Chapter 6 A new perspective: Respecting TAs' beliefs and experiences[9]

6.1 Introduction

Consider the following episode, in which four students are answering a question about the velocity - time graph shown in Figure 9. Their TA, Alan, overhears their conversation and steps in.

S2: [Reading] 'Give an interpretation of the ratio between c to d.' Isn't that just acceleration?
S1: Yeah.
S3: Well, the rate…
Alan: So that's the same thing I said, actually, when I was doing this.
S1: It was not.
Alan: They're trying to trick you, they're trying –
S2: Yeah?
Alan: They tricked me, I mean. Look very carefully at what they're asking you.
S3: C to d?
S1: Oh, it's just the ratio?
Alan: Well no, no, no, but acceleration would be this, d to c.
S3: D to c.
Alan: Because it's change in velocity over time.
S2: Oh, okay.
Alan: But here's its change in time over change in velocity. What the hell is that?
S2: I don't know.
S1: I have no idea. Good question.
Alan: Well, one incredibly legitimate way to say it would be, it's like the inverse of the acceleration. Whatever that is.
S1: Sounds good.

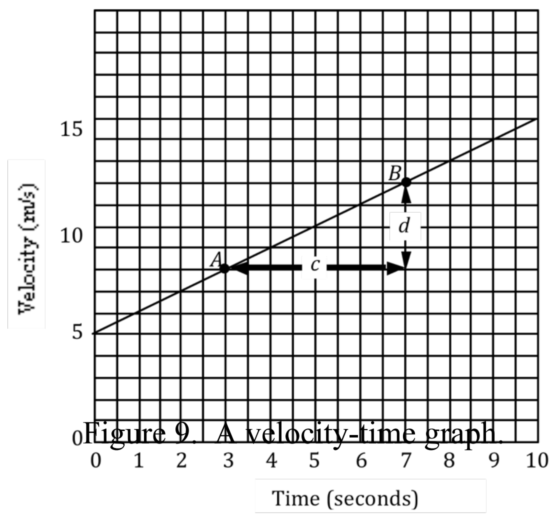

Figure 9. A velocity-time graph.

Our first reaction upon examining Alan's teaching was to condemn it. As teaching assistant (TA) supervisors, we try to teach TAs to support student construction of ideas and to help students value the guided instruction offered by reform curricula such as tutorials. In this episode, we note that Alan prevents the students from discovering the meaning of the ratio c/d on their own. Furthermore, we are concerned about the way Alan dismisses the tutorial question. But when we examine this episode with more knowledge about Alan's experiences and beliefs, we find that his actions here are not ignorant, but rather informed by stable beliefs and

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expectations for teaching. In particular, Alan believes that his students rarely have problems with the conceptual parts of physics and that it is not fair to students when instructors or materials assume that students will get an answer wrong. Alan's teaching is well integrated with these beliefs, which are not, after all, entirely unreasonable. They are, however, inconsistent with the underlying assumptions of the professional development (PD) Alan was offered.

Effective physics instruction benefits from respecting the physics ideas that introductory students bring into the classroom. In what follows, we argue that it is similarly beneficial to respect the teaching ideas that novice physics instructors bring to their classrooms. We do not expect the *findings* about how to support student learning to apply to TAs: TAs differ from students in significant ways. For example, TAs probably expect to do less learning to be an instructor that a student expects to do in the classroom, their primary job in the classroom is framed not as learning, but as teaching. We do think it will be benificial if TA instructors apply the *attititude* toward TAs that we have found benificial with students, which is to respect (rather than ignore or disgarage) the ideas which students convey to the classroom. Learning about Alan's resources for teaching changed our thinking about what might constitute effective professional development for Alan and other TAs. We advocate a new perspective on TA professional development: one in which TAs' ideas about teaching are taken to be interesting, plausible, and potentially productive.

As we conceive it, a respectful approach to TA PD has two primary aspects: (1) treating TAs with courtesy and (2) looking for productive seeds in their beliefs and practices. By the first, we mean that TA instructors should treat TAs as partners in the endeavor of educating students – as thoughtful young professionals who care about doing their jobs well and whose decisions about teaching have a reasonable basis in their beliefs and past experiences. The second aspect is that TA instructors benefit from identifying productive resources and beliefs that TAs hold, in that they are a promising foundation for professional development experiences.

When we call for this kind of respect for TAs, we are not suggesting that TAs can do no wrong. TA instructors are likely to disagree with some decisions novice instructors make, and with good reason. The aim of respectful PD is to go beyond labeling the behavior as wrong and needing to be replaced, in order to understand what beliefs, ideas, and circumstances underlie that behavior. In this way, TA instructors can better understand how to encourage TAs to develop effective teaching practices.

6.2 Previous research on TA PD

6.2.1 There is only limited research that could inform TA PD

Graduate students have been partially responsible for physics undergraduate instruction for decades. The quality of the training provided to graduate TAs in all disciplines has been criticized for almost fifty years (Carroll, 1980), but there is little published research on what professional development is offered to graduate students who are TAs in physics or other science departments. Some TAs participate in workshops and seminars focused on classroom management, grading, facilitating discussion or learning questioning skills (Gilreath & Slater, 1994; Hollar, et al., 2000). These types of PD are often brief, and offered before TAs start teaching. Other TAs can take courses, often for credit, which span a semester or quarter. These courses are department- specific and offer instruction in pedagogical content knowledge and constructivist learning theories (Hammrich, 2001; Ishikawa, et al., 2001; Lawrenz, et al., 1992; McGivney-Burelle, et al., 2001). The effect of these courses is usually assessed by surveys or interviews. Such assessments may demonstrate changes in beliefs or conceptions, but because the TAs' classes are not regularly observed, there is no way to see how or if these courses affect TAs' teaching. Thus, while there has been a limited number of publications describing the various types of PD TAs may experience, it is difficult for TA instructors to know which programs should be used in their institutions to encourage more effective TA teaching.

6.2.2 Professional development offered to science TAs is rarely responsive or explicitly focused on treating TAs as partners

Since TA PD research has frequently assessed effectiveness through surveys, interviews, and written assignments administered at the end of the PD program (French & Russell, 2002; Hammrich, 1994; Ishikawa, et al., 2001; Lawrenz, et al., 1992; Price & Finkelstein, 2006), it is difficult to know whether the PD has been responsive. While it is possible that some PD instructors have modified the instruction they offered based on the ideas they hear from TAs during instruction, we can find no explicit discussion of how TAs' ideas influence what PD they are offered.

There is also little evidence to address the question of whether TAs are treated courteously (i.e. as partners in educating students), but informally we observe that TAs are often considered to be either blank slates or bearers of misconceptions. A work that exemplifies the type of courtesy that we are advocating is found Speer's study (2001) of the fine grained-differences of two mathematics TAs' belief and practices, in which the TA instructor works to develop a shared understanding of the TAs' beliefs and practices with each TA.

6.3 Data and methods

6.3.1 The larger project: Understanding and explaining graduate TA tutorial teaching

The data discussed in this paper was collected as part of a larger project that sought to characterize and explain the teaching practice of physics graduate students who were assigned to teach tutorials in introductory physics courses. During their discussion sections, the TAs taught using tutorials, which are worksheets that support students' conceptual understanding and encourage collaborative learning.

The students who take the introductory course using these tutorials at the University of Maryland are mostly majors in the health and life sciences. A significant portion are pre-med students. More than half are female, and there is wide ethnic diversity. The students are mainly juniors and seniors taking this course to fulfill a program requirement.

The TAs teaching the tutorials during the semesters we collected data were mostly first-year and second-year physics graduate students. All the TAs we observed were male. (Only one female TA was assigned to teach tutorials during the two semesters of observations, and she was eliminated from the study as she was also a physics education researcher.) Almost half of the TAs spoke English as a second language, but all except one communicated fluently in English.

During the fall semesters of 2006 and 2007, we asked all the TAs assigned to teach tutorials in the introductory course to participate in this study. Those who consented were interviewed at the beginning and end of the semester they taught. These interviews were audio taped and transcribed. We selected about a dozen classes to be regularly taped. This selection was based on researcher convenience rather than attributes of the TAs or students, although we only chose among classes taught by consenting TAs. We also videotaped two weekly PD meetings, one attended by all first-year graduate TAs for all courses, and one attended by all tutorial TAs.

6.3.2 Alan: A TA with well-articulated ideas about teaching

6.3.2.1 Choosing Alan

The particular TA selected for this case study, Alan, is a typical TA with respect to many of the demographic characteristics discussed above. He was a first year graduate student when he taught tutorials. He had no previous experience as an instructor of a class, but had tutored students in math and physics. He was a non-native speaker of English, but his English was excellent. He often participated in the discussions held in the weekly tutorial preparation meetings. He was unusually articulate in expressing his views about teaching and physics in both his interviews. It was important to him to convey his ideas about tutorials to the interviewer: he brought a tutorial book with him to his interview so that he could point out specific examples of instructional decisions in the tutorials with which he disagreed. We chose Alan as the subject of our case study because of his readiness to explain his ideas during interviews and meetings and because we found many patterns in his teaching that seemed connected to his views about teaching and learning. Alan is not unique in this respect; as we have discussed in other works (Goertzen, et al., 2009; Goertzen, Scherr, & Elby, 2010) we have generally found consistency between our TAs' beliefs about teaching and learning and their practice.

We taped Alan in two classes each week, one in which he was the lead TA and one in which he assisted the lead TA. Thus, we had a collection of 48 hours of his teaching, which was half of all the tutorials he taught that semester. Each class had two tables that were regularly taped by stationary cameras, so Alan was recorded for a small fraction of each hour, when he interacted with a recorded student group. Of the 48 hours we taped, we have watched and analyzed fourteen hours of his teaching, which is approximately 40 interactions. For this case study we selected episodes that we thought illustrated different aspects of Alan's classroom behaviors and were representative of his teaching overall.

6.3.2.2 Analyzing Alan

Alan was one of six "focal TAs," who we studied in greater detail than most of the UM TAs who participated in this project. We generally watched about five or six hours of teaching for each focal TA. We continued to watch episodes of the TA until we had built up an extensive understanding of the TA's practice.

When characterizing Alan's teaching, we did not try to fit his work into predetermined categories. Instead, we watched multiple episodes of his interactions with students on video, seeking to describe and generate plausible explanations for his actions. We continued to watch episodes until we reached saturation, at which point we could explain new observed behavior by what we had already learned about Alan from his interviews and previous video observations (Lindlof & Taylor, 2002).

We used the data from Alan's two interviews to generate our descriptions of his beliefs. When we refer to Alan's *beliefs*, we use the term to refer to his declarative knowledge about teaching and learning in the context of introductory physics. While others have carefully distinguished beliefs from goals and knowledge, these distinctions are not critical for our argument.

To create descriptions of Alan's beliefs, we read through the transcripts of the interviews and identified excerpts that seemed to reflect Alan's beliefs about teaching and learning physics. These statements were often about his own role as an instructor, the strengths and weaknesses of the tutorials, and what his students "should" be doing. We organized these statements into larger categories that we termed beliefs. For example, Alan's desire for his students to spend more time on quantitative problem solving and his statement that physics provides "extremely powerful machinery" to calculate precise results are both evidence of his belief that quantitative calculations are an integral part of physics.

Identifying Alan's beliefs from his interview data and generating plausible explanations for his practice occurred in tandem. We then used both of these analyses to create narratives of how Alan framed individual activities and how his beliefs supported these framings.

6.3.3 The professional development that Alan experienced

Alan was expected to attend three different types of professional development during the semester we observed him. Physics education researchers ran all three of these programs. The first was part of a three-day orientation offered to all incoming first-year graduate students in the physics department. The portion devoted to teaching preparation lasted about six hours. The orientation introduced the idea of physics education as a scholarly activity, emphasized that learning occurs when students construct their own knowledge, and gave them practical advice about grading and classroom management. The second was a weekly preparation meeting attended by all tutorial TAs. During this hour, TAs would spend about half the time discussing issues that had arisen in the previous week's classes and half the time working through the tutorial for the upcoming week.

Alan also attended ten weekly teaching seminars that all first-year graduate student instructors were required to attend. These no-credit seminars addressed topics of interest to TAs teaching tutorials, traditional discussion sections, and laboratories. Our discussion of Alan's professional development focuses only on the tutorial preparation meeting, because Alan's comments about PD were always about those meetings. This is likely because the one-time orientation workshop and the seminar for all TAs addressed general topics that are not as directly applicable to tutorial teaching.

The weekly tutorial preparation was originally intended to be an hour in which TAs worked on the upcoming tutorial in small groups, as their students would, while the TA supervisor modeled the questioning TAs would be expected to do when teaching. This is the model used at other universities that use the tutorials developed by the University of Washington Physics Education Group. The tutorial supervisor during the year Alan taught was one of the authors (Scherr). Noting that this group of TAs often grew restless after working on the tutorial for half an hour, she modified the weekly schedule so that the TAs spent the first half hour discussing issues from the previous week's teaching and the second half hour working through the tutorial. This allowed for a guided discussion of issues that were important to TAs (because they raised most of the ideas themselves), such as specific student difficulties the TAs noticed or what they thought students should be learning in tutorials. TAs worked through the same amount of the tutorial as they did without this discussion, and spent a similar amount of effort learning questions they could ask and common problems students have.

6.4 Analytic framework

6.4.1 Resources

People do what they do at least partly because it has worked for them in the past. Teachers teach in a traditional manner often because it is the way that they have experienced instruction, and, in the case of physics graduate students, it is a system in which most of them have excelled. Many TAs have learned physics in an environment where lecture and extensive homework sets of quantitative problems were considered the norm. Because these behaviors and experiences have proved sufficiently successful for TAs in the past, it is unreasonable to expect TAs to simply discard them when TA instructors present alternative teaching methods.

We take a theoretical position of respecting naïve ideas. The physics education community has done so regarding people's physics ideas, with the benefit that we can help students identify ideas that can be the basis for effective constructivist instruction (Hammer & Elby, 2003) and where they will need to reconcile these ideas with formal physics concepts. The same theoretical framework applies when the "students" are novice teachers; now the naïve ideas can be a basis for effective professional development.

These positions are supported by a resource-based framework, in which learners (whether they are students or beginning teachers) have a variety of ideas that are activated in different situations. People use these activated resources to construct knowledge and guide their behavior. These ideas are not categorically wrong or right, but rather are appropriate or inappropriate for the particular situation (Hammer, et al., 2005b). Such a framework provides an explanation for how novices can become experts: they begin to use resources from other contexts, adding new ones, and build up a more coherent structure of ideas (Smith III, et al., 1993). Smith et al.

characterized such a framework as one that "emphasizes knowledge refinement and reorganization, rather than replacement, as primary metaphors for learning."(1993, p. 116) When this idea is applied to TAs, it means that we should assume that their problematic teaching practices are inappropriate to the situation, rather than wrong, and that as TA instructors we either need to help them build on the productive ideas they do have or help them activate beliefs and resources more appropriate to the situation (Hammer, et al., 2005b). For example, TAs have discussions with colleagues in which the answer is not known by one of the participants, and they can use this experience to encourage similar conversations among their students. Another productive belief would be the common graduate student understanding that struggling through an idea results in more learning than being told the answer, which most graduate students have experienced when doing their homework.

diSessa warns teachers about judging the "goodness" of student ideas (his remarks are specifically aimed at evaluating representations) because we can miss useful ideas that students have when they do not align with ours (diSessa, 2004). We are advocating a similar perspective on TA ideas, in which instructors respect TA ideas by viewing them as interesting, plausible, and worthy of understanding, with the intent of identifying productive starting points upon which to build responsive professional development.

6.4.2 Epistemic framing

In addition to providing an explanation for how Alan thinks about his teaching, our framework also needs to account for why Alan does what he does. When we considered the examples in the introduction of Alan explaining the ratio c to d, we saw that Alan dismissed the tutorial question and explained his answer to the question to the students. We assume that Alan, like most people, does not behave arbitrarily. Instead, there are reasons why he does these things, and why his students respond by quickly accepting his answer. One way to account for individuals' behavior is by examining their expectations.

Framing is a way of explaining how an individual or group makes sense of the activities they are engaged in (Bateson, 1972; Goffman, 1974; Tannen, 1993a). As people decide (usually subconsciously), "What is it that's going on here?" (Goffman, 1974p. 8), they draw on their past experiences to decide what behavior is appropriate. When a person receives a compliment, they can frame it as either being admiring or patronizing. A game can be framed as a way to have fun or a chance to show who is a better chess player. A TA who thinks it is important to build on student's ideas may frame a discussion as "understanding a student's idea of momentum"; the same discussion could also be framed as "checking a student's answer" if the TA was helping students prepare for an upcoming exam. We refer to these instances of framing as *episetemological framing*, because they involve decisions about how knowledge will be built in the particular situation (Redish, 2003). In the last case, we can see that although framing is actively negotiated moment to moment, it can be supported by potentially stable epistemological views and expectations for teaching. This stability manifests itself as locally coherent sets of resources and beliefs, rather than as a set of beliefs that are uniformly activated in all contexts.

A group's framing of an interaction stabilizes when the individual ways of framing reinforce each other. As people interact with each other, their past experiences influence their expectations and this affects their behavior. Because framing takes place continually, the behavior of others then becomes further information that individuals can use to check whether they are framing in the same way as the group. We see, when examining episodes of Alan's teaching, that Alan often frames *assisting students* as *giving them information.* His students expect help, and consider TA-led explanations as appropriate in discussion sections. They listen attentively, ask questions to clarify what he is saying, and direct their attention to him; these actions all reinforce Alan's idea that unambiguously answering their question is the right thing to be doing.

We identify framings by examining verbal and nonverbal interactions, including linguistic signals and body language. Examples of evidence we use include what people say, along with such things as pauses, laughter, and body positioning. As we consider possible ways TAs are framing their teaching, we look for support for these framings from the interviews where they discuss their tutorial teaching. We do not assume, however, that TAs will behave in ways consistent with the beliefs they espouse during their interviews.

Framing influences our analysis at two distinct points. We need it to explain why Alan does what he does in the classroom, because his expectations about what he is doing, along with those of his students, help us understand pedagogical choices. Framing also informs our analysis as TA instructors: we framed our activity differently at the start and end of our analysis. That is, when we began analyzing Alan's teaching, our unspoken answer to the question "What is it that we're doing here?" was "We are looking for places where Alan's teaching needs to be improved." This led us to concentrate on what Alan was doing wrong. When we reframed our analysis, the answer to the framing question became, "We want to understand why Alan does what he does." In contrast to the previous answer, this way of framing our activity focuses our attention on why Alan's teaching practice is reasonable to him. Thus, our reframing of our analysis caused us to shift our attention from Alan's teaching to Alan himself.

6.5 Contrasting our initial analysis with a respectful analysis of one TA's teaching

6.5.1 Critique of Alan: Interpreting Alan's actions in terms of our values and beliefs

In this section we discuss how our view of Alan changed as we learned more about his beliefs and could interpret his teaching through a more respectful lens. First, we present two episodes of Alan teaching tutorials and our early interpretations of his teaching, when we primarily focused on the ways his teaching failed to meet our expectations. We then describe Alan's beliefs about physics and how it should be taught to his students, drawing on his interview data. Lastly, we reexamine the tutorial episodes to show how a respectful interpretation can help us better make sense of his teaching decisions. Section 6.6 discusses how information we glean from interpreting Alan respectfully could be used to improve the PD we offered him.

6.5.1.1 Episode 1: Alan constrains the conversation and fails to elicit student ideas

This episode occurred during the third tutorial of the year, which helps students reconcile the idea that two colliding objects each feel the same force (Newton's Third Law) with the "common sense" idea that a larger truck causes more damage to a smaller car when they collide. The tutorial begins by asking students to use their common sense to generate a guess about which vehicle experiences a greater force during a collision. After doing so, they apply Newton's Third law to the situation and observe two carts colliding as a demonstration of Newton's Third Law. The tutorial then poses the questions excerpted in Figure 10. A correct answer to part A would be that the car gains 10 m/s because it weighs half as much as the truck and so it will react twice as much. In part B, the students are asked to calculate the truck's acceleration, which is also 10m/s by the calculation $a = \frac{\Delta v}{\Delta t} = \frac{5\,{}^{m}\!/_{s}}{.5s} = 10\,{}^{m}\!/_{s^2}$.

The interaction begins when Student 3 raises her hand and Alan approaches the table. Student 3 tells him that they do not know how to calculate the truck's acceleration. Alan asks them what the definition of acceleration is and then what the change in acceleration and change in time are. The students calculate the acceleration and Alan suggests that they can use the same method for the next part of the problem.

> A. We'll start with a new question. Suppose the truck's mass is 2000 kg while the car's mass is 1000 kg, and suppose the truck slows down by 5 m/s during the collision. Intuitively, how much speed does the car gain during the collision? (Apply the intuition that the car reacts more during the collision, keeping in mind that the truck is twice as heavy.) Explain your intuitive reasoning.
> B. Does your answer to part A agree with Newton's third law? To find out, we'll lead you through some quick calculations.
> 1. Suppose the car and truck remain in contact for 0.50 seconds before bouncing off each other. Calculate:
> i. the truck's acceleration during the collision.
> ii. the car's acceleration during the collision (assuming your guess about its change in speed is correct).

Figure 10. An excerpt of the tutorial on Newton's third law.

Alan: Hi, what's going on?

S3: Um, what's the, what happens to the truck's acceleration during the collision?

Alan: Okay, so you want to compute this acceleration during the collision, right?

S3: Right.

Alan: So, what is the definition for acceleration? If you don't know anything, just try using the definition. What's the definition of acceleration?

S4: [muttered] ???over time

S3: Distance…

S2: [muttered] Over feet time squared

S3: The change in velocity over time.

Alan: Right. So its change in velocity divided by the change in time. Or the time that it took for the velocity to change. So in this case, do you guys know from other things they've said, how much the truck's velocity changed?

S2: Yeah, five-

S1: Is that five…

S3: Five meters-

Alan: Five meters per second. Right, so it changed five meters per second. And how long did it take for it to change?

S3: A second. Sss.

S2: Half a second.

S3: Point five.

Alan: Half a second, right? So now you know the change in velocity and the change in time. You can get the acceleration from … Right?

S2: Like I said-

S3: So its-

S1: Ten.

S3: Ten. Is that a ten?

Alan: Yup. Five divided by a half is ten.

S3: Ten, ten meters-

Alan: Ten meters per second squared is the acceleration. Do you see how I arrived at that?

S1: Yeah.

S2: Yeah.

S4: Take five meters and divide it by the time.

Alan: Okay, the next thing you can also do using the same idea.

S?: All right.

When we first watched this episode, our attention was on the decisions that Alan made that we disagreed with. For example, the questions he asks constrain the conversation, so that the students have fewer opportunities to bring up problems that they may have noticed. Each student participates in the conversation to varying degrees, but Alan's conversational turns are the longest. Alan's gaze is usually on one of the students, but their gazes are mostly on Alan or the papers on their table, not on each other. Thus, the conversation is not one in which they are paying a lot of attention to each other's ideas.

Alan also fails to elicit students' ideas in this episode, even though the importance of building on students' ideas is one of the main ideas underlying the tutorial. When S2 asks her question (lines 2-4), he uses that question to diagnose what their problem is and he does not ask anything else to check if his assessment is correct. He also does not seek student ideas that he could build on: he does not ask what the students have already tried, whether there is some part they do understand, or whether the other students in the group could answer S2's question for her.

Alan makes additional assumptions when determining whether the students understand what he is doing. After his explanation, he asks if they understand how he calculated the acceleration (lines 47-48) and leaves soon after they say yes. The students may follow what he did, but Alan does not have a lot of evidence of the depth of that understanding, because he guided each step of the conversation and allowed few opportunities for students to make mistakes or discuss their thinking.

6.5.1.2 Episode 2: Alan directs the conversation and neglects student ideas

The fourth tutorial Alan taught helped students reconcile the commonsense idea that a net force is needed keep an object moving with the idea (from Newton's second law) that a force is only needed to change an object's velocity. The tutorial considers a child on a rope being reeled up at a constant speed from a well into which he has fallen. The students are led to see that their commonsense idea conflicts with Newton's second law and they then consider what would happen if the upward force of the rope was less than the child's weight. The scenario and the question the students are working on are shown in Figure 11 below. A correct answer to question 5 is that, if the rope force "compromises" between being less than the child's weight (which had made the child slow down) and being greater than the child's weight (which had made him speed up), then the child will move at a constant speed.

I. "Timmy's fallen down the well!"

To rescue a child who has fallen down a well, rescue workers fasten him to a rope, the other end of which is then reeled in by a machine. The rope pulls the child straight upward at a steady speed. The child weighs 250 N, which means gravity pulls him downward with 250 N of force.

[Two pages of the tutorial are omitted.]

5. It makes sense that, if the rope force remains greater than the gravitational force, the child keeps speeding up; and if the rope force becomes less than the gravitational force, the child slows down. By this line of intuitive reasoning, what happens to the child's motion if the rope force *equals* the child's weight, *i.e.,* if the rope force "compromises" between being greater than and being less than the child's weight? Explain.

6. Does Newton's second law agree with your answer?

Figure 11. Two excerpts of the tutorial on Newton's second law.

In the episode examined here, a group of four students is discussing question 5. As Alan approaches, S1 calls him over and asks him whether a child who is not accelerating would experience no force and no movement. Alan discusses the forces and accelerations of an object in a series of examples: first, a stationary object that has equal forces, which does not move; then an object feeling an upward force greater than gravity, which would accelerate; and finally one which is being pushed up with the same amount of force as gravity, which would not accelerate. Alan points out that in the final situation, the object will move at a constant speed. He concludes by telling them that movement does not imply acceleration.

S4: There would just be no change in velocity.

S3: Alan.

[Alan approaches table]

S1: No, but if… if the rope force equals the child's weight.

S4: That’s what we were ask, this is the same question as here.

Alan: Hmmm? Yeah, okay, go, so ask your question.

S4: So net force is zero.

S1: So, there’s no acceleration? And there, does that mean there’s no force too? So does the child stay still?

S4: There’s no net force. But-

Alan: Well-

S4: Like-

Alan: ???

S2: It doesn’t stay still, it moves at a constant velocity.

S1: It’s still moving?

S4: But it could be either, like if it were, if it wasn’t moving, if the kid wasn’t moving, and this equaled this, then he still wouldn’t move. Like, it just means that there’s no change in velocity. Sorry, go ahead.

Alan: So, no, no. Okay, so, so if um, how shall I put this? Suppose something is sitting still. Suppose I try to push, pull up on it, push up on it. With a force, with a force that’s less than is holding it down. The force of gravity.

S1: It wouldn’t go anywhere.

Alan: It wouldn’t go anywhere, right? Suppose I push up with exactly the same force, it still wouldn’t go anywhere.

S1: Yeah.

Alan: The force on it is zero, its acceleration is zero, it’s not moving, right?

S1: Okay.

Alan: However, suppose I push up on it with just a bit more force than necessary to lift it. Just a bit more force than the force of gravity. It’s going to accelerate.

S1: Uh-huh.

Alan: And then suppose I get lazy and I start pushing only as hard as gravity’s pulling it down.

S3: ???

Alan: So, I got it moving. Its acceleration changed from zero to say one meter per second.

S1: Mm-hmm.

Alan: In a, in over a second.

S1: Uh-huh.

Alan: And then I only started pushing just as hard as gravity is pulling it down. At this point it’s not going to accelerate any more. Which means that it’s going to keep moving with the speed it had before I stopped accelerating it.

S1: Okay.

Alan: So, does that make sense?

S1: Yeah.

Alan: That’s what’s going on.

S1: So it’s still moving but there’s no accel-

Alan: But there’s no acceleration-

S1: No acceleration.

Alan: - just because something’s moving doesn’t mean that there’s acceleration.

S2: That’s what I said.

Alan: Only, it’s only if something’s acceleration that there has to be an acceleration.

S1: [quietly] Yeah. [louder]Okay. Thank you.

6.5.1.2.1 Alan focuses exclusively on answering S1's question

This episode begins when S1 calls Alan over, in the middle of a discussion that the group is having about whether the child can be moving if the net force on him is zero. Alan asks what her question is and then he works on answering the question she has asked. In doing this, he ignores the other students' ideas. One example of this occurs at the start of the episode. When S1 calls Alan over, he immediately approaches and leans over the table to read their papers. After S1 asks her question, Alan straightens up and steps back, directing his gaze at them rather than at the paper (line 16). At this point he is interrupted, and he continues to stand about a foot away from the table. When S4 indicates that she is done speaking (line 27), he steps closer to the table, and stands in front of S1. During S4's explanation, Alan has separated himself both physically and mentally from the conversation; he has stepped away and he does not respond to any of the statements between the interruption and when he speaks again. Alan has interpreted his job during the encounter as answering a question, so he spends the rest of the time answering it.

In the previous example, we noted that Alan failed to elicit student ideas, but his misstep here is greater, because he is ignoring ideas that the students have voiced. In this case, S4 discusses her idea that no force just means no change in velocity (lines 22-27), which is correct, and could be expanded to include the idea that if the child were already moving he would stay moving. In addition, S2 asserts that the child is moving at a constant velocity (line 19-20). Alan does not seem to notice either of these potentially useful ideas. At the end, S2 notes that her idea was the same as Alan's when she says, "That's what I said" (line 79).

Alan directs this conversation by providing a series of examples to demonstrate the steps in his reasoning. His final conclusion is the answer to S1's initial question "Does that [no acceleration] mean there's no force too?" The fact that Alan is guiding the conversation comes through in the length and type of conversational turns. After Alan enters the conversation, all of the student responses are one line, or even one word (until Alan has made his point, which S1 reiterates in lines 72-73). He introduces all the examples, and receives a confirmation after each one. The students support his framing of this activity as answering S1's question: S1 affirms that she follows each step, and S2 and S4 remain quiet, sometimes looking at Alan and sometimes looking away, which is consistent with the group's shared understanding that Alan's explanation is aimed mainly at S1. Once Alan starts to speak, no student introduces an idea or asks a question, even to clarify.

When Alan directs the conversation so strongly, it prevents him from doing things we would like him to be doing. Alan does not provide an opportunity for the students to give him feedback about whether he has correctly identified their difficulty. He does not model the practice of building on others' ideas. There is also no chance for the students to demonstrate whether they understand the idea by applying it. Alan is conveying, through his actions, that tutorial is a time when students can get help answering questions. We, in contrast, want the students (and Alan) to see the tutorial as a time when students construct knowledge together.

6.5.1.2.2 Alan misjudges students' skill level

Alan's actions also convey a different understanding of his role than what we, as tutorial instructors, would prefer. We want TAs to see their job in tutorial as that of a guide: this will require the TAs to figure out what ideas the students have, where those ideas fail them, and to help them make the connections between their current thinking and the physics concepts. Instead, Alan's actions seem to be based on the assumption that the students will understand the information he gives them. When Alan explains and expects the students to make sense of it on their own, he is crediting them with more skills than they likely have. Alan knows that his students are not experts, so he adjusts his presentation of conceptual information to a simpler level than he would use with, say, his peers. But his actions are not tailored for an audience that may not share expert values like seeking coherence or skills such as seeing the relationship of concepts in an equation. Furthermore, when he treats them as equals, he is not acknowledging the difference in authority: unlike his peers, Alan's students are less likely to interrupt or disagree with him.

6.5.2 Alan's values and beliefs about tutorials

We began to consider Alan a thoughtful instructor when we understood his ideas about teaching and learning. This section explains some of his beliefs which we think most influenced his teaching in the clips we presented here: his assessment of the tutorials' effectiveness for his students, how he sees his role as an instructor, and his belief that an instructor should be generous when assessing understanding.

6.5.2.1 Alan thinks that tutorials should help students with traditional problems

Alan was concerned that the tutorials were not providing the help his students needed. One reason for this was the conceptual focus of the tutorials. He felt that his students could often understand the concepts and do computations, so the problem was in putting the two together: "I don't think it's the math that's holding them back. It's the translation of intuitive ideas into algebra and then also just dealing with intuitive ideas and putting them together in various ways. It's what makes physics hard, of course." Thus, the tutorials were not helping students develop a skill that he recognized as one needing a great deal of instructional support.

The tutorials' focus on conceptual reasoning also prevented Alan's students from being exposed to aspects of physics that Alan considered fundamental, the predictive nature of physics computations and the cohesiveness of the theories. More than once he complained that tutorials presented equations as if they simply came into existence rather than showing how they derived from more fundamental laws, such as Newton's laws. He also felt that deemphasizing quantitative reasoning meant that students would not be exposed to one of the most important features of physics, the ability to quantitatively predict what would happen to physical systems.

Alan's focus on quantitative problems aligns with the ways his students were assessed. Their grades were largely based on quantitative problem solving. Alan noticed this mismatch, saying, "I'm seeing a lot of frustration from my students, about the homework and what they're being graded on, and the fact that this is not…"

He also saw this mismatch on their exams: "And the tests, they'll have a lot of sort of nonconceptual questions. And so, they're [the students] sort of in a very unpleasant situation." While Alan acknowledged that students needed conceptual knowledge, he would have chosen to spend more time working through quantitative problems during the time allotted for the tutorials. Alan viewed the mismatch between what the tutorials were asking the students to do and what the students were being graded on as unfair. Alan's concern that tutorials did not prepare his students for their tests was separate from his belief that tutorials did not teach important aspects of physics as a discipline. However, both supported the same conclusion that tutorials did not provide what his students needed.

6.5.2.2 Alan treats his students as epistemologically sophisticated equals

Alan talked about his role as a tutorial TA as one in which he was monitoring the students so that they did not "get stuck" for too long. He compared his role to that of a "fifth group member who …has taken the course before… and who happens to know everything, you know, and so you can ask him." This analogy is consistent with the method of guidance Alan uses. Alan might explain a problem to a fellow graduate student and then expect that she would work to really understand that solution herself; he expects his tutorial students to do the same. Alan also explained that he could have a closer relationship with his students than their professor, who is necessarily distanced from them.

Alan often drew upon his past experiences as a learner when deciding what is appropriate and useful for his students. When explaining how it is frustrating for students when a teachers expects they will have an incorrect answer, he discussed memories of his work being marked wrong in high school, even though it was correct, because it was not in the form the teacher wanted. He backs up his opinion that the tutorials let students struggle too much by saying that when he has wrestled with something it is annoying to receive only indirect assistance. He agrees with the premise that traditional discussion sections are not effective, because he remembers finding them "deathly boring." While Alan knew that his students were beginning physics learners (and would likely never become experts), he drew on his experiences as someone who excelled in physics when determining what would help his students learn. In all of these ways, he treated his students as he would want to be treated.

6.5.2.3 Alan thinks teachers should give students the benefit of the doubt

Alan's assessment that students can be frustrated when tutorials expect they will have an incorrect answer, which was based in part on his own experiences in school, is part of a larger belief about how he should treat his students. Alan thinks it is important to give students the benefit of the doubt, a theme we see in many of his statements. He views an assumption that a student will make a mistake as insulting to the student. Likewise, when a student asks a question, he thinks a teacher should assume that student has already thought carefully about the problem. Alan also objected to the tutorials' common tactic of eliciting a common-sense idea that will need to be reconciled with a physics concept. He cited an example:

> "And then the whole rest of the tutorial assumes that they screwed up. So basically, it assumes that they, I mean, they were stupid… I'm seeing that every time I do the tutorial, there's at least one group every time, who doesn't make the stupid mistake. And then they feel, actually, kind of offended."

In Alan's view, such an assumption not only demeans a student who originally had the correct answer, but it also can cause her to be confused about something she initially understood.

Through our interviews, we came to see Alan as a TA who thought deeply about the tutorials he taught and had identified substantive differences between his expectations and those of the tutorials. He was frustrated that students using tutorials could not connect qualitative and quantitative reasoning as well as he expected. He worked to help students so they did not unnecessarily struggle. Lastly, he held a principled view that it is wrong for instructors to assume students do not understand.

6.5.3 "Co-Construction" as an alternative to confrontation

One pedagogical approach to changing Alan's beliefs might be to challenge his beliefs by presenting him with evidence that some are not appropriate or useful in the classroom. This would be similar to the "Elicit-Confront-Resolve" approach that has been used with students (Shaffer & McDermott, 1992). If a TA has such a well-established belief that it is evidenced in both his behavior and his reflections about teaching, then that belief should be stable enough so that a TA could explicitly compare the belief to evidence. This would allow him to discover the belief's shortcomings.

There are several difficulties with using ECR in TA PD. One is that the subject matter is students, not science. It can be difficult for TA instructors to find results that unambigously demonstrate that a targeted teaching technique is either good or bad. Teaching involves maneuvering through situations that involve numerous variables, including different students, varying topics, and individual instructor differences. This makes it difficult to present evidence that TAs' particular beliefs and behaviors are problematic. For example, when TAs are confronted with evidence that practices like lecturing are less effective, it may be difficult for them to determine whether the shorter explanations they might give in a tutorial might also be ineffective. Some TAs we have talked to agree that lecturing in classes is ineffective, but also state that tutorials provide the opportunity for students to hear small, focused explanations addressing their particular difficulties. Unlike an introductory physics class, where it might be easier to devise experiments showing, for example, that charges are not "used up" in a bulb, the interactions between instructors and students contain many contextual issues that can cloud an argument that a particular teaching method is wrong. A second reason to reconsider using ECR in TA PD is that it can be difficult to treat TAs as partners in the endeavor of educating students while simultaneously confronting their beliefs as "wrong." Although as TA instructors we may have the license to confront TAs' wrong ideas, it is not a privilege we should necessarily use. Confrontation makes it more difficult to establish an environment where TAs can discuss their difficulties and consider alternatives to their current teaching practices. These are good reasons to reconsider the professional development approach of confronting TAs.

We are suggesting an alternative to ECR, which we call *co-construction.* We use the term to refer to a professional development method in which the TA instructor seeks to understand the ideas that a TA brings to his teaching, and to create an environment where TAs can understand the TA instructor's recommendations for teaching. Given data, people *can* change the way they think about teaching and learning, but we think that confrontation is an inappropriate metaphor. There is preliminary evidence that such PD can provide experiences that lead to changes in how instructors think about teaching (Close & Scherr, 2010). We want to emphasize that co-construction allows for disagreement among participants. We are not advocating a technique that gives approval to each and every TA behavior. However, ECR does not provide an avenue for authentic disagreements, but rather a line of reasoning that is carefully structured to show the inadequacies in the TA's beliefs. Co-construction provides a means for TAs and TA instructors to authentically discuss differing positions, with the goal of improving teaching practice.

In the remainder of this paper, we will provide an example of what PD that uses co-construction, rather than confrontation, might look like. We will begin by describing how we are better able to understand what motivates Alan's actions when we analyze his teaching with a respectful perspective, and then we suggest activities that could be part of a responsive PD program for Alan.

6.5.4 Courtesy to Alan: Interpreting Alan's actions in terms of his values and beliefs

Looking at Alan's teaching in the previous episodes through a more respectful lens allows us to better explain why he made certain choices. In this section, we re-examine the two episodes of Alan's teaching with the goal of understanding how his actions align with the beliefs that we have just discussed. These reinterpretations help us understand why Alan's actions seem reasonable to both him and his students. In Section 6.5.4, we then show how this deeper understanding can help us identify productive resources and beliefs that Alan has, which can be used as a basis for more responsive PD.

6.5.4.1 Reinterpreting Episode 1: Alan helps his students get "unstuck"

Alan's efforts to help these students solve the problem align with his beliefs about what he and his students should be doing in tutorial. Because Alan is concerned that tutorials do not allow students to translate conceptual ideas into algebra, he is demonstrating how to do that. He is helping them do a quantitative problem, which is a part of physics he particularly values, and this problem will help prepare them for typical homework problems. His respect for the students as learners fits with his belief that it is important to assume students understand what they are doing. In addition, his conviction that a teacher owes it to his students to answer their questions helps him see this as a reasonable action.

Alan gets feedback from the students in this episode that indicates that his behavior is expected and desired. Like Alan, the students know that quantitative problems form the bulk of their homework. Many introductory physics students have had previous classes that lead to expectations that science learning is mainly about problem solving, and that a TA's role in a discussion section is to explain (rather than, say, better understand a student's idea or help them learn from their group members). While we can only speculate as to these students' experiences, they show that Alan's behavior aligns with their expectations. Student 3 has indicated that they need help. Alan is providing this help with an explanation, and they endorse this by answering questions when he asks them, focusing their gaze mainly on him, and not introducing any other ideas. In this way, there is a stable interpretation of the situation: the students ask for help and Alan provides it. Thus, the students are satisfied that they have an answer and Alan is satisfied that he has helped them.

6.5.4.2 Reinterpreting Episode 2: Alan gives a direct answer to a challenging question

From his view, Alan's behavior in the episode makes sense. Alan sees his job as helping his students complete the tutorials. Here, he sees a problem: he needs to help Student 1 understand why something can have no net force acting upon it and yet be moving. Alan must think before answering this question, and if he considers this question challenging to himself, he probably also considers it challenging for Student 1. The combination of a difficult question, an explicitly stated need, and his view that his job is to help mean that he needs to offer assistance.

Alan assists by providing the answer. When Alan is the learner, he prefers to receive a direct answer to his question, because he does not ask for help unless he has already struggled with a problem. Presumably Alan then works to make sense of the answer he is given. If Alan expects the same of his students, then his behavior is reasonable: he assumes that a question asked demonstrates sufficient thought, and that the students can make sense of the answer when he gives it to them. Moreover, Alan thinks that when students do not get a direct answer, they are frustrated. He is equally frustrated as a learner in this situation and sees no pedagogical advantage to not answering the question. Thus, directly answering Student 1's question is the decent thing to do.

In contrast to the previous episode, the students in this episode vary in their support of Alan's framing. Although Alan sees his job as answering a question, only Student 1 acts in a way that encourages him to do so. Student 1 shows Alan that she is listening to his mini-lecture with affirmations and by repeating his concluding idea (lines 72-3, 75). There are indications that at least two of the students would prefer that Alan not give such a detailed answer: Student 4 interrupts Alan to express her reply to Student 1's question (lines 17, 22-27), S2 quietly points out at the end that her idea was the same as Alan's (line 79), and neither of them asks any question of Alan, nor talks to him except to apologize for interrupting him. Nonetheless, they do not interrupt him once he begins presenting his examples. It may be that the students' understanding of what is acceptable behavior in a discussion section (a TA providing a mini-lecture) and their expectations about who has more authority to decide the activity in a class (the instructor) mean that Students 2 and 4 only provide minimal feedback to Alan that they do not endorse the Alan's purpose during the interaction.

In the re-analysis of this section, Alan's actions appear more understandable. In both of the episodes, Alan acts in alignment with his beliefs that connecting qualitative and quantitative reasoning is important, that students should have their question answered, and that students should not unnecessarily struggle. We see that Alan is working hard to teach the parts of physics that he thinks are important and that he wants his students to succeed in the class. His intentions are admirable, but the result of his teaching differs from what the tutorial developers intend for students to be doing when using tutorials. The next section discusses what productive seeds we see in Alan's beliefs. We would like to cultivate these productive seeds so that his tutorial teaching more closely aligns with our intended practices.

6.5.5 Productive seeds for professional development

Just as we often cannot easily change students' incorrect ideas about physics, we cannot easily replace teaching practices that we do not like. As we have shown, Alan's teaching is rooted in his beliefs about what physics should be taught and what help is appropriate for his students. Alan is unlikely to embrace PD that admonishes him to discard these beliefs. What we can do, however, is offer PD that builds on productive seeds in his beliefs and thereby encourages beliefs and practices that are more appropriate to reformed physics instruction.

6.5.5.1 Alan's view of his students

One of the areas in which we see productive seeds is Alan's view of his students: he sees them as epistemologically-sophisticated equals. This is not to say that he thinks that they have as much content knowledge as he does, but rather that he thinks that they have the same abilities to make sense of new physics ideas as he does. Alan's respect for his students contrasts with an unfortunately common instructional view that students are dim or unmotivated. In these episodes, Alan seems to think his students are like him. In particular, the way in which he checks his students' understanding shows that he thinks they are capable of monitoring their own understanding – perhaps even that they are co-equals with him in this respect. He overestimates their self-monitoring ability, but it is commendable that he thinks they can do it. We would have less enthusiasm for a teacher who had the view that only the teacher can judge student understanding.

In order to make Alan's generous estimation of his students' abilities productive, we might guide him to focus on how he can think more like his students, so that he can better anticipate and understand the their difficulties and abilities. Activities with this goal would build on Alan's feelings of fellowship with the students while helping him to appreciate the differences in their learning practices.

6.5.5.2 Alan's view of his job

We can also identify productive seeds for PD in Alan's desire to "do right" by his students. In both episodes, Alan has interpreted his job in the moment as answering a question, and he does not leave until he feels the students understand the answer. While we do not agree with his strategy of providing direct answers, which does not allow for extensive student participation (either in clarifying the problem or in constructing the solution), his teaching decisions align with his desire to help his students. For Alan, "doing right" by his students means affirming their possible understanding. From our perspective, assuming students' ideas are correct can often be detrimental to them because it can cause us to miss problems they have. Responsive professional development would harness Alan's desire to help his students do well, but would direct this desire toward reflection about what students ought to learn and how he can help them do that.

6.5.5.3 Alan's acknowledgement of and response to difficult conceptual questions

Although Alan believes that the conceptual questions in the tutorials are usually easy for students, Alan can recognize exceptions. For example, Alan recognizes in Episode 1 that it is difficult to understand how something can be moving but have no force on it. His rhetorical question, "How shall I put this?" (Episode 1, line 29) suggests that he has to think before he can best answer S1's question. The cognitive resources that helped him identify this exception are resources that PD could build on to help Alan see other conceptual issues with which his students might have problems.

Alan agrees with some of the pedagogical strategies that the tutorials use, sometimes without realizing it. During both episodes, Alan provides his answers in the form of small learning progressions. Tutorials are based on such learning progressions, which guide the students through manageable steps towards the target concept. Frustrating though it may be for TA instructors to see Alan use a progression of ideas that is similar to that of the tutorials and yet not recognize the similarity, Alan's (tacit) recognition that such progressions are useful is a productive resource.

6.5.5.4 Alan's view of small group activities

We also see productive seeds in Alan's assessment of traditional discussion sections, in which TAs typically work problems at the board in front of students. Alan considers these boring and ineffective. He says that they are only occasionally helpful for students, such as when the students have prepared by completing the homework before the section. "So, so that's really boring and I'm not surprised that people don't learn much from it. You just kind of tune out. Um, making [the students] do it would be good." Instead of a TA lecturing, he agrees that group work is more effective, because students can build on each other's good ideas and catch each other's mistakes. From these comments, we can see that Alan is already convinced that traditional discussion sections offer limited opportunities for student learning. His recognition of the need for reformed methods of instruction and the usefulness of group work for student learning are productive resources.

Looking at Alan through a respectful lens allows us to see resources and beliefs he has that could be the basis for more effective professional development. The next section examines Alan's judgment of the PD he had and what changes could be made to make his PD responsive.

6.6 Responsive TA Professional Development

6.6.1 Alan's reaction to the PD he received

The open-ended questions that were asked during Alan's interview did not specifically solicit his views about the PD he was receiving. During his two interviews, however, Alan made many points that referenced the PD sessions. Most of these comments addressed two major ideas: the appropriateness of the challenge tutorials present to students and the tutorials' conceptual focus.

6.6.1.1 Appropriateness of the challenge

Alan reported that his students thought the tutorials were too easy and his experiences by the third week of teaching (when he was first interviewed) confirmed this view. He explains, "I thought… when we were originally presented with this stuff that everybody would be struggling with this and nobody would be able to get any of this... That's not happening. I mean, I've seen a lot of people who do already understand." His students' complaints about the lack of difficulty also fit with his interpretation of what he was being told during his PD,

> "The thing is, unfortunately they're [the students are] right. I mean, it is. This is high school level. I mean, of course, one could make the claim, and Rachel [the TA supervisor] does, some of this has come up in, in training sessions, that people saw this in high school and didn't get it. And, that's true… And honestly, these students are older now, and more mature, and one would hope that they would be able to, that, that they'd get it the first time."

Thus, though Alan heard in his training meetings that students need this kind of instruction, his students and his expectations both contradicted this idea.

It might be hard to imagine how Alan could experience his students as having few conceptual problems with topics such as Newton's Third Law, especially in the context of tutorials designed to help students examine their intuitions. The episodes we have discussed, though, show how Alan's interactions with his students may have reinforced his generous assessment of them. For example, in episode 1, Alan narrowly constrains how his students can respond, which makes it easier for them to provide the answer he is looking for. He then interprets their answers as further support for his belief that they understand, setting up a stable feedback loop.

6.6.1.2 Tutorials' conceptual focus

Alan's assessment of the ease of tutorials was also connected to his belief that the tutorials do not cover a difficult and important part of physics: quantitative reasoning. Alan had heard the TA instructor's claims that the tutorials helped students' scores on the Force Concept Inventory (FCI), but he interpreted an FCI gain as an insufficient goal in an introductory course. He noted that students needed more than concepts to truly understand physics: "I believe the results of the Force Concept Inventory, that I buy. But the Force Concept Inventory, how do I put this, this is designed to get you to pass the Force Concept Inventory. It does not test a whole range of things that would also be good to learn." He also felt that the students' problem solving skills were not improving enough, quoting the TA instructor: This is a phrasing that was given to me by Rachel, 'Tutorials do not harm students' ability to do problem sets.' And I can, I can almost believe that, but it depends on what you mean by "do not harm." If they started at the same abysmal level and you tested it and they stayed at an abysmal level." Although the training that Alan received attempted to specifically address the idea that students who use tutorials can solve problems as well as students receiving traditional instruction, this did not ease his concerns.

We speculate that Alan's judgment that his students' problem solving skills are insufficient may be attributable to his limited teaching experience. Alan has only two experiences which can help him determine where to appropriately set his expectations for his students: his own undergraduate experiences (where he was most likely an above-average student) and his current students, who use tutorials yet cannot solve problems that he considers straightforward.

The PD that we provided Alan did not sufficiently prepare him to teach tutorials as the tutorial developers expected they would be taught. This failure was not Alan's fault, and it was not due to a lack of effort on our part. Instead, the PD did not succeed because it was not responsive to Alan's beliefs. Responsive PD for Alan would have elicited the concerns he had about the curriculum he was teaching and would also have helped him identify ways that he could improve his teaching.

While we analyzed Alan's interviews and teaching in this paper, we do not expect that we would have to do this thousands of times in order to identify the most important beliefs and experiences TAs draw on. As with students, there are probably common issues. But as with students, we cannot just guess their issues; we have to carefully observe and interpret their practices to learn about their ideas.

6.6.2 Improved PD for Alan would account for his beliefs

The PD that Alan received did not anticipate that he would not value the tutorials because of his concern that tutorials were failing to teach his students important parts of physics, such as how physical laws could be derived from one another and that physics provides "extremely powerful machinery that lets you get numbers and get precise and quantitative results." His PD did emphasize the importance of group work, but Alan already agreed that typical recitation sections were "deathly boring" and rarely addressed the needs of particular students. Unfortunately, and unbeknownst to his supervisors, the PD Alan received sometimes focused on convincing him of things he already believed and did not address his worry that tutorials neglect the quantitative part of physics.

Responsive PD is made possible when TA instructors create opportunities for TAs to express their beliefs and opinions and then tailor the PD to address them. In addition, TAs need to feel that they are responsible for their teaching and that their contributions are valued. Literature on TA and teacher PD offers suggestions to help achieve these goals. In a report advising universities on how to better prepare graduate students to become faculty, Adams (2002) called for more varied and extensive teaching experiences and PD programs that incorporated experienced TAs as resources. She suggested following the accepted apprenticeship model for training graduate students in research, in which progressively less scaffolding is provided as more responsibility is conferred. Research specifically addressing science TAs has recommended that departments provide discipline-specific pedagogical content knowledge (Marincovich, 1998) and increase the use of formative assessment (Luft, et al., 2004; Robinson, 2000). Others emphasize providing TAs with the opportunity to integrate pedagogical ideas into their teaching by offering PD as they teach (Hammrich, 2001; Price & Finkelstein, 2006) and connecting novice TAs with more experienced instructors by asking them to observe or team teach with more experienced TAs (Belnap, 2005; Carroll, 1980; Ishikawa, et al., 2001). TA instructors could help TAs identify ways to improve their teaching by observing TAs' instruction and providing feedback (Belnap, 2005). Close (2009) has reported that directing instructors to interview peers with the purpose of understanding their ideas rather than questioning to make a point focuses the instructors' attention on teaching as making sense of students' ideas. Fennema suggests presenting PD as a situation where there are two sets of experts: the PD instructor as expert in research on learning and the TAs as possessing expert knowledge about the particular situation in their classrooms (Fennema, et al., 1996).

None of these activities are *inherently* responsive. They become responsive when they are chosen in response to the beliefs and resources the particular TAs have. In Alan's case, if a TA instructor were observing him to provide feedback, the PD could be made responsive by changing the primary focus of the feedback session from the instructor advising Alan to the instructor eliciting Alan's explanation of *why* he made particular instructional moves. This way the instructor could understand the motivations and beliefs that underlie Alan's behaviors. As we have discussed elsewhere (Goertzen, et al., 2010), the beliefs that underlie a behavior cannot be "read off" from the behavior itself, because different kinds of beliefs can underlie behaviors that look similar. Thus, feedback given to Alan needs to respond not only to behavior like his tendency to assume students understand when they provide the correct conceptual answer, but also to respond to his belief that instructors *should* give students the benefit of the doubt, rather than assume they are incorrect.

Now that we better understand Alan's beliefs, we think that a part of responsive PD for Alan could be meetings in which Alan and a TA instructor meet and watch video episodes of students in the classroom (as used by Speer (2008)). In order to "cultivate" Alan's productive seed that students are capable of monitoring their own understanding, we might show him different clips of students working when the TA is not assisting them, and ask him how accurately the students seem to be evaluating their own understanding. Our purpose would be to give Alan the opportunity to observe and reflect on a wider spectrum of student metacognition. Similarly, we could build on Alan's desire to "do right" by his students by showing him the same video clips, but this time focusing his attention on whether the students have a correct conceptual understanding. This would be done to allow Alan the chance to see and become aware of a wider range of student understanding. As a third example, we would build on Alan's awareness that conceptual questions can be difficult by giving him the opportunity to modify the tutorials for future semesters. If these modifications were suggested after he had watched his students working on the tutorial, we would hope this would encourage reflection about what difficulties he sees his students having and how the tutorial could address those difficulties.

There are many reasons to think that such an approach would have the potential to help Alan improve his teaching. He cares about his students and wants to help them learn. He has demonstrated an ability to be reflective about his students' learning during his interviews. He thinks student group work is a productive activity, so watching videos of student group work would hopefully be acceptable to him as a way to see how they learn. All of these are resources that he can draw upon when improving his own instruction.

6.7 Conclusion

The initial implementations of our professional development program had been directed by our concern with the pedagogy, not the TA. Thus, we paid attention to how to "fix" the TAs' ideas, rather than attending to the substance of the TAs' ideas. We believe that what matters in not the *act* of focusing on TAs' ideas but *why* one is focusing on those ideas. If TA instructors are attending in order to assess and correct TA instruction, then it is much harder to understand the TA's motivation, and harder to provide professional development that is responsive to the particular TA's relevant concerns. Instead, responsive PD should be based in a respectful view of the TAs that acknowledges the beliefs that underlie their teaching decisions and seeks productive resources in those beliefs, which effective PD can be built upon.

We now view Alan's teaching goals as essentially noble, though mismatched with ours. He values the quantitative predictions that physics can provide, and seeks to foster the skills that lead to this. He also endeavors to treat his students with respect, which includes giving them the benefit of the doubt when they ask a question or tell him an answer.

The way we first characterized Alan's teaching was not incorrect; we were identifying pedagogical decisions to which we objected. However, our focus on what Alan did wrong instead of the reasons why he did it caused us to miss opportunities to provide him with useful PD. Only now do we have hope of designing effective PD for Alan and others like him. In general, our study of Alan tells us that we can benefit from knowing more about our TAs in order to design effective PD for all of them.