Transformative professional development: Cultivating concern with others' thinking as the root of teacher identity

Rachel E. Scherr and Hunter G. Close, Seattle Pacific University, Seattle, Washington, 98119,
rescherr@gmail.com, hclose@spu.edu

Abstract: At the university level, science education reform is limited by novice instructors who do not share reformers' educational values. The current challenge is to provide professional development (PD) that will be *transformative:* rather than merely exposing participants to reform instructional materials, it will change what future instructors believe is worthwhile in science education. Our view is that professional development is most effective when it enriches the intellectual life of teachers and builds teacher identity by cultivating concern with student thinking. In an example of an activity that originates in this perspective, participants interview peers about physics concepts and conduct structured reflections on the interviewing experience. The activity holds promise for improving participants' abilities to listen and to teach effectively, increasing their esteem for the intelligence that teaching requires, and increasing their interest in K-12 physical science teaching as a profession.

Major issues addressed

Physics education research has produced a wide variety of high-quality instructional materials for use in introductory university-level courses (Laws, 1999; McDermott & Redish, 1999; Sokoloff & Thornton, 2001; Thornton & Sokoloff, 1997), including tutorials (McDermott, Shaffer, & PEG, 1998). The limiting reagent for physics education reform at the university level is now implementation (Tobin & McRobbie, 1997).

At the university level, reform is limited by novice instructors who do not "buy in"

Experienced educators and developers are well aware that successful implementation of reform instructional materials includes establishing appropriate norms for learning in the classroom (Henderson, Yerushalmi, Kuo, Heller, & Heller, 2007). At the university level, for example, science education reform has often taken the form of collaborative worksheets ("tutorials") used in recitation sessions. In these classrooms, norms include an emphasis on conceptual understanding (and a concurrent de-emphasis of algorithmic application of formulas); an expectation that this understanding is best achieved through explaining one's own thinking, listening and responding to others' ideas, and constructing arguments; and an acceptance of instructors as facilitators of this process rather than sources of correct answers. The establishment of these norms is "among the most critical and subtle features of implementing these reforms" (Finkelstein & Pollock, 2005).

From the students' point of view, the graduate teaching assistants (TAs) and/or undergraduate learning assistants (LAs) who lead each tutorial section are important arbiters of these norms and expectations. The development of these norms by these novice instructors is thus a critical task of tutorial implementation Instructors who "buy into" tutorials are more likely to convey their respect for the material and the tutorial process to the students, as well as learning more themselves. This development is nontrivial: although graduate and advanced undergraduate students may be presumed to be more sophisticated learners than introductory students, they are in some cases more thoroughly embedded in traditional teaching practices. Prior research by the authors on tutorial implementation has provided examples of how lack of buy-in by an individual TA can undermine the effectiveness of tutorials (Goertzen, Scherr, & Elby, 2009).

Lack of buy-in can have roots in impoverished beliefs about the intellectual life of teachers In our culture, the work of a science teacher is not regarded as that which requires the great power of a creative and analytical intellect. Novices who believe that an instructor's job is merely to "check that students get it" may be frustrated with tutorials, in which instructors are expected to facilitate student exploration of a variety of solution paths. The public perception of science teaching as minimally intellectual work diminishes the interest the next generation of talented thinkers might have in doing the work: talented, intelligent students want to grow up to do something that they believe requires talent and intelligence, and teaching is not usually considered to be one of those things. Novice instructors' lack of appreciation for the intellectual rigor and creative opportunities in teaching impedes science education reform.

Typical professional development rarely helps instructors value reform instruction

TAs and LAs receive various forms of professional development (PD) associated with their teaching responsibilities. While these programs may provide novice instructors with necessary information and general skills, few help them recognize the worth of reform instruction. Some novice instructors participate in workshops and seminars focused on classroom management, grading, facilitating discussion or learning questioning skills (Gilreath & Slater, 1994; Hollar, Carlson, & Spencer, 2000). These types of PD are oriented toward providing instructors with specific skills and information, and are not specific or sustained enough to have much effect on their values. In a tutorial program, the most common form of professional development is a weekly session aimed specifically at preparing instructors for the coming week's instruction. The primary activity is usually to complete the tutorial worksheet as if they were students. This specific preparation is surely necessary to effective instruction. However, research indicates that it is not sufficient to help the participants appreciate the power of tutorial teaching. In particular, the social and environmental context of the tutorials – including classroom, departmental, and institutional levels of implementation and support – has been shown to strongly affect whether TAs buy into tutorials, and probably outweighs the influence of the typical preparation activities that we prepare for them (Goertzen et al., 2009).

Some novice instructors take courses that offer instruction in pedagogical content knowledge and constructivist learning theories (Hammrich, 2001; Ishikawa, Potter, & Davis, 2001; Lawrenz, 1992; McGivney-Burelle, DeFranco, Vinsonhaler, & Santucci, 2001; Otero, Finkelstein, McCray, & Pollock, 2006) Where pedagogy courses are offered, there is more potential to help instructors value reform teaching, because the courses address models of teaching and learning directly for a sustained period of time. A pedagogy course is particularly likely to be effective when there is good alignment between the learning theories presented in the course and the practical teaching experiences that the instructors have: if the instructors learn constructivism in the pedagogy course, but are permitted or requested to teach by telling in the classrooms that they lead, they are less likely to appreciate constructivist teaching methods. Assessment of professional development that includes a pedagogy course should thus include systematic observations of the participants' classrooms, not only surveys or interviews.

Potential significance of the work

The current challenge for university physics education reform is to provide professional development (PD) that helps instructors to appropriately value reform instruction. Such PD will be *transformative:* rather than merely exposing participants to reform instructional materials, it will change what future instructors believe is worthwhile in science education. We take the perspective that this transformation is a *philosophical* and *epistemic* one, involving a change in what is thought to be worth knowing.

Transformative professional development enriches the intellectual life of teachers

In the transition from Plato's philosophy of the natural world to Aristotle's, phenomena of the natural world were promoted in epistemic status. In Plato's philosophy, the actual world is not something that is worthy of study in and of itself; it consists instead of a variety of imperfect copies or images of ideal principles These ideals are the "real" things of concern, and the proper subject of contemplation and analysis, while their shadows and distortions (of which the world we experience consists) are not. In contrast, Aristotle's philosophy (which followed shortly thereafter) granted a new and higher status to the world of phenomena, as we experience it. This world is populated with all sorts of things that are themselves worthy of study, as they are. On this, Aristotle says (Aristotle, c. 350 B.C.):

> *It is the business of experience to give the principles that belong to each subject I mean for example that astronomical experience supplies the principles of astronomical science; for once the phenomena were adequately apprehended, the demonstrations of astronomy were discovered. Similarly with any other art or science.*

An Aristotelian might see the Platonist who does not care to pursue truth by first studying the instantiated world as fixated on the world as it should be, rather than the world that is.

A similar dichotomy of perspective exists for novice instructors learning to think about student thinking. Most of these instructors are very (and rightly) concerned with understanding physics as it *should be* understood. This is not to suggest that there is only one way to think correctly about physics; surely, there is not But novices are usually very aware that they have ways of thinking that they may want to avoid, and ways of thinking that they strive to use more consistently and reliably. They are right to recognize that they have not yet mastered basic physics (though they probably also underestimate how long it takes most physics instructors to do so). Thus, initially, novice instructors are generally *fixated* on correct understanding in physics – on their own part, on the part of their peer instructors, and on the part of the students that they would teach. This is not to say that their attention is so focused on correct understanding of physics that they always understand clearly for some bit of instruction what the target understanding is; it means that correct understanding is their primary *concern* during teaching. They are fixated to the point of failing to understand expressions of student thinking in physics as phenomena worthy of study and explanation, as they are, and not only secondarily, as they fail to match up with correct understanding in physics. In this way, beginning instructors are Platonists when it comes to alternative ways students have of thinking and knowing. The most important thing to observe (according to the beginning instructor) about student thinking when teaching is how that thinking is wrong, and since this is teaching, an activity in which the student (we assume) is supposed to be changed by the interaction, the most important action is to fix the wrong thinking as soon as possible.

The key Aristotelian insight, that observable things are worth studying as they are, may be applied in extreme fashion to teaching. According to an excessively Aristotelian view of studying student thinking, we physics instructors might be happy each day to ask our students questions, listen to their answers in detail, write down some observations, and thank the students for their time before inviting them to come back tomorrow. Later we would return to our notes and try to figure out what deeper truth was expressed in all those instances of student expression. But at no point would we distract ourselves from our scientific task with thoughts of what all that student thinking ought to have been. It is easy to see that such an extreme view is not appropriate for a classroom, because it leaves no place for student learning. Thus, neither philosopher's approach to nature is sufficient if it is applied to teaching, for in one, the reality of student thinking is neglected, and in the other, there is no role for instruction. If attention to student thinking is necessary for effective instruction, then the teacher is performing a complex, hybrid intellectual task of understanding clearly both where the students are, and where the teacher wants them to be. To prepare physics instructors is to prepare them to perform all the components of this hybrid task. We believe the greater task for those who prepare physics instructors lies in helping the instructors to understand the Aristotelian component.

Fortunately, however, establishing this Aristotelian component in the understanding of the instructor is not only a task of great effort, but also a great gift to the instructor. Through the recognition that teaching includes the work of making observations about student thinking and making sense of those observations, the instructor's vision opens into an entirely new realm of phenomena of infinite variety. And a scientist takes pleasure in observing and thinking about wonderful new things, as they are.

A teacher solves puzzles of student thinking and learning

As if the news about a fascinating new class of phenomena weren't good enough, there is even more: the instructor also has the pleasure of *figuring out* puzzles of transforming student thinking from state A to state B, and then to state C, *etc.* Thus, teaching has a natural science component (understanding student thinking) and an engineering component (shaping student thinking to become more functional). These puzzles are as numerous as the instructor wishes, and include at least the number of students multiplied by the number of specific learning goals set forth by the instructor. A template for such a multi-part puzzle might look like "How can I better understand how [student name] thinks about [specific topic]? Once I understand well enough, how can I get [student name] to understand [specific aspect of specific topic]? How will I know if it worked?"

Kuhn described how it was this sort of intellectual pleasure that keeps scientists wanting to come back to work each day (Kuhn, 1962):

> *The challenge of the puzzle is an important part of what drives [the scientist] on… What then challenges him is the conviction that, if only he is skillful enough, he will succeed in solving a puzzle that no one before has solved or solved so well.*

Surely these words apply equally well to the science teacher, provided that the science teacher conceives of the job as providing a steady stream (really, a fire hose) of this sort of puzzle material. The main obstacle to conceiving of the job in this way, we believe, is merely the fact that those talented and intelligent people who might love to do such a job are not aware that the possibility exists. The lack of awareness is due in part to how such an approach to teaching has been modeled for potential future instructors by so few, and the other part, perhaps, is due to the lack of explicit instruction in professional development about how to approach teaching in this way.

Theoretical perspective: Resources and framing

While teachers are making observations about student thinking, they are also making sense of what they observe: that is, they are inevitably (and probably implicitly) forming theories of what knowledge is and how learning takes place. This epistemological change is at the heart of transformative professional development. We assume that the cognitive processes underlying epistemological change are similar, in some respects, to the cognitive processes underlying conceptual change.

Resources vs. (mis)conceptions

We take a *resources-based* rather than the more common *conceptions-based* view of the prior knowledge students bring to bear in physical science (Hammer, 2000; Smith, diSessa, & Roschelle, 1993/1994). In this view, learners (whether they are students or beginning teachers) have ideas that are activated by particular 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, Elby, Scherr, & Redish, 2005; Russ, Scherr, Hammer, & Mikeska, 2008). Such a framework provides an explanation for how novices become experts: they begin to use resources from other contexts, adding new ones and building up a more coherent structure of ideas (Smith et al., 1993/1994). Smith et al. characterized such a framework as one that "emphasizes knowledge refinement and reorganization, rather than replacement, as primary metaphors for learning." (p. 116).

To see how the distinction between a conceptions-based and a resources-based cognitive framework plays out in interpreting learner epistemologies, consider a hypothetical introductory physics student named Dan. Even when a tutorial tries to elicit his intuitive ideas, Dan answers in terms of remembered facts and equations. Why? According to the conceptions-based framework adopted by most epistemology researchers (Hofer & Pintrich, 1997; Schommer), Dan's behavior probably stems from an epistemological *belief* that physics knowledge comes from authority, or that physics knowledge consists largely of facts and formulas (Hammer, 1994). In that case, changing Dan's behavior would likely involve an arduous attempt to confront and replace his epistemological "misconceptions" with more productive beliefs.

The resources-based framework provides an alternative interpretation and instructional strategy. In our view, Dan's focus on facts and formulas probably arises not from a stable epistemological *belief*, but from the context-sensitive activation of finer-grained *epistemological resources*. We see evidence of these resources, including resources regarding the source of knowledge, even in small children. When asked how she knows what's for dinner, a child might respond "Daddy told me," reflecting the activation of the resource *knowledge as transmitted stuff* (Hammer & Elby, 2002). The same child, when asked how she knows Mommy got her a present, might reply, "I figured it out, 'cause it's my birthday and I saw her hiding something." This answer reflects the activation of the resource *knowledge as fabricated stuff*, corresponding to the view that knowledge is built up from "raw materials" such as prior knowledge about birthdays and observations of sneaky parental behavior. Along these same lines, we can interpret Dan's behavior as stemming from the inappropriate over-activation of resources such as *knowledge as transmitted stuff* – resources that are useful when learning state capitals, but not as useful when learning physics concepts.

According to this framework, we can change Dan's approach to tutorials without introducing new epistemological beliefs "from scratch." Instead, we can help him activate epistemological resources *he already possesses* and applies in other contexts. For instance, Dan may rely on his common-sense ideas when explaining wave phenomena he sees at the beach, or when having a classroom discussion about psychological (rather than physical) phenomena. As instructors, we would try to help Dan "find" those resources and activate them in physics class (Hammer & Elby, 2003).

Epistemological framing

A learning context such as a lecture or a tutorial can trigger a locally coherent set of epistemological resources, a set that explicitly or implicitly answers the question, "What counts as knowledge and learning in this context?" We call such a set of resources an *epistemological frame*, acknowledging the sociolinguistics literature that helped us formulate this perspective (MacLachlan & Reid, 1994; Tannen, 1993). Examples include *remembering stuff from authority* and *intuitive sense-making*. When Dan frames an activity as *remembering stuff from authority*, he "believes" – in that moment – that knowledge comes from authority and that solving a problem is a matter of finding the right knowledge. But in another context, Dan could frame problem-solving as *intuitive sense-making* and act as if he believes knowledge is constructed from everyday ideas and experiences. In a resources framework, neither of those frames is Dan's "true belief," because he doesn't have a single, universal belief about the nature of problem-solving.

When we study (and try to affect) the epistemologies that novice instructors exhibit while learning and teaching, the distinction between the conceptions/beliefs and resources models – and particularly, the notion of frames – becomes especially important. Instead of assuming that instructors *have* stable epistemological beliefs that they apply consistently and universally, we assume that different contexts can trigger different epistemological frames. For instance, when an undergraduate LA we'll call Lisa does her own advanced physics homework, she may fall – consciously or unconsciously – into manipulating symbols without trying to make sense of the underlying physics. When addressing "brainteaser" physics problems posed in her LA pedagogy class, however, Lisa easily enters an *intuitive sense-making* frame; she tries to make sense of the qualitative physics concepts and doesn't want to be told the answer, realizing that jumping to the answer is detrimental to her learning process. In that context, Lisa "knows" that learning physics is largely a matter of making sense of it for yourself, rather than just hearing a clear explanation or manipulating symbols. Nonetheless, when Lisa got into an introductory physics classroom as an LA, she acted as if she thought her students' learning is mostly a matter of hearing clear explanations and manipulating symbols. Our point here is that instructors' epistemologies appear to display context dependencies best analyzed in terms of resources and frames rather than beliefs.

Fostering epistemological development, in this framework, consists largely of helping novice instructors become more reflective about which frames they're using in which contexts (including when they teach), and eventually to "crystallize" their productive epistemological frames into well-thought-out epistemological beliefs about how people learn (Hammer et al., 2005). With Lisa, for example, we might try to create contexts in which she can observe students engaged in making sense of physics concepts, reflect on the similarities to (some of) her own most satisfying learning experiences, and consider how she might foster such learning experiences in the classrooms in which she is an instructor. This approach embeds our philosophical perspective: By posing student thinking about physics as an observable phenomenon, we support novice teachers in strengthening the Aristotelian component of their understanding of teaching Excitingly, we sometimes find that "once the phenomena [of student thinking] are adequately apprehended," novice instructors spontaneously draw valuable conclusions about cognition. Lisa, having thoughtfully observed students express a variety of ideas about force and motion, might express a new conviction that people hold multiple, perhaps contradictory ideas at the same time, or that people hold ideas that are neither right nor wrong but rather are applicable in certain contexts.

Our framework embeds a deep respect for novice instructors' existing beliefs and prior experiences, seeing them as the essential material from which expert conceptions of teaching are constructed The physics education community has long taken this perspective regarding learners' physics ideas, with the benefit that we can help students identify ideas that can be the basis for effective constructivist instruction (Hammer & Elby, 2003). Our theoretical framework extends this fruitful perspective to professional development We also go one step further by explicitly entrusting novices with the cognitive ability to figure things out: not only do they possess the building blocks of cognition, but also, we believe, they are capable of doing the building. This is in contrast to a view in which students need to be led step-by-step through a logical sequence prescribed by an expert.

Methodology for facilitating and understanding transformative professional development

Our view is that professional development is most effective when it enriches the intellectual life of teachers and builds teacher identity by cultivating concern with student thinking. We are in the early stages of a project with two mutually supporting purposes: (1) to provide novice instructors with professional development that shapes what they value in science education, and (2) to better understand novice instructors' experiences of potentially transformative professional development.

Design and implementation of transformative professional development

We have selected undergraduate Learning Assistants (LAs) as our initial target population because Learning Assistant programs can be centerpieces of university science education reform. LAs are talented undergraduates who work with faculty members to make large-enrollment courses more collaborative, student-centered, and interactive. Research has shown that LA programs improve undergraduate performance in physics courses, facilitate multi-disciplinary collaboration among faculty, involve more faculty in teacher preparation efforts, and recruit talented science majors to teaching careers (Otero et al., 2006; Pollock & Finkelstein, 2008). That is, a quality LA program is at once a mechanism for course transformation, for teacher recruitment, and for TA and faculty professional development.

LA programs integrate content, pedagogy, and practice and produce documented improvement in all three areas (Otero et al., 2006; Pollock & Finkelstein, 2008). LA programs are effective partly because LAs take a low-credit pedagogy course that instructs them in the nature of teaching and learning and introduces them to interactive teaching techniques. (TAs are usually not required to take a pedagogy class, partly because their typical course load is already very high.) Thus, in an LA program, university educators have the opportunity to shape participants' perceptions of teaching. LAs whose pedagogy class helps them appreciate the worth of reform instruction are a valuable resource for their institution and for science education reform generally.

Our design and implementation work is focused on the most flexible and most potentially innovative component of the LA program, which is the pedagogy session. The over-arching goal of these sessions is to provide LAs with a sense of the intellectual depth that a physics teacher can experience and enjoy by thinking deeply about student thinking. One promising activity that we have piloted is the Physics Interview Project (PIP). In this key example of an activity that originates in our theoretical perspective, participants interview peers about physics concepts and conduct structured reflections on the interviewing experience The activity holds promise for improving participants' abilities to listen and to teach effectively, increasing their esteem for the intelligence that teaching requires, and dramatically increasing their interest in K-12 physical science teaching as a profession.

In the PIP, each LA interviews a peer in order to study that person's thought process about some physical system. LAs perform three interviews throughout the academic year; the protocol for the first one is designed by the LA program director (HGC), and the later protocols are designed by individual LAs. After conducting each interview, LAs transcribe part of it and perform it in class, explaining why they thought the selection was interesting. They write a reflection paper that includes a characterization of the interviewee's thinking and the LA's thoughts on the difficulty and value of the experience. The PIP puts LAs face to face (literally) with the phenomena that are the subject of physics education research, and thus provides a particularly compelling entry point into that research. Importantly, LAs are exposed not only to the *refined results* of physics education research (as they might be in other LA programs) but also to the *raw data.*

Research on participants' professional development experiences

The research arm of the project documents and analyzes individual instructors as they work together in preparation for teaching, as they teach, and in reflective interviews, with the goal of understanding transformative experiences they may have and learning about the processes by which novice instructors develop into intelligent and talented educators.

Data sources

The aim of data collection for this project is to enable rich representation of individual LAs' experiences in the course of the program. To this end, we document novice instructors in all three environments that directly relate to their teaching: their pedagogy course (1.5 hours biweekly), their preparation course (1.5 hours weekly), and the classes in which they are instructors (2-4 hours weekly for each focal LA). Because the nature of the activity that people perceive themselves to be engaged in affects how they interact (Bateson, 1972; Goffman, 1986; Goodwin, 2000; MacLachlan & Reid, 1994; Tannen, 1993), we keep the recording subordinate to normal classroom practices. The approach has served us well in other projects (Goertzen et al., 2009; Goertzen, Scherr, & Elby, accepted (2010)).

In addition to the naturalistic videotaping, we conduct twice-yearly clinical interviews with a protocol similar to the one described in Goertzen et al, 2009, in which the primary question is "How is [name of course] going?" Open-ended prompts such as this have been shown to initiate conversations that result in epistemologically rich responses; participants volunteer which aspects of the course they judge to be successful, which aspects are lacking, what features they believe should get more emphasis, and otherwise reveal their values and expectations for instruction and their views about how students learn (Hammer, 1994).

Analytic framework

The primary research activity of this project is to develop rich case studies of individual LAs' experiences in our professional development program, with the goal of understanding transformative experiences they may have. Case studies are particularly powerful for this project in that they get at the *mechanisms* by which our program may affect LAs. Fortunately, the increasing ease of video recording offers new opportunities to create richly detailed records of classroom activities. These recordings call for research methodologies that balance generalizability with interpretive validity.

Classroom behavior as the primary data source. When developing a case study, we use video recordings of LAs' classes as the primary source of data. We watch video episodes of LAs teaching and/or working together in the pedagogy and preparation courses and seek to provide plausible framings that might explain their classroom behavior. Transcriptions of the interviews are used to support or contradict the conclusions we develop while watching video episodes. This contrasts with many studies of TAs and teachers, which attempt to first understand the instructor through interviews or surveys, and then (in some cases) compare these assessments to actual behavior (Hammrich, 2001; Ishikawa et al., 2001; Lawrenz, 1992). We consider interviews to be secondary data because we conduct them with the intent of understanding LAs' overall beliefs and attitudes about tutorials, and thus they are unlikely to reference particular teaching situations (Goertzen et al., 2009). Depending on such interviews to fully explain TAs' framing would be attributing more consistency within an individual than we have argued is warranted.

Insight-oriented analysis. The primary purpose of "insight-oriented" analysis is to identify and richly describe the events in an episode as they unfold in the interaction among the participants. "Coding-oriented" analysis, in contrast, aims to generate categories that will be used to document the frequency and distribution of events of interest. (Of course, insight-oriented analysis may generate a coding scheme, and coding may lead to deeper insights.) The backbone of video analysis as we conduct it is collaborative analysis of short episodes of classroom activity. Having selected an episode, we play the video for a multidisciplinary analysis group, and members of the group call to stop the playback whenever they see something they want to discuss. We often benefit from replaying the video multiple times. In many cases, we do not approach the data with pre-conceived categories of interest. Rather, the goal of the group work is to progressively deepen our understanding of the participants' activities and to challenge the biases of individual analysts. There is a constant effort to ground assertions in the evidence of the video episode, and to limit proposed hypotheses to those for which the video episode (or others like it) could provide confirming or disconfirming evidence. The resulting discussion is often a lively, multidimensional conversation reflecting the diverse interests of the participants as well as the focal interest of the project.

Observational methodology

The challenge presented by our theoretical perspective is to identify the ways that LAs frame their teaching and learning. No meter measures framing; instead, we infer people's sense of the nature of their activity primarily through their behavior, and secondarily through explicit statements in interviews. Participants' understanding of the nature of the activity in which they are engaged — i.e. their framing of the activity — guides their selective attention, provides cognitive structure for interpreting events, and manifests itself in their observable behavior.(Hammer et al., 2005) To the extent that framing is an interpretation based on previous experience, it is informed by an individual's broad history and experience with related events and systems. In the moment, though, participants mutually construct their sense of shared activity by means of verbal and nonverbal interactions, including linguistic signals, prosodic features, and body language (Bateson, 1972).

When we analyze LAs' teaching and learning behaviors, we use evidence such as how much they talk, the types of questions they ask, the conversational pace, their body positioning, gestures, and register (word choice, syntax, pitch, etc.), to infer how they are framing the situation. We look for additional support for these analyses from the ways LAs reflect on their teaching and learning in interviews. While we use LAs' stated beliefs to corroborate our ideas about how they frame, we are careful not to assume that these beliefs will necessarily match their actions. We also do not attribute framing solely to the LA: negotiations with students either support or undermine the instructor's sense of what's going on, so that together they construct a shared framing of the activity. (This is not to say that participants always have the same framing: mismatched framing is common, and can lead to humor or conflict depending on whether the participants recognize that they are framing in different ways (Goffman, 1986).)

Findings

The main goal of our present work is to illustrate the fruitfulness of our theoretical and philosophical perspective rather than to demonstrate empirical results. That said, preliminary observations of the LAs' experiences with our professional development program include:

- LAs initially find it very difficult to ask questions to learn about another person's thinking. Their urge to guide them to a particular conclusion is so strong as to almost preclude thoughtful listening.
- LAs grow to understand the superficiality of questioning about vocabulary and trusting in answers in which proper vocabulary conceals the quality of understanding.
- LAs learn that people do not necessarily say what they really think, even if they are not trying to deceive.
- LAs come to recognize that the complexity of a real person's thinking is much greater than is indicated in summaries of research about tendencies in student thought.
- LAs learn that people who have no formal education in physics often have some surprisingly productive intuitions.
- LAs find that people can make a surprising amount of intellectual progress simply by having the opportunity to reason things out.
- LAs find the PIP valuable for relating to people in general, because of the practice with listening for understanding without imposing your own point of view.

The PIP seems to us to be extremely promising for transformative professional development. We look forward to learning more about the details of what happens in the interviews that the LAs conduct, and to better understand how the experience is meaningful to the LAs.

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