAs.

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Kristen Miller received a B.A. in Animal Behavior from Bucknell University and two M.S. degrees from the University of Georgia (UGA): Biopsychology and Conservation Ecology and Sustainable Development. She currently serves as the Laboratory Coordinator for the Division of Biological Sciences at UGA, coordinating approximately 94 laboratories per semester while supervising and mentoring the 40 GLAs who teach them. She also serves as an academic advisor for biology majors, lectures in organismal biology courses and helps revise introductory biology laboratory curricula. Kristen is a first-year doctoral student in UGA's Mathematics and Science Education graduate program. Her research interests include TA training and writing in science.

APPENDIX A
Program summary form & instructions for administering the *Lab Methods Inventory*

Dear Biology Lab Coordinator:

At the 2007 ABLE annual meeting, we will be conducting a major workshop entitled "Teaching the Teacher: Introducing and Training TAs in Inquiry–Based Learning Methods." We are conducting a survey to determine the baseline level of knowledge about concepts of inquiry based learning among biology TAs, and the extent to which they use inquiry based teaching methods in their lab courses. The survey is broken down into three parts:

- Which teaching methods TAs actually use most often when teaching undergraduates.
- Which teaching methods TAs have experienced themselves while they were undergraduates.
- How well TAs understand the general principles and methods of inquiry–based instruction.

If you are thinking about attending our workshop at the ABLE conference, PLEASE have your TAs complete this pre–workshop survey. After attending the workshop and implementing any new methods, we will ask you to conduct the survey again, so that we can compare pre– and post–workshop data. This will help us evaluate the success of our workshop as well as the methods that we have found to be "best practices" at our own universities. These comparisons also will help you evaluate the success of any new methods you have implemented as a result of attending the workshop.

Even if you are not planning on attending our workshop, we would still ask that you give out this survey to your TAs and return it. This will provide us with a larger pool of baseline data for comparisons.

Thank you in advance for helping us create a baseline dataset!

Which TAs are eligible to participate?

All TAs who teach biology labs in your department. It includes both undergraduate and graduate TAs, teaching in both introductory and upper level courses.

How do I administer the survey?

There are two survey items. The first is a brief, 2–page *Summary of Your Departmental Program*. Please respond to these questions yourself. The second item is the main survey, titled *Laboratory Teaching Methods Inventory* to your TAs. Print out and photocopy the *Methods Inventory*, then give a copy to each TA in your program. The *Methods Inventory* has a cover page of its own, with instructions to the TAs and some general free–response questions that the TAs should answer as best they can. The rest of the survey has 3 parts. All three parts ask the TA to rate the same items, from three different points of view. After they have rated each item in each of the three parts, have the TAs return their surveys to you. The TAs should NOT identify themselves on the sheet; all responses should be anonymous.

Mail the 2–page *Summary of Your Departmental Program* and the inventories that your TAs completed to:

> Dan Johnson
> Dept. of Biology
> Wake Forest University
> Rm. 226 Winston Hall
> Winston–Salem, NC 27109

The deadline for mailing in surveys is April 17, 2007. If you have questions, please feel free to call Kelly

Bohrer at (937) 229-2155, Alma Ferrier at (859) 257–5489, or Dan Johnson at (336) 758–5320.

How Will the Surveys and Data Be Handled?

When we receive your completed surveys, your program summary and inventory sheets will be marked with a six–digit random identifying code number. Once the data are transferred to a computer file, all further references will be by the ID number. **Only aggregate scores will be used at the workshop, or reported in any future publications**; your specific institutional data will not be made available to anyone else except you. You can request your data be withdrawn from use at any time.

Summary of Your Departmental Program

1. How many biology majors does your department service each year?   _____
2. How many non–majors does your department service each year?   _____
3. How many TAs do you coordinate/supervise each semester?   _____
4. What biology lab courses do these TAs teach? (Please list topics, not course numbers)

5. Are you responsible for designing the curriculum of the biology   YES   NO
   labs that these TAs teach?
       If not you, then who is?
6. Are your TAs solely responsible for the lab section that they teach?   YES   NO
       If not, who else is present in the lab room to help them?
       How often/long is this additional person in the lab?
7. Do you train TAs on teaching methods for biology labs?   YES   NO
       If so, how many new TAs do you train each year?
       If not, who trains the TAs that you coordinate/supervise?

8. What does your current TA training involve? Please check all that apply.

Method of Training	YES	NO
Peer mentors		
Semester course on pedagogy		
If yes, how many credits?	_____ credits	
If yes, is the course specific to biology?		
Pre–semester orientation		
If yes, how many hours or days?	_____ hrs/days	
If yes, is the course specific to biology?		
Teaching demonstrations		
TAs design laboratory activities		
Before TAs teach a lab, they perform the lab in advance, as the students would.		
Watching video scenarios		
Watching other TAs teach first		
Observing other faculty teach first		
Reading articles or other text regarding teaching		
Practice teaching a lab to a mock group of students		
TA discussions		

9. Please describe any other methods you use for TA training that were not listed above.
10. Do the biology labs that your TAs teach use inquiry–based learning?   YES   NO
       If yes, please describe an example of one of the activities they would typically use.
       If yes, what how many of your lab sessions include opportunities for
       inquiry–based learning?   _____ out of _____.

11. If you use inquiry–based learning in your biology labs, do you
    train your TAs specifically on inquiry–based teaching methods?   YES   NO
       If yes, please specify what training techniques you use.

12. If you use inquiry–based learning in your biology labs, how successful do you think your TAs are in
    using this method with their students?

13. What are the major barriers that your TAs face when trying to use or implement inquiry–based learning?

APPENDIX B
Laboratory Methods Inventory

(Estimated time to complete is 15 minutes)

Purpose of this Survey
This survey is designed to provide information about several issues related to teaching:
- How well instructors understand the general principles and methods of inquiry–based instruction.
- Which teaching methods instructors actually use most often when teaching undergraduates.
- Which teaching methods instructors experienced themselves while they were undergraduates.

Answer honestly, based on your own experiences and behaviors. There are no better or worse answers for the open–response questions or survey items. All responses are anonymous, and only collated, aggregate data from this inventory will be used or reported.

Directions
First, answer the five open–response questions on the next page. Then respond to each item in the 3 Inventory sections that follow. The same list of teaching methods or techniques is repeated in each of the 3 Inventory sections; only the lead–in question is different. For each item, circle only one response on the 1–5 rating scale. You may want to read quickly through all the choices before rating them.

If you do not understand what a particular item or certain question means, simply circle the number and leave it blank. If you were unable to answer a question for some other reason, your feedback would be appreciated. Simply write a note at the bottom of the sheet explaining what is confusing about the question.

Open Response Questions
A.   Circle one of the following. What is your teaching role currently?
        Teaching Assistant
        Course Coordinator
        Faculty member teaching a corresponding lab with lecture

B.   In your own words, please define inquiry-based instruction

C.   Do you utilize an inquiry-based approach to instruction in your course, currently? Circle:
        Yes   or   No

D.   If you currently use an inquiry-based approach to instruction, please provide an example of an inquiry–based teaching method that you utilize in your course. (Should you require additional space, please complete on a separate sheet of paper and attach it to your survey).

E.   If you are a teaching assistant (either graduate or undergraduate), what are your three biggest concerns as an instructor?

Inventory Section 1: *Specific Teaching Methods You Currently Use*
How often do you <u>actually use</u> each of these techniques when you teach, or expect students to use them when you are teaching lab courses? Rate them using the following scale:
  (1) Not used at all
  (2) Infrequently; I use in <25% of lab meetings
  (3) Some of the time; I use in ~25–50% of lab meetings
  (4) Most of the time; I use in ~50–75% of lab meetings
  (5) All of the time; I try to use in ~75–100% of lab meetings

Item #	Description	Rating				
1	Completing worksheets	1	2	3	4	5
2	Listening to the instructor lecture	1	2	3	4	5
3	Taking multiple choice/true or false/fill in the blank tests	1	2	3	4	5
4	Reading assignments in a textbook	1	2	3	4	5
5	Engaging in experiments with predetermined outcomes	1	2	3	4	5
6	Engaging in experiments with predetermined, written procedures	1	2	3	4	5
7	Memorizing concepts	1	2	3	4	5
8	Writing lab reports for experiments with preset procedures and results	1	2	3	4	5
9	Receiving factual information from the teacher	1	2	3	4	5
10	Passively watch a demonstration of a principle or process	1	2	3	4	5
11	Identifying variables and designing appropriate controls for experiments	1	2	3	4	5
12	Answering questions about prior knowledge	1	2	3	4	5
13	Asking clarification questions during or after class	1	2	3	4	5
14	Participating in an in-class simulation or group exercise	1	2	3	4	5
15	Participating in a class discussion	1	2	3	4	5
16	Developing new examples of a specific concept or process in action	1	2	3	4	5
17	Making predictions based on prior knowledge	1	2	3	4	5
18	Giving individual presentations, or participating in group presentation in class	1	2	3	4	5
19	Writing formal lab reports on novel results	1	2	3	4	5
20	Students reviewing or critiquing another student's work	1	2	3	4	5
21	Searching outside primary literature sources to learn what is already known.	1	2	3	4	5
22	Designing and implementing new procedures or models	1	2	3	4	5
23	Exploring alternative methods for solving problems	1	2	3	4	5
24	Identify questions/concepts that guide scientific investigations	1	2	3	4	5
25	Comparing data or otherwise collaborating with other groups	1	2	3	4	5
26	Communicating findings to the rest of the class	1	2	3	4	5

27	Using graphs, basic statistics (mean, st.dev., t-test, etc) to summarize & analyze results	1	2	3	4	5
28	Explaining unexpected results, and considering potential sources of error	1	2	3	4	5
29	Asking new questions based on data analysis from a previous experiment	1	2	3	4	5
30	Reflecting on one's own work or learning	1	2	3	4	5
31	Explaining data from experiments without a predicted outcome, or using other evidence to make & defend conclusions	1	2	3	4	5

Inventory Section 2: Prior Experience With Specific Teaching Methods

How much experience did you personally have with each of the following, in the <u>lab courses</u> that you took in biology as an undergraduate student? Rank them using the following scale:

    (1) Never; we did not do this in labs I took
    (2) Rarely; we did this in <25% of labs I took
    (3) Sometimes; we did this in around 25–50% of labs I took
    (4) Frequent; we did this in around 50–75% of labs I took
    (5) Extensive; we did this in 75–100% of labs I took

Item #	Description	Rating				
1	Completing worksheets	1	2	3	4	5
2	Listening to the instructor lecture	1	2	3	4	5
3	Taking multiple choice/true or false/fill in the blank tests	1	2	3	4	5
4	Reading assignments in a textbook	1	2	3	4	5
5	Engaging in experiments with predetermined outcomes	1	2	3	4	5
6	Engaging in experiments with predetermined, written procedures	1	2	3	4	5
7	Memorizing concepts	1	2	3	4	5
8	Writing lab reports for experiments with preset procedures and results	1	2	3	4	5
9	Receiving factual information from the teacher	1	2	3	4	5
10	Passively watch a demonstration of a principle or process	1	2	3	4	5
11	Identifying variables and designing appropriate controls for experiments	1	2	3	4	5
12	Answering questions about prior knowledge	1	2	3	4	5
13	Asking clarification questions during or after class	1	2	3	4	5
14	Participating in an in-class simulation or group exercise	1	2	3	4	5
15	Participating in a class discussion	1	2	3	4	5
16	Developing new examples of a specific concept or process in action	1	2	3	4	5
17	Making predictions based on prior knowledge	1	2	3	4	5
18	Giving individual presentations, or participating in group presentation in class	1	2	3	4	5
19	Writing formal lab reports on novel results	1	2	3	4	5
20	Students reviewing or critiquing another student's work	1	2	3	4	5
21	Searching outside primary literature sources to learn what is already known.	1	2	3	4	5
22	Designing and implementing new procedures or models	1	2	3	4	5
23	Exploring alternative methods for solving problems	1	2	3	4	5
24	Identify questions/concepts that guide scientific investigations	1	2	3	4	5
25	Comparing data or otherwise collaborating with other groups	1	2	3	4	5
26	Communicating findings to the rest of the class	1	2	3	4	5

27	Using graphs, basic statistics (mean, st.dev., t-test, etc) to summarize & analyze results	1	2	3	4	5
28	Explaining unexpected results, and considering potential sources of error	1	2	3	4	5
29	Asking new questions based on data analysis from a previous experiment	1	2	3	4	5
30	Reflecting on one's own work or learning	1	2	3	4	5
31	Explaining data from experiments without a predicted outcome, or using other evidence to make & defend conclusions	1	2	3	4	5

Inventory Section 3: Specific Teaching Methods You Ideally Would Use
Look back at the definition for inquiry–based learning that you provided for Question B on the first page. Based on that definition you provided, **how important do you think each of the following activities is to an inquiry–based laboratory?** Rank them using the following scale:
  (1) Not important
  (2) Rarely important
  (3) Moderately Important
  (4) Very important
  (5) Essential

Item #	Description	Rating				
1	Completing worksheets	1	2	3	4	5
2	Listening to the instructor lecture	1	2	3	4	5
3	Taking multiple choice/true or false/fill in the blank tests	1	2	3	4	5
4	Reading assignments in a textbook	1	2	3	4	5
5	Engaging in experiments with predetermined outcomes	1	2	3	4	5
6	Engaging in experiments with predetermined, written procedures	1	2	3	4	5
7	Memorizing concepts	1	2	3	4	5
8	Writing lab reports for experiments with preset procedures and results	1	2	3	4	5
9	Receiving factual information from the teacher	1	2	3	4	5
10	Passively watch a demonstration of a principle or process	1	2	3	4	5
11	Identifying variables and designing appropriate controls for experiments	1	2	3	4	5
12	Answering questions about prior knowledge	1	2	3	4	5
13	Asking clarification questions during or after class	1	2	3	4	5
14	Participating in an in-class simulation or group exercise	1	2	3	4	5
15	Participating in a class discussion	1	2	3	4	5
16	Developing new examples of a specific concept or process in action	1	2	3	4	5
17	Making predictions based on prior knowledge	1	2	3	4	5
18	Giving individual presentations, or participating in group presentation in class	1	2	3	4	5
19	Writing formal lab reports on novel results	1	2	3	4	5
20	Students reviewing or critiquing another student's work	1	2	3	4	5
21	Searching outside primary literature sources to learn what is already known.	1	2	3	4	5
22	Designing and implementing new procedures or models	1	2	3	4	5
23	Exploring alternative methods for solving problems	1	2	3	4	5
24	Identify questions/concepts that guide scientific investigations	1	2	3	4	5
25	Comparing data or otherwise collaborating with other groups	1	2	3	4	5
26	Communicating findings to the rest of the class	1	2	3	4	5

27	Using graphs, basic statistics (mean, st.dev., t-test, etc) to summarize & analyze results	1	2	3	4	5
28	Explaining unexpected results, and considering potential sources of error	1	2	3	4	5
29	Asking new questions based on data analysis from a previous experiment	1	2	3	4	5
30	Reflecting on one's own work or learning	1	2	3	4	5
31	Explaining data from experiments without a predicted outcome, or using other evidence to make & defend conclusions	1	2	3	4	5

Appendix C
TA Observation Protocol

Teaching Assistant - Inquiry Observation Protocol (TA-IOP)

I.	BACKGROUND INFORMATION

Name of Evaluator _____   Announced Observation? _____

Date of Class _____   Topic of Exercise _____

Start time _____   End Time _____

Name of TA _____   Prior Experience _____

II.	OBSERVATIONS	
Time (mins.)	Use the spaces below to take descriptive notes of your observations. Provide specific examples of exchanges that demonstrated the TA's pedagogical skills, classroom management skills, content knowledge, and preparation.	
0-15		
15-30		
30-45		
45-60		
1hr-1hr15		
1hr15-1hr30		
1hr30-1hr45		
1hr45-2hr		

This instrument is to be completed during/following observation of laboratory classroom instruction. Refer to the specific examples you noted in your observations (previous pages) that demonstrate each of

the items. Use the numerical scale as follows: 0 = not observed, twice), 2 = observed occasionally (3-4 times), observed throughout (>75%)

1 = observed rarely (once or 3 = observed often (>50%), 4 =

III. PEDAGOGICAL SKILLS

1. The TA asked questions that elicited student responses built on the students' own ideas rather than the TA leading students to answer a specific way.

0   1   2   3   4

Provide examples below:

Example of a question that worked: After showing students a graph of data displaying unexpected results the TA asks, "How would you interpret the results?"

Why did it work? Asks students to analyze their expectations/thoughts, mesh these idea with inconsistencies presented before them, and analyze and evaluate data, rather than just telling the students what the graph indicates.

Example of a question that didn't work as well: "What's wrong with this data?"

Why did this not work as well? TA is leading them, telling them a little about what they should be looking for or analyzing rather than letting it be student-instigated.

2. The TA encouraged students to reflect upon (explain in their own words) how they learned something/came up with an answer (metacognition).

0   1   2   3   4

Provide examples below:

Example of a question that worked: Students ask a TA why they got unexpected results and the TA responds, "First tell me what you got and then tell me what you did to get these results."

Why did it work? Asks students to first state their results and then retrace and verbally explain (i.e. reflect) how they got them; Reflecting on their methodology often leads students to answer their own questions because it forces them to think out what they did and how they did it (and therefore where they went wrong).

Example of a question that didn't work as well: Students ask a TA why they got unexpected results and TA responds "It seems to me based on what you wrote that you forgot your control, so redo the experiment with a control and see what kind of results you get."

Why did this not work as well? TA is identifying the problem and instructing students how to fix it. Students don't have to do any thinking to solve the situation, identify other possible errors, etc.

IV. CLASSROOM MANAGEMENT

1. The TA provided a holistic view of the lab.

Example of a strategy that worked: TA opens the beginning of lab with a brief summary of what will take place in lab as whole and then provides detail about each lab activity: "Today we are

0   1   2   3   4

Provide examples below:

working with enzymes, and we'll complete three activities about how enzymes do their jobs. The first looks at XXXX, and at the end of the activity you should be able to XXX. This sets up the next activity on YYYYY, etc."

Why did it work? Students have an overall view of the lab topic and how the lab will run, but they are also clear on how each activity is connected to the rest.

Example of a strategy that didn't work as well: TA opens the beginning of lab by stating "We are working on enzymes today and by the end of lab you should have the following complete to turn in to me."
Why did this not work as well? TA is providing a broad outlook of lab and what is due at the end, ignoring connections that should be made between activities.

2. The TA regularly checked on group interactions to ensure a collaborative working environment where all students were contributing equally.

0   1   2   3   4

Example of a strategy that worked: While students are working on activities, TA observes group interactions to see how work is being completed. TA also checks in with each group to inquire what roles each team member is playing: "Who is doing the timing in this experiment? Who is writing down results?"
Why did it work? Students are reminded that everyone should be participating equally in the lab.

Provide examples below:

Example of a strategy that didn't work as well: TA talks with members of one or two out of five groups, but only visually observes the remaining groups.
Why did this not work as well? TA has not reached all groups to check how work has been divided amongst members. This may communicate to students that TA is not concerned with equal work loads, so some students may continue to do all the work while others do little.

3. The TA managed the progress of groups, ensuring that they finished tasks and redirected them if they were "struggling."

0   1   2   3   4

Example of a strategy that worked: While students are working on activities, TA checks with each group to see how much progress they have made and where they might be stuck. TA also asks a "check-in" question to make sure they are completing the work and looking ahead: "This looks like a good idea. How many replicates will you run?"
Why did it work? Students are shown that TA is concerned about their group's progress and are given an opportunity to ask questions. Students are also held accountable for how they will

Provide examples below:

finish the experiment in the allotted time.

Example of a strategy that didn't work as well: TA visually observes the groups, only checking on those that are clearly struggling.

Why did this not work as well? TA has not made efforts to verbally discuss progress with students. This may communicate to students that TA is not concerned with them understanding the lab and completing work and therefore may lead to lower effort on students' part.

V. CONTENT KNOWLEDGE

1. The TA had a solid grasp of the subject matter content inherent in the lesson and could apply it to real-world situations.   0   1   2   3   4

Example of a teaching strategy that worked: TA asks "After reading the article in the New York Times comparing the abilities of children and chimps to imitate, you read some letters to the editor. In one letter, the author wrote about "unschooling": a child-led form of homeschooling. Has anyone ever heard of this term? Can you give me an example?...Pause…The best example I can think of is this lab! You are experiencing traditionally taught science laboratories in a non-traditional way where YOU often figure out the science instead of me teaching it to you in a lecture or you following a series of steps to get an answer."

Provide examples below:

Why did this work? TA used an unfamiliar term and is able to draw a direct comparison to the students themselves.

2. The TA acted as a resource person, working to support and enhance student investigations.   0   1   2   3   4

Example of a strategy that worked: As TA checks on groups' progress, he states "This experiment looks pretty good, but don't forget that there are other reactants available to work with on the table. How could they help your investigation?"

Provide examples below:

Why did this work? TA recognizes and compliments current progress while encouraging students to look beyond their current work and possibly enhance their experimental results

Example of a strategy that didn't work as well: Student has only used 3 of 5 solvents on lab bench for experiment and asks TA if she should use the rest. TA responds "Well, I'm not really sure why they are there so I'd say don't use them. I'm sure what you did is fine."

Why did this not work as well? TA communicates to student that he does not understand all possible variables in the experiment and how students should utilize them.

VI. PREPARATION

1. The TA presented information that was accurate.   0   1   2   3   4

Examples of inaccuracies: 1) TA has lectured on material that she later realizes had some inaccuracies. For instance, she gives the incorrect end products of photosynthesis; 2) incorrect methods to dilute solvents; 3) incorrect identification of organism on slide.

Provide examples below:

2. The TA selected teaching strategies that made content understandable to students.

0   1   2   3   4

Example: TA wants to explain "denaturation." She draws a flower on the board, representing an enzyme. She explains: "Let's say this flower is an enzyme. If we put this flower in an environment that it wasn't used to, such as really high heat, what might happen?...it will wilt." She redraws the flower, this time crumpled and wilted. "This is what happens when you put enzymes in unfavorable conditions such as high heat; the break apart and lose their shape."

Provide examples below:

Why did this work? TA uses a simple example to explain a more complex scientific concept.

Example of a strategy that didn't work as well: Student asks who in the real world would want to isolate specific genes. TA replies an in-depth description of his master's research project.
Why did this not work as well? TA is giving a real life example, but it is too detailed and complicated for the general connection that the student is trying to make. A connection to a larger picture would work better (i.e. someone interested in trying to find a specific genetic link to Alzheimer's disease).

3. The TA covered all that was required in the time allotted.

0   1   2   3   4

What are some reasons why the TA was not able to cover everything?

VII.   STUDENT BEHAVIORS

1. Students were actively engaged in thought-provoking activity and stayed on task.

0   1   2   3   4

Examples of off task behavior observed: text messaging, talking about social events, talking on the phone, head down on desk/sleeping

Provide examples below:

2. Most student questions were reflective (asking about *why* they were doing something) rather than procedural (*how* they were doing it).

Example of reflective question: Student states "I don't understand why we are measuring how long a behavior occurs instead of the number of times a behavior occurs."

Example of procedural question: Student states "I don't understand how to adjust the temperature setting on the water bath."

0   1   2   3   4

Provide examples below:

3. Students actively shared ideas and problem solving strategies, including how they learned and what they learned with each other, rather than turning to the TA for corroboration.

Example: Students are given a set of materials and need to design an experiment on how to measure the amount of starch hydrolyzed in a given solution. Students begin by discussing/debating with one another how they are going to conduct the experiment, rather than waiting for the TA to tell them or searching for the answer in their lab manuals.

0   1   2   3   4

Provide examples below:

VIII. POST-LESSON INTERVIEW QUESTIONS

1.   What do you think went well in the lab?

Answer:	Observers suggestions:

2.   Can you give an example of an interchange you had with the students that you felt went particularly well? Why did it work well?

Answer:	Observers suggestions:

3.   What did you feel did not go well with the class?

Answer:	Observers suggestions:

4.   What is the reason you think these problems happened?

Answer:	Observers suggestions:

5.   How would you modify your teaching next time to deal with this problem?

Answer:	Observers suggestions:

6.   Are there any materials or instructions you felt would have helped you better prepare to teach this lab?

Answer:	Observers suggestions:

7.   If you could teach this same class over again, what would you do differently? (In particular any interactions you had with the students during class.)

Answer:	Observers suggestions:

Appendix D
Comment Lists from Participants

Collated List of Instructional Behaviors And Skills That Foster IBL

- Good question–asking skills, especially in encouraging students to think.
- Ability to listen actively.
- Can move about and interact with students without being overly disruptive.
- Routinely checks students' understanding and progress.
- Uses students' names.
- Encourages students to push further, and praises them if successful.
- Encourages and EXPECTS undergraduate reflection on learning.
- In thinking about teaching, is able to step back into the mindset of the undergraduate.
- Understands why "positive confusion" is an essential part of the learning process and knows how to encourage it without discouraging students.
- Gives responsibility for learning back to the students.
- Encourages discussion.
- Assumes core knowledge by students; does not rehash factual knowledge that it is reasonable to expect students would (or should) know.
- Expects and elicits participation of all students.
- Encourages multiple hypotheses for testing.
- Can model important behaviors.
  This idea applies to both physical things such as safe lab practices (no mouth pipeting for example) and pedagogical skills (for example, breaking a complex problem down to demonstrate how they would perform a stepwise analysis.)
- Collegiality.
- Good general communication/presentation skills.
- Cool under fire.
   o Can manage confrontational students
   o Maintains professional boundaries
   o Has ability to manage students without denigrating them
   o Can manage harassment
   o Maintains a sense of humor
- Knowledgeable about institutional policies, rules, regulations, and ethics.

Collated List of Participants' Barriers to Training TAs and Implementing IBL

- TAs fail to understand purpose and goals of IBL.
- TAs may short–cut IBL methods to reduce lab meeting time.
- TAs lack sufficient content knowledge. Solutions include:
   o Create a database of core knowledge, supported by a textbook
   o Train TAs to use clarifying strategies, such as "I don't know, but I will find out." Creates a 'near–peer' learning environment.
   o Build up a library of prior editions of basic textbooks for TAs to consult, particularly if you have TAs who may not have strong backgrounds in the topics they are teaching.
- Time constraints. TAs feel torn between research and pedagogical duties.
   o Reduce or remove first year teaching requirements.

- o Use time sheets to document actual time spent; if necessary, modify demands, or provide supplemental training on strategies to reduce time spent grading.
  - o If concern is about different courses, critically evaluate the hourly time commitments between different courses (time sheets can be useful for this).
  - o Educate TAs about the relative amounts of time they will spend in their career on teaching versus research activities. Show them how their current teaching work prepares them for professional demands in the same way as research work.
- Overt resistance to shifting from didactic teaching to IBL methods.
  - o Provide TAs with data or evidence showing improved outcomes of IBL.
  - o Set clear goals for IBL in the context of a course. Then help TAs become comfortable with IBL by using "post–mortem" analysis of past labs' successes and shortcomings in achieving those particular goals.
  - o Encourage TA involvement in IBL development and implementation.
  - o Some resistance comes from anxiety about failure. All TAs need a safe space in which they feel they can comfortably try out ideas, express concerns, even fail and then try again until they learn their new skills.
- Limits on time and materials restricts opportunities for TA training.
  - o Start building a resources database through collaboration; do not try to reinvent the wheel.
  - o Use courseware programs like Blackboard to create your own TA training database. Encourage TAs to contribute to it, and refer to it in your meetings with TAs.
- Lack of motivation. Can be due to a lack of buy–in or lack of basic engagement with teaching duties as a whole.
  - o TAs need to know this is a central part of their professional development.
- TAs may believe content is more important that the learning process. Which one is more important is a false dichotomy. Both are necessary, so both should be stressed.
- TAs can be overwhelmed by IBL. Encourage them to start small in skills development and build over time.

Collated List of TA Training (Other Than for IBL) Recommendations

- Develop TAs' basic motivation to teach well.
- Use any or all of the following to move expectations and goals from implicit to explicit.
  - o Guidelines
  - o Open discussion about pedagogical practices
  - o Modeling
  - o Checklists
  - o Participatory demonstrations
- Help TAs get past pressures on their time and intellect by:
  - o Finding out TAs' interests and assigning them accordingly.
  - o Gaining faculty support for lab teaching methods.
  - o Providing TAs with a cost–benefit analysis of the skills set they will develop.
  - o Providing specific awards that can be used to build a CV.
- Ensure that there is comparable output and expectations of TAs in a variety of situations.
  - o Conduct routine evaluations and grade comparisons.
  - o Consider using a standardized exam format.
  - o Conduct workshops on grading formative and summative assessments.
  - o Elicit TAs to help in developing grading rubrics.
- Provide TAs with practice scenarios.

- o Casual cases (for example, have TAs discuss each others' student issues during lab prep meetings).
  - o Formal cases
- Teach TAs about syllabus development.
- Assess the TAs perspective on support they are receiving from you.

Future Workshop Topics (based on preceding three lists)

- Basics of inquiry. How do you present an effective "inquiry" based lead–in to a lab activity.
- Developing active listening strategies.
- Specific methods and strategies for evaluating effectiveness of your TA training program.
- Effective ways to engage and encourage students.
- How to encourage lab preparation (setting expectations about roles and responsibilities).
- Videotaping as a tool for evaluation.
- Writing and revising lab manuals from cookbook to IBL. General strategies, managing materials, timelines, etc.
  - Drafting an ABLE position statement on best practices for biology labs.

Appendix E
5E Learning Cycle (aka 5E Instructional Strategy)

Engage:
- ❑ Students' attention is captured
- ❑ Students' prior knowledge is activated
- ❑ Teacher assess misconceptions

Explore:
- ❑ Explore activities are hands-on, inquiry-based, and student-centered:
  - o Students do the activity in groups
  - o Students make decisions
  - o Students can manipulate objects to see how they interact/react
  - o Students can manipulate objects to produce a desired effect/result
- ❑ The teacher facilitates exploration with probing questions and poses problems ("what if?")

Explain:
- ❑ Students explain their ideas using observations/ evidence from their exploration
- ❑ The teacher introduces new vocabulary based on students' explorations
- ❑ Teacher facilitates discussion between students

Extend/Elaborate:
- ❑ The extend activity requires an understanding of the concepts in order to be successful
- ❑ The activity is different from, but related to the exploration activity
- ❑ Students extend and refine their knowledge through problem solving, another inquiry/exploration process, group project, etc.

Evaluate:
- ❑ Multiple forms of assessment are used
- ❑ Assessment occurs for each stated objective
- ❑ Assessment tools selected fit their purpose
- ❑ Assessment occurs before/ during/ after instruction

Appendix F
Termite Lab for Modeling IBL with TAs

This lab is useful both as an introduction to inquiry based approach to teaching (i.e. TAs as the participants) and learning (i.e. undergraduates as the participants). By using this lab as a model participant's experience, first hand, the inquiry approach to learning (IBL), gaining insight as to the strengths of this teaching approach for scientific exploration. The benefits of introducing this lab, during TA training and in the beginning of the semester for the students, provide a reference point from which students can use for future lab topics.

The lab begins with a leading question, designed to **engage** the students in the process of designing an experiment using the scientific method.

> *"While foraging through Robinson Forest, a fellow graduate student mentioned to you that several termites had landed on their field notes and, oddly enough, the termites did not move in a random fashion about the page, but seemed to, specifically, follow the writing on the paper."*

The first inclination for many teachers is to lecture to the students on the scientific method. However, this defeats the purpose of the inquiry approach to learning and the students quickly become disinterested. The facilitator simply encourages the students to observe and **explore** termite behavior while attempting to re-create conditions for the original observation, using the materials provided (see materials list). Students are asked to propose a hypothesis as to a plausible explanation for the termite behavior that they observe. They are to use the scientific method to make predictions and design experiments to validate their hypothesis. The facilitator should not discuss the scientific method, prior to students observing the termite behavior.

The facilitator moves among the groups to discern the student's knowledge base, pertaining to experimental design. After the students have had time to design some preliminary experiments, the facilitator will call upon various groups to share their experimental design and results, as well as, provide plausible **explanations** for the behavior that they observed. Select a couple of student groups to present their hypothesis and **explain** their experimental design. Encourage an interactive discussion between the student group presenting and fellow students by facilitating discussion with leading questions about the experimental design. Was the hypothesis a testable hypothesis? Did the data support the predictions? Was a control included? Were there replicate trials? Why is this important? Was there more than one type of termite? Was a difference in behavior observed between the two types of termites? If so, what might be an explanation for the differences in behavior?

Students can be **evaluated** by their experimental design on the elaboration phase of this lab. Encourage students to **explore** other **explanations** by expanding upon their current experiment or designing further experiments as a take home assignment.

After the discussion of the initial experimental phase, the facilitator presents a short presentation on the instructional model for constructivism, called the 5E instructional model (Bybee et al., 1989). This allows for the participants to actively experience the inquiry approach to learning and allows for a reference by which to grasp the constructivism philosophy about learning. Modeling the inquiry approach to learning in both TA training, as well as, seems to set the expectations whereby the participants are more accepting for deviating from the traditional method of "cookbook" style delivery of the labs. Students have been overheard while leaving the lab saying to one another "this is my favorite science course".

Materials: Students work in groups to compare data after their initial observations and before the discussions. Each student will receive a Petri plate with a termite.
- 1 Petri plate containing 1 termite each. (If possible, place one soldier and one worker termite in each plate. Each group will need to have at least one worker termite)
- White paper
- Small paint brush

A selection of pens in different colors shared among student groups.
- Ball Point
- Dry Erase
- Sharpie
- Highlighters with scent
- Colored pencils

Background information for facilitating discussion.

Termites live in colonies located in wood or in the ground. They are social insects, much like ants, with a hierarchical system. There are workers, soldiers and queen termites. The workers are sterile and perform the main work for the colony. Worker termites are smaller and more opaque in color than soldier termites. The workers primarily construct the galleries and collect food (by decomposing plant materials) for feeding the queen, soldier and young termites. Their energy source comes from the decomposition of cellulose in the plants. The cellulose is digested from the plant material by small symbiotic protozoa in lower termites (*Trichonympha*) that reside in the termite gut or by symbiotic bacteria (*Spirochetes*) in higher termites (Breznak, et. Al, 1994). The soldier's main function is for defense and can be distinguished from the workers by the large jaws and head that are reddish-brown in color.

As a way of recognizing their colony and trails, termites emit a pheromone (Peppuy, et.al, 2001). Worker termites lack compound eyes; therefore they utilize olfactory cues as a means of identifying their colony. While the worker termites emit and follow the pheromone trails, the soldiers only follow the trails. They do not have the means to lay the trail and will wander randomly until a worker emits the pheromone. Apparently, the ink in ball point pens mimics the olfactory cues whereby termites will follow ink trails made only by ball point pens and not other types of ink.

Literature Cited

Alexis Peppuy, Alain Robert, Etienne Semon, Christian Ginies, Martine Lettere, Odile Bonnard and Christian Bordereau. *(Z)-dodec-3-en-1-ol, a novel termite trail pheromone identified after solid phase microextraction from Macrotermes annandalei.* Journal of insect physiology yr:2001 vol:47 iss:4-5 pg:445 -53.

John Breznak and Andreas Brune. *Role of Microorganisms in the Digestion of Lignocellulose by Termites.* Annu. Rev. Entomol. yr:1994 vol:39 pg.453-87.

This lab has been adapted by ***Alma F. Ferrier, University of Kentucky, September 2007*** from the following websites:
http://www.uky.edu/Ag/Entomology/ythfacts/resourc/tcherpln/termtrails.pdf #search=%22termites%20and%20ink%22
http://www.accessexcellence.org/AE/ATG/data/released/0106-LanaHays/index.html

Appendix G
Static Electricity Lab for Modeling IBL with TAs

Static Electricity Elicitation Questions

1. How many types of charge are there? Explain how you know. (E.g., what evidence do you have for your answer?)

2. Below is a small ball hanging from a string. The ball is known to be "charged."
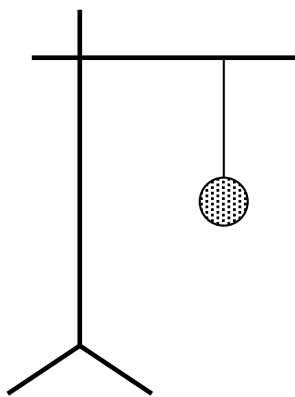
Each of the following objects is brought near, but not touching the hanging ball. For each of the objects, predict whether the ball will attract, repel, or do nothing. Give an explanation for each of your predictions. If your prediction depends on some unknown information, indicate what information you need.

   a. An identically charged ball hanging from a string.

   b. A paperclip

   c. A Styrofoam cup

   d. A north pole of a bar magnet

   e. A south pole of a bar magnet

Static Electricity: Investigations with Tape

In this activity, we will begin to develop a model for charge. Try to answer the questions based solely on the observations you are making today. Work in groups to conduct the investigations and answer the questions. Before moving on to a new part, make sure all the members of your group have reached the same conclusions.

I. Pull a piece of tape, approximately 8 to 10 cm off the roll and fold an end over to make a "handle" so the tape doesn't stick to your fingers. Put the tape sticky side down on a cleaned, dry tabletop. With a pen label the tape **1**. Vigorously pull the tape off the table and stick it on the edge of the table so that it can hang freely.

    A. Slowly bring objects like your finger, a pencil, etc. near, but not touching, tape **1**. Describe what happens to **1**.

    B. Were there any objects that did not interact with tape **1**?

II. Pull off a new piece of tape, make a handle, and label this tape **2.** Put it on the table, rip it off, and slowly bring the non-sticky side of **2** near the non-sticky side of **1**. (This is so they do not get stuck together.

    A. Describe your observations.

    B. How does the distance between the two tapes affect the interaction between the tapes?

We say that an object is "electrically charged" when it interacts as you have observed the tape interact.

III. Pull off a new piece of tape, make a handle, label it **B** for bottom, and stick it to the table. Pull off another piece of tape, make a handle, label it **T** for top, and put it "piggy back" on the top of side **B**, sticky side down. Gently pull the **B-T** combination up off the table. Touch the sticky side of the tape combination with your hand, taking care not to wrinkle the tapes. Stick the **B-T** combination to the edge of the table.

    A. Is the **B-T** combination "charged?" How do you know, what is your test for charge?

    B. What does it mean for something to be "uncharged" or "neutral?" Is your finger neutral? Explain.

If the combination is charged, then touch the **B-T** combination again and test it again until it is no longer charged.

    C. Now vigorously rip **B** and **T** apart and hang the tapes to the edge of the table. Bring an object like your finger or pencil near **B** and then near **T**. Describe your observations.

    D. Describe the interactions when the following pairs are brought together.

        • a **B** tape with a newly charged **1** tape

- a **B** tape with a newly charged **2** tape

- a **T** tape with a newly charged **1** tape

- a **T** tape with a newly charged **2** tape

E. Do you think there is more than one kind of charge? What is your evidence?

F. How do you know when two objects have the same or different charge? Explain.

G. How do you make two pieces of tape with the same kind of charge?

IV. Predict how two **B** tapes would interact and how two **T** tapes would interact. Justify your prediction.

A. Each member of the group should now make new **B** and **T** tapes to test your prediction.

B. Before the B-T combination was taken apart it was not charged. After they were pulled apart the tapes were charged. Were they now charged the same or different? What is your evidence?

V. Predict how the north pole of a magnet would interact with the **B** and **T** tapes. Justify your prediction.

A. Obtain a magnet from the instructor, make new B and T tapes, and test your prediction.

B. Is the pole of the magnet charged? What is your evidence?

VI. **Extension Questions:**
A. How many different types of charge do there appear to be? Justify your answer.

B. How do two objects that have "like" charge interact with each other? How do objects of unlike charge interact?

C. What evidence would you look for it you thought there might be yet another kind of charge, more than what you have found so far?

D. If you were to stick **B** and **T** back together, do you predict the combination would be neutral or charged? Explain your prediction with words and pictures.

Appendix H
PBL Case & Teaching Notes

Edward's Discussion

(An interrupted case developed by A. Daniel Johnson, Wake Forest University)

Session 1
Page 1
10 minutes

SCENARIO:
You are a seasoned teaching assistant (TA) in charge of three lab sections for BIO100: Biological Principles during the spring semester. You and the five other TAs for the course have formed close friendships, and you frequently help each other with grading, reading and evaluating student papers, and so on. The TAs meet every Friday afternoon with Dr. Liu Zhung, the faculty coordinator, to discuss the exercises for the upcoming week, and work out any unfinished details. These meetings also have become a time to discuss problem students, difficulties with assignments, and other lab issues.

Celia Franklin is the newest member of your group. She joined the Biology Department in January, as a mid–year entrant to the Master's program. Unlike you and the rest of the crew, this is Celia's first experience as a TA. On a recent Friday, she brings up a concern she has.

"Okay, I need some advice. Remember the lab reports the students were supposed to turn in last Monday by noon? My student, Edward Biggs, turned in his on Tuesday morning."

Tyrell O'Neil, another seasoned TA, doesn't hesitate. "Ten percent per day penalty for late assignments. That's the policy, unless he has a permissible excuse from Dr. Zhung. Problem solved."

Celia responds, "You didn't let me finish. I read Edward's report last night, and something seemed odd about the Discussion section, like I'd read it before. I looked at all of the other reports though, and his was not copied. This is all new to me, and I'm confused about what to do. What do you guys think?"

QUESTIONS:
- What are the possible reasons why a student's paper might look familiar?

- How would you respond to Celia? In particular, is there any specific information you would want to see before making a decision?

Stop: Discuss these questions before you go on to the next page

Session 1
Page 2
20–30 minutes (shortened to 10 minutes for ABLE Conference)

SCENARIO:
A couple days after the meeting, Celia mails a copy of Edward Biggs' report to the rest of the TAs. His discussion <u>does</u> seem familiar, particularly the second paragraph:

> "There is no one solution to the problem of water and ion regulation, so different organisms typically use several strategies(3). In general, animals have a system that lets them swallow ionically different solutions, then excrete excess water or ions they do not need. Meanwhile, plants take up the correct ratio of water, nutrients, and ions from their surrounding soil automatically."

You compare it to the laboratory manual, where you find this passage:

> "There is no one solution to the problem of water and ion regulation, so different organisms typically use several strategies. Moreover, balancing ionic excretion or absorption with other energy requirements only becomes a limiting factor when…"

The rest of Edward's paragraph still looks familiar though, so you compare it to your own students' papers waiting to be handed back. Halfway through the stack, you find this paragraph in Joan Moore's paper:

> "Animals and plants use different tactics to deal with ion imbalances. Animals have one or more mechanisms that let them ingest unbalanced solutions, then actively excrete any excess water or ions they do not require. Conversely, plants usually absorb a balanced solution of water, nutrients, and ions from their surrounding soil initially."

You walk down to Celia's desk, and break the news. "I found the source of Edward's discussion section. It was definitely copied from the lab manual, and one of my students' paper, no doubt about it!"

"Wow. What should we do now?"

You respond, "I've not had to deal with this before. I think we need to talk it over with Dr. Zhung and the other TAs at our next meeting, "

QUESTIONS:
- Do you agree that Edward Biggs' paper was plagiarized? Why or why not?
- Put yourself in Dr. Zhung's place for a moment. What additional information would you want Celia and the other TA to bring to the Friday meeting?

TASK FOR NEXT SESSION:
- Find out your institution's official definition and policy towards plagiarism. Be ready to share that information with the group.
- Locate answers to any other learning issues you identified as part of this case.

Stop: end of Session 1

Session 2
Page 1
30 minutes

TASKS:

How does your institution define plagiarism? Does the second paragraph from Edward's discussion fit that definition? Why or why not?

Report on anything you discovered regarding the other learning issues from last session.

Page 2
30 minutes (shortened to 10 minutes for ABLE conference)

At the next Friday meeting of the BIO100 TAs, Dr. Zhung asks if Celia has her course syllabus handy. After scanning it for a moment, Dr. Zhung passes it around for the rest of you to see.

BIO100 Syllabus

T.A. Celia Franklin   E-mail: cfranklin@wcd.edu
Office: 239 Harrison Hall   Office Hours: Appt please

Lab Attendance: Attendance is **mandatory**. Excused absences are permitted in cases of family emergency, serious illness or injury, or approved school activities. For unexcused absences:
      One unexcused absence: **10% off** your final lab grade.
      Two unexcused absences: **25% off** your final lab grade.
      Three unexcused absences: **ZERO** for a final lab grade.

Lab Conduct:
- Come to lab prepared. Reading the manual beforehand shortens the time spent in lab and doing so will also prepare you for weekly quizzes.
- Refrain from talking while I am talking. It is disrespectful to everyone, and will result in a lower lab participation grade.
- Cell phones must remain off while in lab. Laptops are required for some of the labs, but they are to be used only when needed for lab. No IM'ing and e-mailing during the lab period.
- No food, drink, or gum in the lab.
- **You** are responsible for cleaning up your lab area before you leave.

Grading:
Quizzes and homework	25%
First Lab Report (Enzymes)	20%
Second Lab Report (Physiology)	25%
Oral Presentation (Species Interactions)	20%
Participation	10%

Your lab grade constitutes 25% of your lecture grade.

"Celia, your syllabus does not specifically state anywhere that you expect students to abide by the University guidelines. If we try to report Edward to the Judicial Office, he can claim he was not aware that he was committing plagiarism."

Celia is livid. "You mean he can get away with copying and cheating unless I specifically tell him not to?! This is insane! Besides, I told them in class that I expected them to do their own work, and hand in individual reports. Edward knew better than to do this. He should be punished for what he did to Joan Moore."

QUESTIONS:
- Do you agree with Dr. Zhung that Edward could get off because he was not told specifically by Celia not to copy from another student? Why or why not?

TASKS:
Working as a group:
- Formulate a consensus plan for dealing with this situation. Take into consideration your institution's rules on academic honesty, and any rules you may have found relating to students' rights.

- Devise a set of guidelines you can give to future TAs that would reduces the chances of this same situation happening again.

End of Case

Facilitation Notes for "Edward's Discussion"

General Background

Plagiarism is a very common situation for TAs to deal with, both now and later in their professional lives. Evidence is conflicting on whether it truly is on the rise, or we merely are identifying and prosecuting it more frequently. This training case was designed to introduce novice instructors to three ideas:
- Most institutions have formal policies outlining their definition of plagiarism, and procedures for reporting and investigating it.
- Plagiarism takes many forms, and may not be clear–cut.
- Clearly stated, rational policies and guidelines can help students know what is expected of them, and also help an instructor enforce high academic standards.

The case also encourages TAs to rely on their teaching colleagues as sources of information and professional assistance.

Session 1, Page 1:

In this section we are introduced to the potential problem with Edward's discussion. As participants answer the questions, the facilitator should encourage them to think beyond the obvious. For example, experienced instructors know that after reading a dozen papers, many will begin to sound alike. Novices may not be aware of this though. Students who work together as lab partners often discuss the structure of their papers, but do not overtly copy each other; often these papers have similar structure, yet be independent work. Finally, highly restrictive writing guidelines may force students to compose reports that are very similar.

Session 1, Page 2:

In this section, participants learn that Edward's paper does appear to have a plagiarized paragraph. However, the passage was intentionally written not to be a direct quote. One feature that participants should identify is that the first sentence has a reference number after it. At WFU, our lab writing guidelines specifically forbid extended quotes, even with proper citation. In practice though, our students have more experience using the MLA writing format, which allows extended quotations from sources. While we are less rigid in enforcing this particular violation, other institutions may have different policies they want TAs to follow.

The remainder of Edward's passage presumably was copied from another student. Individual words have been changed, but the overall flow and structure was preserved. Most instructors would consider this to be plagiarized. Once again though, without clear, unambiguous guidelines in place, a student could rightfully claim that the work was a result of collaborative discussion, not overt copying. At WFU, we adopted a very specific definition of what we consider too close to be the result of collaboration.

The goal of the questions at the end of this page is to stimulate a discussion of these issues. The tasks are designed to make participants locate key factual information they will need to complete the final assignment in the second session.

Session 2, Page 1:

At the start of the second session, participants should be sure they all understand their own institution's definition of plagiarism. If there is a departmental or program–level supplement to that policy, make sure that the participants have identified it and included it as well.

If participants have found other relevant information, be sure to have them report it to the rest of the group. For example, a participant may find an article reporting on a student that successfully appealed their judicial citation, for one reason or another. These bits of supplemental information do not detract from the case at hand, but rather enrich it.

Session 2, Page 2:

Question:

This question has two purposes. First, there have been cases where students have won a judicial review, despite being guilty, by claiming they were not informed of the expectations of a specific instructor. While these cases seem unfair, they do point out why instructors should provide students in larger courses with clear, unambiguous instructions.

The more important purpose of this question is to prime students for the tasks that follow. It is very likely that the discussion of this question will segue on its own into the tasks. Do not be concerned if this happens. Let the discussion move that way for a short time, then simply ask participants to begin developing specific consensus plans and recommendations based on their discussion.

Tasks:

In problem–based learning, the most effective cases will include a tangible group product or project. This product may be part of the tasks between Sessions 1 and 2, or a final product of Session 2. In this case, the participants have two group assignments. In the first assignment, they must decide how to deal with this specific case. As the facilitator, press them to ensure that they account for ALL elements and variables? Questions you might ask:
- Is this plan fair to Edward Biggs? Does it preserve his rights under our University policies?
- Is this plan fair to Celia Franklin and Joan Moore?
- Does this plan adhere to institutional guidelines?

In the second assignment, participants are asked to project the current experience forward, and develop a policy that anticipates the problems raised by this case. To make the case richer for participants, let them develop a plan that they agree upon, then bring in (anonymously) the facts from a case of plagiarism or academic dishonesty that you personally have dealt with. Let the participants see if their

policy would make the decision–making process easier. BE SURE that they realize you are describing an actual case you had, not a theoretical construct.

Appendix I
Building a TA Observation Protocol

Here is a simple structure to follow to continue building a TA observation protocol. I suggest that you keep the handout on the NRC inquiry standards with you while you build your protocol; it will be a good reference for you to work with as you finding yourself continually asking "why" and "what" questions: Why do I want to give my TAs feedback? Why do I feel it is important for students to learn through inquiry? What goals do I have for my TAs and my students?

1. Think about student goals. What do you want them to get out of your inquiry labs? (This is where the NRC handout will be most handy).
2. Think about what your **TAs** need to have to reach those student goals.
3. Use your responses to the first two questions in a form that can applied to **every** lab and apply them to your protocol.

Example Responses:
1. In my inquiry labs, I want students to be asking their own questions about what they are observing. I hope that these questions will lead to their own (i.e. student-led) investigations.
2. In order for students develop scientific questioning skills, TAs will to learn how to redirect student questions. For example, students are used to having their instructors give the information that the students want; if the students have a question, their instructor tells them the answer. In an inquiry lab, if a student asks "I want to study how changing pH levels of aquarium water will effect the Elodea growing in it, how do I start?", TAs need to fight the urge to answer directly with "Well, you can do…" and instead redirect the question to make students struggle with answering it: "Think about what you want to measure. How are the materials you have in front of you going to help you?"
3. In order for students to gain scientific questioning skills and for TAs to be the main facilitators of this goal, TAs will need feedback on how they are encouraging students to think on their own in order to find answers. I might develop a category called "**Questioning Strategies**" and have the following observation points*:

TA observations
TA redirects student questions on "how" to do something so that the student must consider "why" s/he is interested in doing something.
Example: XXXXXXXX
Ranking Scale:

Student observations
Students indicate development of questionings skills by asking their TAs metacognitive questions rather than procedural ones.
Example: YYYYYYYY
Ranking Scale:

*Note that TAs are gaining feedback via direct observations of their abilities to redirect questions but ALSO through types of student questions being asked.

Appendix J
Supplemental Resources

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