Alignment of TAs' Beliefs with Practice and Student Perception

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Abstract. Graduate teaching assistants (TAs) play an important role in introductory physics courses, particularly in large enrollment courses where the TA may be viewed as more approachable and accessible than the lecture instructor. Thus, while TAs may still be in the process of developing their views on teaching physics, their practices directly influence a large number of introductory students. As the first steps in reforming our introductory courses and TA training program, we collected multiple types of data on TAs teaching in traditional algebra-based physics laboratories. Drawing on prior work on TAs' pedagogical knowledge, we explore how the beliefs expressed by TAs in interviews align with their practices during a laboratory video-taped mid-semester. Additionally, we explore how both the TAs' expressed beliefs and practices align with students' responses to an end-of-semester TA evaluation survey.

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INTRODUCTION

Graduate teaching assistants (TAs) are responsible for much of the direct interaction with students in large enrollment courses. Although TAs have often been ignored by the physics education research community, they have recently become the focus of several research programs. Goertzen and Spike studied TAs in *Tutorials in Physics* recitations, while DeBeck studied TAs in a studio classroom [1-4]. Goertzen's studies suggest that "responsive" TA training, which builds on the resources or "productive seeds" TAs possess for teaching, will be more successful than traditional training methods and that while TAs' behaviors and beliefs are related, the same behavior may result from different beliefs [1]. Goertzen has also shown that TAs may differentially "buy-in" to and support reformed instruction [2]. Spike has worked on a framework for identifying TAs' resources for teaching and has demonstrated variation between TAs about the level of active participation of TA versus students [3]. Drawing on this prior work, we seek to explore the alignment between TAs' statements about teaching in an interview with their classroom practices and students' responses to an end-of-semester evaluation.

BACKGROUND & METHODOLOGY

In this paper, we present data from a first semester, algebra-based introductory physics laboratory at a large research university. The laboratory format is fairly traditional, although it was revised for the Fall 2011 semester to engage students in more independent thinking. The previous lab manual had included detailed derivations and calculations, step-by-step instructions, and ready-made data tables. These were removed from the manual to support laboratory goals that students would be more actively engaged in thinking about the experimental procedure and organizing, presenting, and analyzing their data. Additional changes included the addition of pre-lab assignments to prompt students to think about the experiment before class, lab reports due at the end of class to promote group work, and post-lab assignments to encourage students to review what they had learned. The TAs attended a weekly, one-hour training session where they practiced the upcoming experiment and discussed difficulties experienced the previous week.

In Spring 2012, six TAs were assigned to teach 19 total lab sections of about 30 students each. As part of evaluation of our TA training program, all TAs were video-recorded teaching the Newton's Second Law lab, which was the sixth of 14 labs. Although the entire lab session was recorded, in this paper we focus on the introduction TAs gave before students began the lab. A few weeks later, the TAs were interviewed about their experiences teaching in the lab; the interviews lasted between 18 and 38 minutes. Five of the six TAs agreed to allow their data to be used for research. All of the TAs except Lena (pseudonym) are international students, and all had various amounts of prior teaching experience. Several TAs (Zeke, Neil and Sara) had taught the lab before the revisions. Hari was teaching the lab for the first time. In the final lab, students evaluated their TA on a paper survey (based on the university faculty survey) as one of several course assessments. Transcripts of the interviews and videos of the presentations were analyzed for emergent categories. Overall ratings for each TA from the student evaluations are presented; analysis of open-ended responses is reserved for a longer discussion.

INTERVIEW ANALYSIS

The trends from the TA interviews are summarized in Table 1. The TAs were asked to describe the purpose of the lab component of the course. All TAs discussed that the lab helped students to *enhance their understanding* of the physics concepts. For example, Sara explained, "You know the lecture class is not going to be enough for understanding physics… So maybe some of the people like can understand what they are saying, but they can really understand using, doing the experiments." Another common theme was that the lab shows how physics is *related to the real world*; three TAs made comments like the following from Lena: "So they can see the concepts, their own action, make it relevant for them. Otherwise they might not believe that it's true." Interestingly, only Hari discussed that the lab could help students learn the *process of science*. Hari explained that in his schooling, he did not have experience with this sort of lab. He continued, "So we didn't know how Newton discovered his law, or how people formulate the laws… They [students in this class] do it directly, so they can like, uh, appreciate the thing that Newton put in to find his laws because he did the experiment, he got some data, and we are going to interpret that to get some relationship." Thus, the TAs' awareness of lab goals appears to be at an appropriate level for a useful TA-lead discussion during the training session.

The TAs were also asked to describe what they do to support the students' experience in the lab. All TAs discussed *answering students' questions* and *explaining how the concepts related to lab*, however, the emphasis of their responses were varied. Zeke's response mainly focused on *answering student generated questions*, including questions about the software, the equipment and data analysis. Neil and Lena also discussed answering students' questions, but with an emphasis on the TA *recognizing when students needed help*. Lena described, "Usually I go around and make sure they're doing okay, or I just look at what they're doing on the computer, if it looks like the right thing, otherwise I'll go over and fix it." Neil and Lena also discussed giving short introductions to the lab. Lena explained that she had shortened her introductions because students did not pay attention to longer introductions. Neil described giving the students information he felt was missing from the lab manual, such as how the data tables should be organized. Hari's and Sara's explanations focused I mostly on the *introduction* they gave in the beginning of the lab. Sara stated, "I try to tell them almost everything, every concepts… A lot of explain, explanations so that I can, so that people can understand better." Zeke's description seems to be the most student-centered, while the other TAs' responses were more instructor-centered. Neil specifically described giving students information that undermined one of the goals of the lab redesign.

TABLE 1. Trends in TA Interviews.

	L	S	H	Z	N
1. Purpose of lab component					
1a. Enhance students' understanding of concepts	x	x	x	x	x
1b. Show how physics is related to the real world	x	x		x	
1c. Help students learn the process of science			x		
2. TAs' actions to support students' experience in lab					
2a. Answering student questions	x	x	x	x	x
2a-1. Answering student generated questions				x	
2a-2. Recognizing when students needed help	x				x
2b. Explaining how concepts related to lab	x	x	x	x	x
2c. Giving introduction to lab	x	x	x		x
2c-1. Emphasized short introduction	x				x
2c-2. Provide "missing" information					x
3. Degree of support of lab revisions					
3a. Statements in support of pre- and/or post-labs	x	x	x	x	x
3b. Statements in opposition to lab changes				x	x

We tracked responses that TAs made across questions indicating their support or lack of support of the changes made to the lab. All TAs made statements in support of the pre-labs or the post-labs, although many raised concerns about students copying from each other or not taking the assignment seriously. For example, Lena said: "I don't know that they actually look at the pre-labs that much… but if there was something that they were graded on that they had to say what the objective of the lab was or something." Hari discussed adding post-labs to sections of the course that did not have them "because they give a lot of thought in answering those questions. So they have to talk about the experiment, what they learned from the lab." However, Zeke and Neil also made statements in opposition to some of the changes, such as suggesting students complete lab reports at home, including ready-made data tables and calculations in the lab manual and incorporating post-lab questions into the lab report. Many of these oppositions were grounded in concern for the students' abilities to complete the in-class assignments in time. This is similar to Goertzen's finding that TAs' actions in opposition to curricular goals may be based in their own beliefs about how students learn [5]. In general, Hari and Sara were observed to be most in support of the lab changes, while Zeke and Neil were observed to be least in support of the changes.

CLASSROOM ANALYSIS

The video-taped lab session involved application of Newton's Second Law to two systems: an inclined plane and an Atwood's machine. In the pre-lab assignment, students were asked to make predictions and to draw free-body diagrams for each system. In the in-lab background section, students were asked to use Newton's Second Law to derive expressions for the accelerations of the systems. In the laboratory, both systems were pre-constructed by the lab manager on each table and could be manipulated by students. Students collected data about the motion of the systems using DataStudio. The analysis focused on comparing theoretical and experimental accelerations and interpreting graphs. Below we describe trends in our preliminary analysis of how the TAs lead this lab session, focusing in this paper on the introduction TAs provided before students began independently working on the lab.

As discussed above, the laboratory was restructured to engage students in more independent thinking. Whereas pre-made data tables and detailed derivations were previously provided, students are now asked to organize data presentation and figure out derivations and analysis questions with their groups. Since the TAs lead these lab sessions, they can either support these changes, or subvert them by providing students with details that have been removed from the lab manual. Table 2 presents the emergent themes of behaviors TAs' exhibited that did or did not support the lab and course goals. Lab-specific behaviors were rated as *student-centered* if the emphasis was on students performing the behaviors (supporting course goals), *instructor-centered* if the TA performed the behaviors (not supporting course goals), and *shared* if the TA lead the behavior but required student involvement or sometimes performed the behavior and sometimes required students to perform it.

TABLE 2. Trends in TA Lab Presentations.

	L	**S**	**H**	**Z**	**N**
Time for Intro (mins)	6.5	12	11	22	29
Lab specific behaviors: Student-centered (St), Instructor-centered (I), or Shared (Sh)					
Data table construction	St	I	St	I	I
Derivation- steps	Sh	Sh	I	Sh	Sh
Derivation- result	St	Sh	Sh	I	I
Graph interpretation	St	Sh	St	I	I
General behaviors: High (H), Medium (M), or Low (L)					
Emphasized general solution methods	M	H	L	L	M
Emphasize connections	L	M	L	L	H

For *Data Table Construction*, Sara, Zeke and Neil were coded as *instructor-centered* because they drew sample data tables on the chalkboard for students to use, thus subverting the lab goal that students learn how to organize and present their data independently. On the other hand, Lena and Hari did not provide sample data tables in the introduction and were coded as *student-centered*. For *Derivation- steps*, most TAs were coded as *shared* because they performed the derivations on the blackboard, but actively involved the students by asking questions; Hari was coded was *instructor-centered* because he did not involve students in the derivation. All TAs provided the full derivation and result for the inclined plane system. However, they provided different amounts of information for the Atwood's machine. For *Derivation-result*, Zeke and Neil were coded as *instructor-centered* because they provided all derivation steps and results for the Atwood's machine. Sara and Hari were coded as *shared* because they provided the final result, but required students to independently fill in some of the derivation steps. Lena was coded as *student-centered* because she required students to complete many of the steps and to find the final result. For *Graph interpretation,* Zeke and Neil were again coded as *instructor-centered* because they told students the answers to analysis questions related to their graphs, such as the meaning of the slope and y-intercept and/or how to get acceleration from the velocity-time graph. Sara was coded as *shared* because she discussed the meaning of the slope but involved students through questions, while Lena and Hari were coded as *student-centered* because they did not include graph interpretation in their presentations.

Two additional categories of behaviors emerged from the videos which were related to overall course goals. TAs were coded as *high*, *medium* or *low* for how strongly their behaviors supported these more general goals. TAs put varying emphasis on the use of Newton's Second Law as a *general solution method.* For example, Sara was coded as *high* because she explicitly and repeatedly reminded students that they should focus on the relationship $F = ma$ instead of specific solutions with statements like: "You don't need to memorize any value, right? You just remember our general equation. We can draw every expression." On the other hand, Hari was rated as *low* because he did not begin his derivations with the general form $F = ma$. Additionally, TAs put varying emphasis on making *connections* between the experiments and students' previous experiences. Neil was rated as *high* because he related the experiment to a quiz the students had completed and related the equation for the acceleration of an object on an inclined plane to freefall. Sara was coded as *medium* because she compared the Atwood's machine experiment to the previous week's experiment. All other TAs were coded as *low* because they did not point out explicit connections.

Thus, TAs were observed to differentially support the revised lab structure. Lena and Sara provided the most support, while Zeke provided the least.

STUDENT EVALUATIONS

Figure 1 presents the results of the end-of-semester student evaluations of the TAs, highlighting six of the nine questions most closely related to the TAs' in class interactions with students. The evaluations were completed on paper during the last lab of the semester. Overall, the students rated the TAs quite highly, with Hari scoring most favorably and Zeke scoring least favorably. However, the variation between TAs is quite small. In particular, items 1 and 3, which focus on the TA's ability to help students understand, provide the most discrimination.

DISCUSSION

We compare across data sources to investigate alignment between TAs' statements, their practices and students' evaluations. From the interview data, Zeke stands out as emphasizing student-centered instruction while speaking against the revisions made to the lab. In the classroom analysis, he is observed to engage mainly instructor-centered behaviors and to poorly support course goals. Specifically, Zeke discussed that students did not like long derivations, but was observed to present long derivations. Zeke was also rated least favorably by his students. In the interviews, Hari and Sara spoke most in favor of the lab revisions, but also describe their role as instructor-centered. However, in the classroom, they were observed to engage in relatively student-centered behaviors and Hari only weakly supported the general course goals. Yet, Hari was the most highly rated by

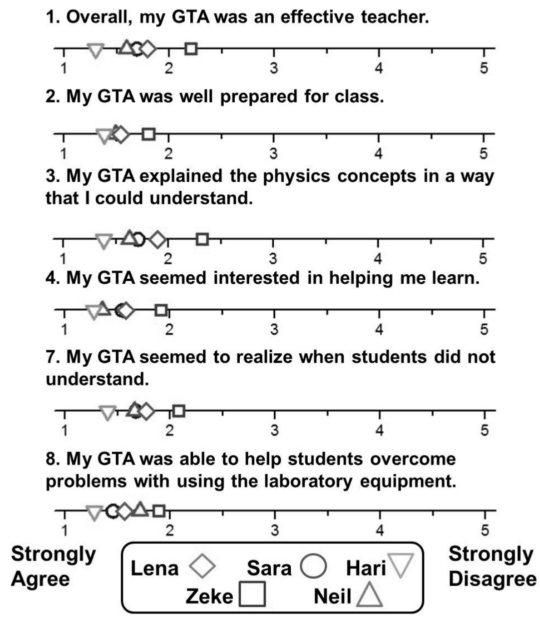

FIGURE 1. Student Ratings of TAs.

his students. Thus, the alignment between statements and practice seems to be weak. While the TA observed to engage in the least student-centered and course goal-supportive behaviors was least favorably rated by students, the other ratings are less closely aligned.

As suggested by Spike [3], a framework to identify TAs' resources for teaching would be useful to guide responsive TA professional development. We have also observed that TAs' with low buy-in to reform instruction will provide less support for course goals and may be viewed less favorably by students [2]. Further research is needed to support these findings.

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