

An Active Learning, Student-Centered Approach to Training Graduate Teaching Assistants

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Abstract - For over a decade, new graduate Teaching Assistants (TAs) from four departments at the Colorado School of Mines have been part of a three-day training program prior to the start of the fall semester. The unique feature of this training program is the strong emphasis on active learning philosophy and methods. Our goal is to teach new TAs how to employ active learning methods in their laboratory and recitation teaching. We do this by having TAs experience most of their training as students in active learning classes and then having them discuss the activities for form, student involvement, and purpose. The TAs spend half their time together focusing on general aspects of effective teaching and the other half with their respective Department faculty focusing on the specific course they will teach. This paper will present specifics of activities, logistics, teaching sound bites, and feedback on this TA Training program. We feel that it is a model adaptable to other institutions.

Keywords: active learning, student-centered teaching, TA training

INTRODUCTION

When the Colorado School of Mines (CSM) teacher development office, currently called the Center for Engineering Education [1], began in the early 1990's, one of its first tasks was to develop and conduct teacher-training workshops for new graduate Teaching Assistants (TAs) working in service courses in several departments. The primary purpose of the TA Workshop (TA-W) was to train TAs to become effective 1-on-1 teachers who use active learning techniques. To do this, we modified a successful TA workshop model, used for a decade by the first author and his chemistry colleagues [2] to prepare TAs to teach inquiry-formatted freshmen labs [3]. The primary feature of the model is to have TAs experience active learning classes as students with the workshop presenters acting as teachers. After each such "role-playing" class, the TAs discuss the experience and identify particulars of the format, the teacher's actions, the level of student involvement and the purposes served by the class structure. During the wrap-up of these discussions, "sound bites" are presented to help TAs organize the ideas. After several such experiences, the workshop shifts to a focus on 1-on-1 teaching skills that the TAs practice by role-playing

as students and teachers. Thus the Workshop is an intense active learning and inquiry experience for the TA.

This workshop format does not have as its focus class logistics (taking role, testing equipment, learning the content, course schedules, office hour rules, etc.). The two logistics aspects that we consider important, and thus include in the TA-W, are (1) learning the content and (2) being familiar with the rules of the course. In the chemistry active learning workshops [2], this was handled by using the labs TAs will teach as the vehicles for the active learning. Thus they re-learn the content and see the course rules, but as a secondary part of the active learning training. To accomplish this same thing with TAs for four different departments, we devised a two-tiered workshop. The TAs spend half the workshop time together concentrating on active learning aspects, but spend the other half with just their departmental colleagues and a professor experiencing and discussing active learning in the actual course they are scheduled to teach. Our goal in this second tier of the workshop is to have TAs experience the first month of content they will be teaching.

That this model of TA training is effective and is worth considering for adapting is attested to by TA and professor feedback. Two examples will be given here. It is typical at the end of the TA-W for several TAs to compliment the effort with statements like "I thought three days of TA training was going to be very boring and trivial. This wasn't, it was exciting and very helpful in getting me ready to teach". Recently a faculty member at a well-known engineering school who was a TA at CSM in 1992 commented, "I learned more about effective teaching in that workshop than I have anywhere else since."

LOGISTICS

The four departments who have used the TA-W consistently over the years are the Engineering (housing mechanical, electrical and civil engineering), Economics and Business, Physics, and Chemistry departments. As new TAs are identified in the Spring recruiting, their information is sent to the Center for Engineering Education (CEE) which sends them a letter of invitation to the TA-W explaining that they will be paid for their attendance (\$150 each) and that the TA-W is considered mandatory by their department. Follow-up contact is made with those who do not give a timely reply. Generally about 35 new TAs attend the TA-W. The schedule for the three-day workshop is given in Table 1. Note that TAs from all

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Table 2
"Sound Bites"

1	Teaching is getting the students' minds active on the subject
2	The college has hired you to stimulate thinking, not baby sit
3	On techniques, give answers; on concepts, ask questions
4	Wait for the relevant data to be collected before asking questions
5	Active, group formats can increase learning by 0.5 sigma
6	Plan your questions for each lab or recitation

four departments attend common sessions on the first day and the last half-day, but work within their departments in the middle 1½ days. During the summer, the TA-W Coordinator from CEE works with the designated faculty from each department to coordinate the philosophy and approach to be used in the departmental sessions. Each of the faculty in charge of their department's portion of the training gets an honorarium from CEE.

Table 1
Workshop Schedule

Day	Time	Activity
Friday	8:30 am	Introduction
	9:30	Inquiry Chem Lab
	11:30	Discuss Lab Teaching
	1:30 pm	Read Economics
	2:00	Act Lrn Econ Recitation
	3:00	Discuss Recit Teaching
	4:00	Dept Sessions #1, Intros
Saturday	8:30 am	Dept Sessions #2
	1:30 pm	Dept Sessions #3
Monday	1:00 pm	Dept Sessions #4
Tuesday		Classes Begin
Saturday	9:00	1-on-1 Teaching Skills
	10:30	Levels of Thinking

Most departments have weekly meetings with the new TAs during the semester to continue their training in content and teaching practices. These are run by departmental faculty with CEE staff enlisted for special topics.

DAY ONE

The purposes of the first day are to get the TAs enthused about being stimulators of student thinking and to show them how that can be done in laboratory and recitation classes. The introductory hour is used to have them introduce themselves, fill out paperwork for their \$150 honoraria, explain the TA-W schedule and start talking about teaching. Throughout the TA-W we use "sound bites" to help them visualize and remember the philosophy and practices we are espousing. These are listed in Table 2. During this first hour, #1 and #2 are put on the board and emphasized. We then put the TAs in random groups of three and have them generate lists of poor teaching practices they have seen in the past. Debriefing the groups is fun and illuminating; we emphasize that we want them to do the opposite of these things. The two "classes" for the day are set up by telling the TAs that they are to experience and then analyze two approaches for stimulating student thinking. They are to role-play students as a professor plays the teacher. They are to be students, but are also to be observers of the teaching process.

An Inquiry Lab: The first "class" is a freshmen chemistry laboratory structured as Guided Inquiry [3, 4]. In this format the student studies nothing about the chemistry or concepts beforehand. The laboratory data and the students' reasoning with it reveal the reactions and concepts during the lab time. The lab write-up consists only of experimental instructions and questions calling for data analysis. Thus the students are expected to develop ideas of reactions and concepts from data, much as a researcher does. The teacher's role is to guide them, by questioning them and having them justify ideas from the data.

The TAs are given 20 minutes to read the safety and technique instructions for the experiment, the heating of hydrated compounds (Expt C-1 in ref 3). The teacher then gives a brief lecture on safety, chemical disposal and techniques. The TAs then do the experiments in pairs and the teacher asks questions of them in these pairs or in small groups. Questions used by the teacher during this time may include

"What do you think is happening during the heating?"
 "Can you write a reaction saying that?"
 "If I were skeptical, how would you convince me?"
 "Are all the reactions reversible? What do the data indicate?"
 "What is happening to the weight during heating? Why?"
 "What pattern do you see from weight tracking trials?"
 "Do your weight data support your suggested reaction? Show me how."

After about 90 minutes of data taking and teacher-student interactions, we call a halt to the lab work and retire to a classroom. The TAs are put in groups of four and asked to analyze the experience. The two key questions they discuss are "What did the teacher do?" and "Why did he or she do that?" They quickly come to consensus on both questions: that the teacher was a questioner and prober of student thinking and that the purpose was to get the students themselves to think deeply about what was happening. They also invariably express their pleasure with that type of learning environment. We then recall sound bite #1 and bring up #3 and #4 with elaborations. Finally, the differences between the format of inquiry labs and traditional labs (called verification labs) are presented [5]. The TAs are told that laboratories in Chemistry and many in Physics and Engineering are in the Inquiry format, specifically to help them as teachers stimulate student

DEPARTMENTAL SESSIONS

thinking. Further, if they find themselves teaching a more traditional lab, they should work that much harder to incorporate stimulating questions.

An Interactive Recitation: The second "class" is a recitation for a sophomore microeconomics class. Again, the TAs role-play students while a professor plays the teacher. The TAs are given 30 minutes to study the textbook chapter on Elasticity of Demand aided by four questions to guide that study. The teacher opens the class by putting an outline of the class and key terms from the readings on the board. He then asks for definitions of the terms and leads elaborations of the ideas as the students answer his questions. This is a full class approach where volunteers answer some and selected students answer other questions. Where confusion seems present, the teacher gives a short explanation to clarify the topic. He then hands out a set of raw data on two products from which the students are to calculate the price elasticity of demand. After a few minutes of individual work, he asks a student to put his/her work on the board and leads a class discussion from that. Finally he puts the TAs in groups of three and gives them sets of situations they are to rank by increasing elasticity. Two examples are: oil from Venezuela versus from South America versus from the southern hemisphere, computers in 1980 vs. 1990 vs. 2000. After some teamwork time he leads the groups through comparisons of their answers and their rationales. In effect, the teacher has, with questioning, taken the TAs from recall thinking to mathematical application, to evaluative thinking on the topic.

After 50 minutes of "class", we stop the exercise and have the TAs analyze it. This analysis is usually done in full-class mode and again centers on the two questions "What did the teacher do?" and "Why did he do that?" The TAs identify his outline, his recall questions and his handout questions as procedure. They also point out, as good teaching practices, his openness to their answers and questions, his moving near them when they talk, his board work and his patience with answerers. They are then asked to contrast the amount of learning that went on here with what they would have achieved sitting through a 50 minute lecture by the teacher. They all strongly agree that the interactive mode was far better because they were engaged and they agree that the small group final exercise was most useful. We then recall sound bite #1 and bring up #5 and #6 with elaborations. On #5, we briefly discuss the findings of increased learning using group work in engineering and science college classes [6]. On sound bite #6 we show the notes of the two teachers they have observed that day to illustrate the extent of planning needed for a well run class. We finally point out that the Economics TAs and some of the Physics TAs will be teaching recitations.

Day One ends with the TAs going to their respective departments to meet faculty and get an introduction to their specific teaching assignments for the semester.

Next, faculty from each of the four departments take their TAs through training on the specific courses they will teach. Normally this is done on the Saturday and Monday preceding the beginning of classes. In general, the pattern of these sessions mirrors that given above: the TAs experience a lab or lesson as students and then analyze it for the teaching methods used and for how it can be best taught. In Chemistry and in Physics, we take the respective TAs through the first month of student labs they will teach. A slight departure from this occurs in Economics and Business where each TA is given a topic around which to design and present a mini recitation class. This recitation is presented to faculty and other TAs and is critiqued by them.

In Engineering, the TAs all complete one lab from the first sophomore Multidisciplinary Engineering Laboratory [7] and discuss it with course professors and experienced TAs. They then join a mentoring group of professors and experienced TAs for the specific course they will teach and begin study of that course. Each week during the semester the new TA is required to go through the lab for that week before his/her class and discuss it with members of the mentoring group.

As mentioned above, it is in these departmental sessions that the TA sees the content they will teach and the departmental procedures they will be asked to follow. These are both seen from the experience of the role-played class and its discussion. The focus of the departmental sessions continues to be best teaching practices; however, by using the labs to be taught as a vehicle, the content is also presented and TAs can refresh their understanding of it. A session where TAs practice and discuss grading is also included in each department's sessions.

FINAL SESSION

The purpose of the final half-day session is to sharpen the TA's specific 1-on-1 teaching skills. This is held on the Saturday after classes start. First we debrief a few TAs on what they are teaching and how their first class went, if it had met already. Then we recall the six sound bites and reiterate their rationale.

The 1-on-1 teaching skills we discuss on the final day are listed in Table 3. Once again, we emphasize these skills by using an interactive approach. The TA-W presenter role-plays a professor who is being visited during office hours by a student, role-played by one of the TAs. In each of four 2-3 minute interactions, the professor shows a clear lack of a skill and then turns to the TA audience and says "What am I doing wrong?" For example, for skill #1, after the student's initial question, he launches into a two minute lecture on the problem asking only rhetorical questions like, "Isn't that right?" For skill #4, he acts exasperated and checks his watch when the student comes in and then decries the general lack of student understanding of the topic before launching into a brisk set of questions. After the TA audience gives their take on what he is doing wrong, the presenter puts the appropriate item from

Table 3 on the board and gives a 3 minute elaboration on it. This is continued until the first four skills have been identified.

Table 3
1-on-1 Teaching Skills

1.	Don't Lecture
	(30 seconds of talk is a lecture)
	(get the student talking)
2.	Be Diagnostic
	(ask them to explain, elaborate)
	(get inside their thinking)
3.	Use Wait Time
	(give them and you a chance to think)
	(question -- 3 sec -- response -- 3 sec -- etc.)
4.	Set a Collegial Atmosphere
	(welcome them to the inquiry, share interest)
	(don't be gruff, impatient, parental, belittling)
5.	Use Various Thinking Levels
	(recall vs. convergent vs. divergent vs. evaluative)

The TAs are then put into groups of three or four, by department, to practice the first four skills. They are told to do this as was modeled by the TA-W presenter: one TA is to play a student needing help, another is to be the teacher, while the third and fourth TAs are observers. This is called a Triad approach. Each group of departmental TAs had been told, during their departmental sessions, to study a particular piece of content to be used in this exercise. Before the TAs get in their Triads, they are given 10 minutes to review their notes on the content and to think of how a student might have difficulty with it. Each Triad then goes through a series of practices (teach for 3 minutes, get feedback from the observer, switch roles) until each TA has had at least one chance to practice as teacher. We then get back together as a full group and discuss interesting items, concerns or questions that came up during the Triad practice.

The final activity introduces the TAs to a taxonomy of thinking and leads to the fifth 1-on-1 teaching skill given in Table 3. One could use any of several taxonomies, but we use Patricia Blosser's of *Recall, Convergent, Divergent* and *Evaluative Thinking* [7]. Again, an interactive approach is taken, rather than a straight lecture. The TA audience is given a "group quiz" consisting of four questions; each designed to invoke a different kind of thinking. Typical questions used are:

- "What is the formula of hematite?"
- "How much iron per ton can be gotten from ore that is 15% hematite if the process is 80% efficient?"
- "If oil prices quadrupled, what changes might occur on campus?"
- "You suspect a student cheated on a report, what will you do?"

After the TA-W presenter has led the TAs through the quiz and their answers, he puts them in groups and asks them to define any differences in thinking required by the four

questions. Debriefing of the groups naturally leads to Blosser's Taxonomy. Its value to teaching is shown by positing that all professionals do all four kinds of thinking (Recall, Convergent, Divergent and Evaluative Thinking), but normal undergraduate classes focus on only the first two (and mainly on the first type, Recall). This analysis leads to a goal for curricula of having students practice all four types of thinking, with feedback. Thus we come to the fifth 1-on-1 Teaching Skill in Table 3. The final exercise has students developing questions in their courses that would inspire Convergent and Evaluative Thinking in their students.

We end the three-day TA-W by thanking the TAs for their solid work, repeating the sound bites and then handing out three reprints for later reading. The three (refs 8, 9 and copies of an email exchange on active, group learning) focus on the last two topics: 1-on-1 Teaching Skills and Taxonomies of Thinking.

EVALUATION OF THE TA-W

In the first three years that the TA-W was offered, TAs were given an evaluation/suggestion form in the final meeting to be mailed back. Results were positive; they complimented the topics covered and the emphasis on teaching skills. As mentioned in the Introduction, these data are augmented each year by individuals TAs verbally expressing their pleasure with the TA-W, particularly for getting them enthusiastic and confident about their teaching. Before the sixth year of using this TA-W format, we interviewed each of the faculty who had been Departmental trainers and had overseen TAs who went the workshop. Each faculty member expressed their pleasure with the results, especially for the student focus and confidence the TAs bring to their teaching. Final pieces of data relative to the TA-W are the evaluations of TAs by their students at the end of each semester. Invariably, these are high. For example, in the Chemistry Department, most TAs average a 4 or higher on a five-point scale in their overall rating. By contrast, one department on campus that does not use the TA-W is having a serious problem with low rated labs and TA teaching.

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