# Examining the Beliefs and Practice of Teaching Assistants: Two Case Studies

Benjamin T. Spike and Noah D. Finkelstein

*University of Colorado at Boulder, Department of Physics, 390 UCB, Boulder, CO 80309-0390*

**Abstract.** In an effort to study the impact of teaching experience and preparation on the pedagogical beliefs of physics Teaching Assistants (TAs), we investigate the beliefs expressed by TAs following several semesters of teaching with the *Tutorials in Introductory Physics*. The beliefs of TAs mediate the actions they take in working with students, as well as the classroom norms they set for participation in the Tutorial activity. In this paper, we build upon existing analytic frameworks to characterize two distinct sets of TA beliefs gathered from pre- and post-semester interviews. We also present preliminary indications of coordination between these beliefs and the in-class practices of TAs. We then conclude with implications for the training of TAs in order to promote more pedagogically sophisticated beliefs at a potentially critical time in their professional development.

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## INTRODUCTION

The physics graduate Teaching Assistants (TAs) of today represent the physics faculty of tomorrow, who will be teaching courses, designing and implementing curricula, and working with future graduate students. In the absence of formal pedagogical training, it is expected that TAs will develop and refine teaching beliefs through their experiences in the classroom and any accompanying weekly preparation sessions. Therefore, the potential for long-term impact on the beliefs of future faculty encourages us to examine how these experiences shape TA beliefs.

The connection between instructor beliefs and practice is the subject of increasing attention in education research. In physics, efforts to characterize faculty beliefs have led to a greater understanding of how curricula are adopted and implemented [1]. Furthermore, there is evidence that the self-reported beliefs of faculty may not align with their practice based on situational constraints [2].

Being students themselves, graduate TAs are in a unique position of negotiating their role as both teacher and learner. Recently, studies of math and physics TAs have employed a combination of video observations and interviews to provide a more complete picture of how TA beliefs inform their practice [3][4].

In this paper, we adapt existing analytic frameworks to present an analysis of the beliefs of two physics TAs who served in introductory physics courses during their first year of graduate study. While further analysis of this substantial set of classroom observations will provide a more robust characterization of TA practice, we provide examples from select observations to demonstrate how the beliefs of TAs may be reflected in their interactions with students.

## BACKGROUND

The TAs under consideration served in consecutive semesters of calculus-based introductory physics courses (Physics 1 & 2) at the University of Colorado (CU). These courses both use the *Tutorials in Introductory Physics* [5] in their recitation sections. At CU, in order to address the need for greater instructional resources, we employ at least one undergraduate Learning Assistant (LA) [6] to assist the TA in each 50-minute section. The average enrollment for these courses is about 450-600 students overall, and 28 students per recitation each semester.

The TAs and LAs all attend a weekly preparation session a few days before they teach. Following the model of the University of Washington [7], weekly Tutorial preparation sessions at CU are intended to guide graduate TAs and undergraduate LAs to think about and discuss potential student difficulties as they complete the Tutorial in small groups. During this session, TAs complete the same Tutorial pretest that their students do, view sample responses to the pretest, and work on the Tutorial in small groups as one of the course instructors models appropriate TA behavior.

As currently implemented, Tutorial preparation sessions tend to be focused on content, with minimal explicit discussion of teaching practices or the motivations that underlie them. Rather, it is expected that TAs will develop desirable beliefs and behaviors by having them modeled by course instructors or by LAs (who participate in a weekly seminar on teaching and learning [6]).

## DESIGN OF STUDY

During the fall semester of Physics 2 and the spring semester of Physics 1, we collected video recordings of all TAs and LAs for each course. Seven weeks of recordings were collected during the fall semester, and twelve weeks during the spring semester. These videos are in the process of being analyzed and will form the basis of further research.

In order to elicit self-reported beliefs, interviews were conducted alongside these video observations. Three sets of interviews were conducted: once during the first weeks of the fall semester, again before the first week of the spring semester, and once more after the spring semester concluded. A total of 8 TAs (some TAs served in both courses) and 14 LAs participated in this study.

## DATA & ANALYSIS

Before we present the framework for analysis, we will begin by highlighting two case studies to introduce TA thinking and exhibit the type of data from which we have drawn dimensions for categorization. "Daniel" and "Sarah" are both first-year graduate students who taught Physics 1 in the spring. (In the fall, Daniel had taught Physics 2 and Sarah had taught Physics 1, both with Tutorials.)

### Beliefs: "Daniel"

Daniel describes learning as a process consisting of an initial struggle followed by the internalization of the "complete given right answer." He thinks it is good for the students to hear how the TA thinks about the problem once they have gotten off track. Daniel values efficiency in his teaching, as when he expressed admiration for a particular Tutorial that he found "very efficient in teaching them something substantial."

Daniel views his role as being ancillary to that of the Tutorial. At the time of the final interview following the spring semester, Daniel was serving as a summer Physics 1 TA, and the course instructor had provided no direction for how the TAs were to structure their recitations. He described how during the semester, the Tutorials provided much of the guidance, and without them he had to provide more of that guidance himself.

This reliance on the Tutorial to guide student thinking appears to conflict with the high value that Daniel places on correct, expert-like reasoning provided by an instructor. Although Daniel relies on the Tutorials to serve as a guide, he may not be comfortable with allowing students to proceed with incorrect reasoning even if the Tutorial provides a consistency check. This conflict provides an opportunity to examine how Daniel actually resolves these beliefs in his own practice.

The following transcript is from Week 7 of the spring semester of Physics 1, which used the "Work and changes in KE" Tutorial. In this problem, a force $F_0$ is applied to two blocks, C and D ($m_C < m_D$), as they move between two lines on a frictionless table. The students are asked to agree or disagree with a student who claims that block C will have a greater KE than block D at the time they each cross the finish line. On the next page, the Tutorial prompts the students to check the consistency of their own reasoning with the work-energy theorem.

*[Daniel sits down at table where S1, S2 are seated.]*

**Daniel:** Do you guys feel good about the one on the previous page, this guy? You agree! Uh oh.

**S1:** Yeah, see, I didn't want to agree.

**Daniel:** So, let's think about this. So, we know that the force is the same on each block, right?

**S1:** Yeah.

**Daniel:** And we know the distance the blocks travel is the same.

**S1:** Right.

**Daniel:** So, what's work? Force times distance. And work is equal to change in kinetic energy.

**S1:** Right.

**Daniel:** So if the force is the same on both and the distance traveled is the same on both, the work done on both--

**S1:** Is the same.

**Daniel:** --is the same. Which means the change in kinetic energy of both is the same.

**S2:** But if you look at it, like F=ma, then wouldn't the acceleration of one have to be bigger than…delta KE, 'cause like $\frac{1}{2}mv^2$…

**Daniel:** It's not totally obvious how you would relate the acceleration from, to the velocity. But you can apply this principle that the change in kinetic energy is equal to work done.

*[S1, S2 erase their previous responses and respond again. Daniel waits a few moments and leaves.]*

Daniel's interaction with these students is consistent with his professed lack of interest in incorrect student reasoning. Note that upon observing that the students had responded incorrectly to the first question, he chooses to explain in detail his own reasoning instead of asking them to explain how they reached their conclusion. Throughout this conversation, Daniel provides few opportunities for the students to express their own ideas, apart from agreeing or disagreeing with his explanation.

As further evidence of his focus on efficiency, Daniel describes himself as "not interested" in hearing students' incorrect responses, preferring to step in with a correct explanation than let the students "go around in circles." This view is reflected in Daniel's perception of weekly preparation, as he didn't feel like he learned anything from reading student responses.

## Beliefs: "Sarah"

Sarah describes an important aspect of the TA's role as "facilitating [the students'] discussion", and says that just listening to their ideas can be part of an effective teaching strategy. Student discussion is important to Sarah because it allows the students to "put out a whole bunch of different ideas" rather than simply adopting the TA's reasoning.

Sarah thinks that the Tutorials are good at developing students' intuition, but may not do enough to connect concepts to problem-solving strategies. In contrast to Daniel, she observes that it's "not necessarily bad" when students are confused, and that she might not step in with an explanation depending on what the Tutorial does.

In this transcript, Sarah is discussing the same two-block problem with her students. To conserve space, the first half of this dialogue—in which Sarah discusses why the final velocities of the blocks are not simply inversely proportional to their masses—has been omitted.

**Sarah:** So what did you think about the kinetic energies of the two?

**S1:** They're different, but we can't tell which one's greater and which one's less because we don't know how much… *[moves hands alternately up and down]*

**Sarah:** So how do you know they're different?

**S1:** They both have different masses and different velocities.

**Sarah:** Okay, but what do we know about the work done?

**S1:** The same.

**Sarah:** And we had this work-kinetic energy theorem. So if we just look at that, it seems like the kinetic energies ought to be the same.

**S4:** The change in kinetic energy should be the same.

**Sarah:** Right. So if they start at zero velocity…

*[S1 erases a previous response.]*

**S3:** And it's zero kinetic energy.

**S4:** So the final kinetic energy should be the same.

**Sarah:** Right. So is that consistent with what we were talking about? We don't really know a whole lot about… I guess you could work it out carefully, but it's sort of not very easy to see.

**S4:** Yeah. Yeah.

**Sarah:** And that's why we do this work-kinetic energy thing, is because it makes a really simple way to solve some problems.

**S4:** Okay. So the kinetic energies are the same. *[To Sarah]* Right?

**Sarah:** Right.

**S4:** Because the net work is the same, the change in kinetic energies are the same.

**Sarah:** And what you guys were thinking about was right, it's just it's hard without knowing specifics to say exactly what the velocity and mass relationship is, but it should work out to be this exact same answer. Looks good.

*[Sarah leaves the table.]*

**TABLE 1. Summary of Daniel & Sarah's professed beliefs.**

| | | Daniel | Sarah |
|---|---|---|---|
| *Beliefs about teaching* | **Role of the teacher** | Demonstrate expert reasoning, supplement lecture | Facilitate discussion, listen, answer questions |
| | **Role of the Tutorial** | Serve as pre-made guide (designed to improve learning) | Develop intuition, address common misunderstandings |
| | **Focus of preparation** | Know the Tutorial through and through | Think of ways to explain, brainstorm interesting questions |
| *Beliefs about learning* | **Role of the learner** | Engage with Tutorial, ask for help when stuck | Share ideas with peers, ask for help when needed |
| | **Nature of learning** | Initial struggle followed by internalization of correct answer | Involves repeated exposure to concepts |
| | **Student variation** | Everyone can learn from expert-like reasoning | People respond differently to different types of explanations |
| *Beliefs about physics* | **Learning physics** | People shouldn't learn physics if they won't use it | Everyone can learn physics if they are motivated |

While she also appears to have a particular chain of logic that she wants the students to follow, Sarah provides more opportunities than Daniel for the students to fill in the logical steps. She also directly asks whether the result is consistent with a previous conclusion. Before she leaves, Sarah addresses correct aspects of the students' reasoning, even if it resulted in an incorrect conclusion.

## RESULTS & DISCUSSION

Daniel and Sarah's professed beliefs are summarized in Table 1. We have categorized them by adapting the broad belief categories from Speer [3], along with subcategories drawn from Dancy and Henderson's inventory of instructor conceptions (they do not distinguish conceptions from beliefs) [1]. Here we see that Sarah's relatively greater focus on student ideas suggest an overall pedagogical model that is more student-centered than Daniel's.

The difference in outcomes between these models may not be apparent in the performance of the students, but we may expect an impact on student attitudes and beliefs. For instance, it seems apparent from the above examples that Daniel's students are being exposed to a different perspective about where scientific knowledge originates than Sarah's students.

Similarities that emerge from the professed beliefs, such as the fact that both TAs value group work, provide an opportunity to examine how similar beliefs manifest differently in the classroom. For example, one TA might value group work because science is a collaborative endeavor, while another might value group work because students will correct one another. This finding would be consistent with Speer's description of two TAs who value questioning but have different motivations for asking questions [8].

Finally, although Daniel was more explicit about his lack of interest in incorrect student reasoning, neither Daniel nor Sarah described viewing sample student responses as particularly helpful for preparing to teach. Other beliefs, such as Daniel's assertion that students who won't use physics principles should not take physics, are not immediately apparent from the video observations but may manifest in how he chooses to interact with students of different majors.

## CONCLUSIONS & IMPLICATIONS

We have described the beliefs of two graduate TAs by building on existing frameworks for analysis. Further review of the in-class practices of these and other TAs throughout the semester will strengthen the claims we can make regarding the relationship between beliefs and practice for these instructors.

Since the completion of pretests and the viewing of sample student responses are consistently ranked among the least helpful aspects of preparation, we might start by considering how to make these activities more engaging and relevant to TAs. Goertzen suggests that a structured professional development program, possibly involving videos of students discussing their ideas, may impact their beliefs [4]. We may also look to the LA program [6] for ideas on how to support the development of desirable pedagogical beliefs.

Ultimately, we must assume that beliefs about teaching and learning may be difficult for TAs to externalize, let alone reflect upon. We believe that by actively researching the nature and development of TA beliefs, we may better understand how to structure interventions that encourage self-reflective teaching and allow TAs to develop pedagogically sophisticated beliefs that are both internally consistent and coordinated with practice.

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## REFERENCES

1. M. Dancy and C. Henderson, *Phys. Rev. ST Physics Ed. Research* **3**, 010103 (2007)
2. C. Henderson and M. H. Dancy, *Phys. Rev. ST Physics Ed. Research* **3**, 020102 (2007)
3. N. Speer, *Cognition and Instruction* **26**, 218-267 (2008)
4. R. M. Goertzen, et al., *Phys. Rev. ST Physics Ed. Research* **6**, 010105 (2010)
5. L. C. McDermott, P. S. Shaffer and the Physics Education Group at the University of Washington, *Tutorials in Introductory Physics*, First Ed. (Prentice Hall, 2002)
6. V. Otero, et al., *Science* **313** (5786), 445-446 (2008)
7. L. C. McDermott, P. S. Shaffer and the Physics Education Group at the University of Washington, *Instructor's Guide for Tutorials in Introductory Physics*, First Ed. (Prentice Hall, 2002)
8. N. Speer, *Connecting Beliefs and Teaching Practices: A Study of Teaching Assistants in Collegiate Reform Calculus Courses* (University of California, Berkeley, Berkeley, CA, 2001)