

Toward an Analytic Framework of Physics Teaching Assistants' Pedagogical Knowledge

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Abstract. Graduate Teaching Assistants (TAs) are the subject of increasing attention in education research, both as partners in supporting the goals of research-based curricula, and as future faculty learning about the nature of physics instruction. In previous work [1], we began documenting TA beliefs and presented two contrasting case studies of TA beliefs about teaching physics. In this paper, we begin to build a framework that identifies categories of epistemological and pedagogical resources that TAs draw upon when talking about and when engaging in teaching practices. By applying this framework to observations and interviews of a set of TAs from an introductory physics course, we demonstrate emergent differences in how these instructors talk about their own teaching, as well as examples of how these differences appear to be reflected in their framing of the instructional activity. We conclude with implications for teacher preparation and professional development at the graduate level.

Keywords: teaching assistants, teacher preparation, professional development

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INTRODUCTION

As research-based instructional strategies become more widespread, increasing attention is being paid to the instructional role of Teaching Assistants (TAs), as well as to the impact of the teaching experience on the TA's own pedagogical development. Being students themselves, graduate TAs are in a unique position of reconciling their role as both teacher and learner. The potential for long-term impact on future physics faculty encourages us to examine the nature and development of TA pedagogical knowledge.

In accordance with recent publications [2], we recognize that graduate TAs are not "blank slates" when it comes to conceptions of teaching and learning. Indeed, TAs have spent many years participating in educational environments, and have accordingly developed a sense of what science education generally looks and feels like. However, we likewise cannot assume that TAs have robust and stable belief structures that can be "mapped out" from observation or interview data.

The nature of teacher knowledge and its connection to instructional practices is the subject of broad attention in education research, spanning a multitude of educational levels and contexts. In physics, efforts to characterize faculty beliefs have led to a greater understanding of how curricula are adopted and implemented [3]. 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 practices [4][5]. Our goal in this research is to construct a robust analytic framework that captures both how TAs *talk about* and how they *enact* their roles as teachers. We then seek to connect these two contexts for examining teacher knowledge.

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 use the *Tutorials in Introductory Physics* [6] 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) [7] to assist the TA in each 50-minute section. The average enrollment for these courses is about 450-600 students per 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 [8], 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, they 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 underpinning motivations for them. It is expected that TAs will develop desirable beliefs and behaviors by having them modeled by course instructors or by LAs (who participate in an additional weekly seminar on teaching and learning [7]).

DESIGN OF STUDY

During the fall semester of Physics 2 and the spring semester of Physics 1, we collected video observations of all TAs and LAs for each course. Seven weeks of observations were collected during the fall semester, and twelve weeks during the spring semester. Results from this paper are drawn from Week 7 of the spring semester, “Work and changes in kinetic energy.”

Interviews were conducted alongside these video observations. Interviews were conducted before and after the semester, and consisted of a TA video commentary followed by more general questions about the TA’s instructional role and conceptions of teaching. A total of 8 TAs participated in this study.

FRAMEWORK

In previous work [1], we presented a preliminary analytic framework for coding TA beliefs along broad categories of *Beliefs about teaching*, *Beliefs about learning*, and *Beliefs about physics*. This characterization was mostly descriptive and intended to demonstrate not only a contrast between two instructors, but also preliminary indications of coordination between their professed beliefs and instructional practices.

In this paper, we refine this framework by identifying four critical (although not exhaustive) dimensions for describing the finer-grained knowledge TAs draw upon when engaging in instructional activities: *Agency*, *Goal*, *Assessment*, and *Motivation*. These (non-orthogonal) categories are based on both existing literature [9][10] and emergent patterns within the data. We argue that these categories underpin the practical, strategic choices TAs make when interacting with students or describing their own teaching.

Agency refers to who is the active participant (“agent”) in the learning process. Naturally some choices have already been made for both students and TAs; for instance, students are not free to decide which tutorial is conducted each week (or whether tutorials are used at all), but they have some freedom

in deciding how they will participate in the tutorial activity. We identify a *teacher-as-agent* perspective as emphasizing clear explanations and/or directions from the teacher, and a *student-as-agent* perspective as emphasizing student discussion and collaboration.

Goal is the TA’s tacit answer to “What is to be learned?” and corresponds to the intended outcome of the learning process. This may include facts and formulas, concepts, and/or ways of participating and behaving in the social system.

Assessment refers to how understanding is to be determined. For example, an instructor may value improved performance homework or test as demonstrating understanding, versus their level of discourse or argumentation. This dimension also encompasses broader perspectives on the role and nature of assessment in instruction.

Finally, *Motivation* corresponds to perceived reasons for learning physics, as well as why an understanding of physics is important. For instance, a TA may view physics as providing a new way of thinking about the world, organizational tools, or necessary skills intended for subsequent coursework.

In order to illustrate the types of differences that emerge between TAs within the same course, we now turn to elucidate the dimension of *agency*.

DATA & ANALYSIS

We identify interview and classroom as separate contexts for observing patterns of TA behavior (since talking about teaching is itself a form of practice) and have accordingly developed coding schemas for each. We present sample codes for agency below, along with contrasting examples of coded TAs: “Sarah,” “Daniel,” and “Simon.” Sarah and Daniel are first-year physics TAs who taught with Tutorials the previous semester; Simon is an experienced engineering TA but had never previously used Tutorials.

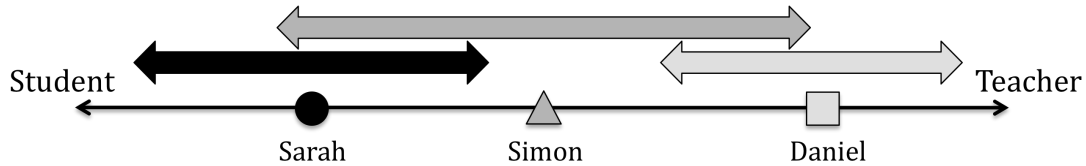
Analysis of Interviews

Table 1 summarizes codes for patterns in interview language with respect to the agency dimension. These codes resulted from open coding of interview transcripts followed by separation into categories of “student-as-agent,” “teacher-as-agent,” and “mixed.”

In talking about her teaching, Sarah tends to emphasize the importance of student discussion. She values multiple perspectives and multiple ways of thinking about physics concepts, and talks about TAs and LAs providing an “alternate” viewpoint rather than the “correct” viewpoint. Additionally, she says that confusion can be okay for students and the TA should know when not to intercede.

TABLE 1. Interview coding schema for the “agency” dimension.

<i>Student-as-agent</i>	<i>Mixed</i>	<i>Teacher-as-agent</i>
Facilitate discussion ●	Summarize student points ▲	Give complete answer □
Let students discuss ●	Confirm & correct student ideas ●	Show how I would do it ▲ □
Listen to discussion ● ▲	Answer questions with questions ●	Tell/explain □
Let students think ▲	Clarify the tutorial question ●	Start from scratch ▲
Know when to stop/not interact ●	Provide real-world examples ● □	



Daniel values both the guidance provided by the tutorial and the expert-like reasoning provided by a TA. In Daniel’s opinion, it’s very helpful for students to learn by seeing “how my mind works” after struggling with a difficult problem. We associate this notion of students “struggling” and being helped by the TA with a high degree of teacher agency.

Simon exhibits an interesting variation in how he talks about classroom agency. On one hand, he emphasizes that the TA should not interrupt students while they are thinking or discussing by telling them the right way to think. However, he goes on to describe how he often starts “from scratch” when talking with students, so they can see the step-by-step reasoning leading to the correct answer.

Analysis of videos

Clearly the TA’s moment-to-moment thoughts are not visible to us when viewing classroom videotape. In examining instructional practices we are therefore identifying patterns of behavior that appear consistent with particular perspectives of instructor/student agency. Each TA’s practices were coded along 3 sub-dimensions we associate with agency: *Initiation*, *Role of curricular tools*, and *Primary forms of discourse*. A summary of the results is given in Table 2.

Initiation: As noted by Scherr et al. [11], the initiation of tutorial interactions provides evidence for the motivation and purpose of the interaction. Sarah tends to request permission to interact, asking “Are you ready to go over this page?” Her body language in approaching tables also tends to be somewhat hesitant, as though she is reluctant to interrupt students at work. Simon almost never initiates interactions, and instead waits for students to call him over. When they do, Simon tends to provide highly individualized assistance, thereby emphasizing instructor agency over that of the group. Neither form of initiation is predominant in Daniel’s class.

Role of curricular tools: Our social (educational) interactions are mediated by tools [12], which in this environment may include physical artifacts such as tutorial books, large sheets of paper provided for collaborative work, and experimental equipment. In Daniel’s classroom, the tutorial tends to be the focus of interactions involving the TA. This is illustrated by a brief episode in which a student slides his book in front of the TA and asks, “All this look good?” After reading through and repeating the correct responses out loud, Daniel confirms, “Looks good. Looks real good.” In this way, the tutorial facilitates teacher agency as the judge of correctness. In contrast, Sarah is almost never observed to look at individual student responses, but is reliant on the provided “checkpoints” to structure her conversation with students.

Primary forms of discourse: The prevalence of certain discursive moves indicates how each TA expects students to participate. Of these TAs, Sarah tends to ask the most questions and provides the most time for students to respond. Sarah’s use of wait time communicates her expectation that students contribute to the discussion. In contrast, Simon’s highly directive approach stifles student collaboration and reflects a low value of student ideas. Daniel also asks questions, but rarely deviates from the standard *Initiation-Response-Evaluation* form [13]. He often shifts to a more explicative framing in which he steps through the correct reasoning with students, providing little opportunity for students to respond other than to indicate they are following along.

Sarah most consistently exhibits a *student-as-agent* perspective in her observed practices, which coordinates with how she describes about her own teaching. Similarly, Daniel’s practices coordinate with his described *teacher-as-agent* perspective. Simon, who exhibited a large variation in described perspectives of agency, tends to emphasize teacher agency in the classroom.

TABLE 2. Video coding schema for the “agency” dimension, with associated subcategories.

	<i>Student-as-agent</i>	<i>Mixed</i>	<i>Teacher-as-agent</i>
<i>Initiation</i>	Students control ●	Mixed control □	TA controls ▲
<i>Role of curricular tools</i>	For students (safe space to try ideas) ●	Mixed role	For teacher (indicates correctness) □▲
<i>Primary forms of discourse</i>	Questioning (with wait time); Listening ●	Explaining; Guiding □▲	Directing ▲

DISCUSSION & IMPLICATIONS

These three TAs exhibit differences in their perspectives of agency in the learning process, which is reflected both in how they talk about their own teaching and how they interact with students. We observe not only variance in TA talk along this dimension, but indications of coordination between the contexts of talking and teaching.

TAs with a high variation along this dimension, such as Simon, provide an opportunity to examine the finer details of how instructor perspectives coordinate across contexts. Simon appears to place a high value on both allowing students an opportunity to think for themselves and stepping through the logical reasoning for them. This could be a case in which structured reflection centered around the practice of teaching could help Simon resolve the apparent tension between these patterns of behavior.

We should stress that we differentiate *coordination* of perspectives across contexts from *inflexibility*. We view sophisticated teacher knowledge as inherently fluid and adaptive, and we therefore not associate either side of this dimension with “sophistication.” Rather, we expect more sophisticated instructional practices to be flexibly applied and informed by local contexts and student feedback.

In this paper we have presented one dimension for analyzing TA across contexts, and characterized differences between instructors for the same course. Subsequent work will characterize similar differences between these and other TAs along the three remaining dimensions as well as over time, to provide a more complete picture of how TAs think about and enact their role in the classroom.

We acknowledge that these TAs are operating within a particular curricular environment, with corresponding affordances and constraints on instructor behavior. However, we argue that there is sufficient freedom for TAs to establish different classroom norms through their instructional practices, which are based on their own perspectives of agency

in the learning process [14]. We hypothesize that the different opportunities for students engagement afforded by these norms will manifest in students’ attitudes and beliefs, which may represent avenues for future research.

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