Beyond "Repeating the Textbook" and "Problem Solving": Teacher Candidates Talk about Learning to Teach Physics

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Abstract: The way that science teachers learn to teach is profoundly influenced by the effects of what Lortie (1975) called the "apprenticeship of observation." Teacher candidates' long experiences as students in schools serve as a powerful acculturation into a dominant culture of teaching and learning. Science teacher candidates come to pre-service teacher education program with a default set of ideas about what science teaching and learning look and feel like. This paper is an in-depth study of how physics teacher candidates' visions of teaching physics develops over the course of a B.Ed. program with a particular emphasis on how they construct professional knowledge during field experiences and in the context of a physics curriculum methods course. The results indicate that the practicum, a familiar and often unquestioned feature of teacher education, tends to encourage candidates to adopt conservative views of education. Attention to student-centred, active-learning pedagogy in a methods course, however, has the potential to disrupt many assumptions about teaching and learning. This paper considers the notion that coursework need not be perceived by teacher candidates as irrelevant to their development as teachers. A coherent pedagogy of teacher education can help candidates to reframe their understandings of how to teach.

Theoretical Framework

Teachers' professional knowledge is often framed in terms of the tensions between propositional and experiential ways of knowing (Munby, Russell, and Martin, 2001). Although teacher candidates can and do learn from propositions, this paper focuses on describing and interpreting how science teacher candidates construct professional knowledge from group discussions of their personal experiences of teaching and learning. Before physics teacher candidates can reframe their conceptions of teaching and learning based on experiences, however, they first must be given an opportunity to describe and interpret their prior assumptions about teaching and learning physics.

Lising and Elby (2005) demonstrated a causal relationship between science students' epistemology and their learning behaviours. To account for the gap between students' theoretical reasoning and their everyday reasoning, they posited the existence of an "epistemological barrier" (p. 372) between formal knowledge and everyday knowledge. This paper extends the idea of the epistemological barrier to science teacher education by arguing that science teacher candidates have significant prior assumptions about the nature of science, learning science, and teaching science. Many of these assumptions come from prior acculturation experiences as learners in primary, secondary, and tertiary education in a lengthy "apprenticeship of observation" (Lortie, 1975, p. 62). New science teachers have been exposed to decades of teaching behaviours from their science teachers; the net result is that they come into teacher education programs with a well-developed (if tacit) idea about what science teaching should look and feel like. Such assumptions could result in an epistemological barrier of learning to teach. Thus, in addition to the tension between propositional and experiential ways of knowing, there are often tensions between individuals' personal epistemologies.

This research explores the more nuanced relationship between theory and practice suggested by Loughran (2006) by interpreting the “swampy lowlands” of teaching within the “high ground” of the academy in a physics curriculum course (Schön, 1983). Participants in the research had the opportunity to confront their prior assumptions about the process of learning to teach physics both in focus groups and in individual follow-up interviews. Participants were also encouraged to discuss the ways that teaching and learning experiences in their B.Ed. program supported or challenged these prior assumptions, and the ways in which their ideas about teaching physics were shaped by experiences in their methods course and during their practicum placements. According to Mezirow (1991), transformative learning is a process through which learners move beyond the acquisition of content knowledge to reframe their prior assumptions and change their conceptual understanding of an experience. This research pays special attention to any data indicating that a participant’s experiences were transformative.

Methodology and Research Questions

This paper reports on some of the data from an in-depth study of how physics teacher candidates’ visions of teaching physics develop over the course of a B.Ed. program (Bullock, 2009). Two of the research questions that guided the study were:

1. How do physics teacher candidates construct professional knowledge from teaching experiences during their practicum placements?
2. How do physics teacher candidates construct professional knowledge from learning experiences in a physics curriculum course?

The overall study combined methods from the qualitative research traditions of ethnography and self-study, two traditions that pay particular attention to the role of experience in constructing “culturally constituted understandings of the social world” (Holland & Quinn, 1987, p. 3). In particular, I attended each meeting of the physics methods course as a participant-observer and I conducted both focus group interviews and semi-structured personal interviews with a subset of volunteers from the course.

Five teacher candidates enrolled in the physics methods course volunteered to participate in the research; their identities are known only to one another and to the author. Four focus group interviews with the participating teacher candidates occurred during each of the on-campus blocks (September 2007, November 2007, January 2008, and April 2008). Each focus group lasted for approximately 90 minutes. Following each focus group interview, I conducted follow-up individual interviews with each participant as a way to revisit themes that came out during the focus group interviews and to give participants an opportunity to provide additional thoughts about the process of learning to teach. The follow-up interviews lasted between 20 and 60 minutes, depending on the nature and extent of the participants’ responses. Each of the five teacher candidates participated in four focus group interviews and four individual follow-up interviews. Thus, 24 interviews were conducted with teacher candidates over an 8-month period, and I was solely responsible for interviewing the participants. The data analysis reveals that the process of participating in this series of interviews added a unique element to participants’ experiences of their preservice program.

This paper considers only the data obtained from focus group interviews. The data were organized and coded using ATLAS.ti qualitative data analysis software (Muhr, 2008) with a view to exploring the contexts in which physics teacher candidates construct and refine professional knowledge both as learners and as beginning teachers. The issues and patterns in the data resulted from both inductive and deductive analysis: inductive in the sense that they arose from the data as I read, deductive in the sense that they were often named based on literature that I have reviewed in the past (Patton, 2002).

The multiple interactions that occur between teacher educators, teacher candidates, and associate teachers during teacher education programs constitute a text with multiple levels of interpretation (Segall, 2002). The interpretation of a particular text of teacher education depends on the researcher who reads the text. In this case, the term *text* is not limited to words on a page. A text of teacher education includes all the experiences and interactions reported on and interpreted by the person who constructs the text. Thus, an objective text is not waiting to be revealed; rather, the official text that I constructed as I analyzed the data incorporated my prior experiences as a teacher candidate, a physics teacher, and a science teacher educator. These experiences provided “reading positions” (Segall, 2002, p. 8) from which I interpreted my data and framed new understandings of how physics teacher candidates learn to teach.

Early Ideas about Teaching and Learning Physics

The first focus group provided a chance for the participants to get to know one another in a different context than the physics class. Although the first question asked participants to consider the ways in which learning experiences in recent physics classes contributed to the development of their knowledge about teaching, the group quickly steered the conversation in a different direction. The teacher candidates were more interested in discussing their prior experiences of learning physics, both in high school and in university.

The picture of teaching and learning physics painted by the teacher candidates was not surprising. As one participant stated, “I thought coming into this program that there was really only one way to teach: You get up and you talk to your students.” The metaphor of teaching as talking is overwhelmingly represented in the data, even though candidates did acknowledge that “you might do labs here and there, and give tests and assignments.” High school physics was characterized as “mostly driven by curriculum content; writing and taking notes and working problems.” One participant went so far as to suggest that “if you repeat the textbook, but do it really well, it can be effective” and characterized the difference between high school physics and university physics as a “well-recited textbook” versus a “not well-recited textbook.” He acknowledged that his reason for becoming a teacher was an overwhelming sense of “I can do that . . . repeating the textbook in a better way.”

Although the language that participants used to describe their prior experiences learning physics might be a source of dismay for many science teacher educators, the teacher candidates were quick to point out that they were engaged by the teacher-centred approaches used in physics classrooms. One participant provoked approving laughter with this comment:

> When I think back on physics, I really dug physics, and when I think back to the physics I did, I think the physics I liked the best was when the prof just wrote on the board for an hour . . . that’s where I learned the most, just watching these really complicated proofs.

It was clear from the reactions of the other members of the group that the participant had named a common experience. One of the other group members built on the idea by commenting that “I was so happy when I got to school and the prof would just lecture, and I could write it and read it on my own time one day.”

One of the shared understandings that developed during the discussion was the idea that the participants were unique because they were able to learn physics regardless of the way it was taught. A representative comment from the group was “I could pick up a textbook and read it and pass the class if the teacher didn’t teach anything. I’d remember most of the concepts.” Some of the participants stated that they spent considerable amounts of personal time thinking about physics concepts beyond the classroom because they “were so interested” in the concepts. Each of the participants reported that they realized early on in their physics education that “you don’t have to remember the equations because you can derive them.”

After a considerable amount of discussion that confirmed that participants had the same lecture-oriented, self-directed approach to learning physics, the group turned its attention to theorizing about the experiences of less successful peers in earlier physics classes. One participant stated, “My sense is that someone who has gone on to study physics probably gets it and probably enjoys it. Those people who decide to be teachers are again probably those people who ‘get’ that way of teaching.” Another participant lamented that most of his peers “were caught just learning the steps [to solve physics problems]; they memorized the formulas and they had no idea what the letters in any of the formulas meant.” The group felt that they were in the “20%” that could learn a certain amount of physics from lectures and textbook-based instruction. At the same time, they recognized that their responsibility as teachers was to find ways to engage the other “80% of students” that would not be able to learn physics in the same way that they did. Participants did not want to abandon the majority of students to “just memorizing formulas” in hope of finding the right answer to a physics problem.

The teacher candidates who participated in the research were eager to reconcile their prior assumptions about teaching and learning physics with some of the “new” ideas they perceived from coursework at the Faculty. Early in the first focus group, a participant lamented that people seeking qualifications as physics teachers were “predisposed to transmission.” Participants recognized that they could learn by listening and that they had sufficient background interest in the topic to ponder concepts and problems on their own time. They also recognized that their approach to learning physics was somewhat unique and that they would need to account for students who did not learn in the same ways that they did. Even early in the teacher education program, physics teacher candidates realized that their prior assumptions about teaching and learning physics were not going to provide enough guidance in their careers as teachers. Teaching was clearly something more than “repeating the textbook in a better way” and the physics methods course was surely more than “polishing that ability [to repeat the textbook].” At this early stage in the research, however, the participants were unable to articulate alternate approaches to teaching beyond a general sense that students should focus on learning concepts rather than memorizing problem-solving algorithms. The end result was an overall willingness to consider the ideas being offered in the physics methods course, as well as a fear of “messing up” students’ knowledge when they went out on practicum.

Significant Learning Experiences from the Practicum and the Methods Course

During the second and third focus groups, the participants moved from theorizing about how they learned physics to discussing their perceptions of students’ learning physics during their practicum and their own learning in the physics methods course. Although they had confronted the shortcomings of teacher-centred, lecture-based instruction and resolved to find ways to reach the other "80%" of students (those who did not learn physics well via transmission-based instruction) during their first practicum, participants reported that during their first placements they tended to teach as they had been taught. The result was that the candidates returned to their coursework feeling as though they were not able to enact their visions of teaching and learning.

The second focus group, in particular, was characterized by statements of frustration about the nature of teaching and learning in schools and the particular challenges that the candidates encountered during their first practicum. When asked how recent practicum experiences had helped them learn to teach, the focus group participants immediately began discussing some pragmatic issues that they encountered. For example, the group spoke at length about the challenges of using "board work" in their classrooms. Some candidates commented that students were unsure of when to copy things down from the board, and one candidate commented that he grew weary of being asked "Do I have to write this down?" by his students. Another thread of the conversation found participants reacting with shock to their perceptions of "an active resistance to learning" in many classrooms. Nearly all of the participants commented that students seemed more interested in getting the right answer than in understanding a concept. As one participant stated, "At the end it comes down to 'What's the answer? What do I put on my sheet?'" The participants bonded around many common concerns that teachers have, such as the difficulty of asking meaningful questions during class time, and the seemingly endless marking they were required to do.

One of the most telling moments in the focus group came when participants were asked to compare their experiences of learning to teach in the host school environment with their experiences of learning to teach in the physics methods course. As a group, the participants labelled the methods course environment as one that facilitated "active, student-centred" approaches to learning. A participant introduced what would become an important metaphor for the group in the following response:

> I think that the things we learn here [at the Faculty] . . . once you've figured out *the basic ideas* of teaching you'll want to incorporate all of these things in your teaching. But at school, you're learning those *basic ideas* of how to get your class to pay attention and make them learn the thing you're trying to teach. (Emphasis added)

The other participants picked up on the metaphor of *basic ideas* for teaching, believing that they had to "master the basics" before moving on to the pedagogies advocated in their physics methods course. One person stated, "I don't feel like I am ready to try a lot of things they [instructors in the B.Ed. program] mentioned would be good." Another participant commented that "because we [teacher candidates] spend so much time getting ready for the next day, we don't have time to go through a manual; we have to teach the next day." There was a sense that it was difficult to do anything other than "the basics" of teaching, which was characterized by one participant as "writing on the blackboard kind of teaching," because many associates wanted their classes to be taught in a particular way. Participants in the study felt like they were doing the ideas they had learned in their physics methods course an injustice by focusing on mastering the basics. By the end of the third focus group, the participants expressed serious reservations about their abilities to do anything creative during their placements because, ultimately, their associate teachers were responsible for the class. Three out of the five participants expressed serious reservations about going on the final, 2-month practicum. One participant went so far as to label the practicum an "artificial" learning situation.

One consistent theme in the data is the high regard that the teacher candidates had for the pedagogy being used by their physics methods professor. The course began with two Predict-Observe-Explain experiences (Baird & Northfield, 1992) that set the tone for much of the rest of the course. During the first two focus group interviews, the participants were more concerned with issues that were relevant to the practicum than with issues regarding what was occurring in the physics methods course. Although they expressed uniform approval of the methods course, they were largely unable to articulate what or how they were learning during the methods course beyond that they appreciated the effort that the professor made to get to know the class. For the first half of the year, they seemed content to trust the direction that the class was going based on the mutual trust between the professor and the candidates. As one candidate put it, "After the first two blocks [of on-campus classes] I liked the course and I thought 'This is going well . . . but I can't really think of anything I've learned in that class."

In sharp contrast to the previous two focus group interviews, the third focus group focused almost exclusively on teaching and learning experiences in the physics methods course. The third focus group occurred in mid-January, at the halfway point in the program in the middle of the longest stretch of on-campus classes before the candidates returned to an extended practicum in February and March. Rather than talk about their learning experiences during practicum placements, the teacher candidates were interested in theorizing about why they were being taught in particular ways in their physics methods course. The interview began with the following comments:

> One big thing I've noticed this time—well, it's not like I didn't notice it before but—how Tom [the professor] really cares about what we think about his class and the education program in general. And it just goes back to that whole idea about good teachers really care about their students.

Another candidate suggested that the "genuine concern" that Tom showed for the quality of candidates' learning "modelled" what he hoped they would do with students during practicum placement. Participants in the research were quick to link Tom's positive relationship with the class with the main pedagogical approach that he used in January: providing time for candidates to engage in self-directed learning activities of their choice. As one participant pointed out, "In terms of physics content I could be reviewing it and Tom could be dragging us all through it, but instead I think what we are learning is 'looking at physics means looking at the teaching aspect.'"

Participants in the research indicated unanimous support for Tom's approach to self-directed learning. One candidate quipped that open-ended learning often means "choose one of the three articles to read" but that Tom had taken it to new levels by providing class time "to do whatever we want . . . I can't think of any restrictions he's placed on us at all." The in-class time to work on self-directed learning was designed to, according to one participant, "foster the desire to do something meaningful and substantial for ourselves."

After the initial comments were made linking the opportunity for self-directed learning and the overall pedagogical approach used by the professor, many of the participants began to name features of their learning in the physics methods course. Tom excelled at "taking what we [candidates] want to look at and what we want to learn and incorporating that [into class]." He gave participants the sense of "throwing ideas out, many things during a class" and although “everyone isn’t going to pick up on exactly what he’s doing each time . . . if you pick up on a good idea you can run with it.”

The participants believed that Tom worked hard to avoid “telling” them what to believe about teaching, so much so that one person wished “he would offer his point of view a bit more.” One person named Tom’s tendency to avoid giving right answers a key feature of the experience in the methods course:

> The atmosphere seems really to be one of peers, as opposed to mostly peers and one instructor. It just seems like he’s facilitating . . . . I mean, you can act like a peer all you want but if you’re still in the end saying, “This is what you’re going to do” then it sort of defeats the purpose. So he’s walking the walk and talking the talk for everyone.

This comment sparked a lengthy discussion about the reason that Tom preferred to model pedagogy rather than tell candidates what they should be doing in the schools. Even though a few of the participants wished that Tom would provide a “stronger opinion” about teaching physics, one participant was adamant that Tom’s opinion “is that he could do that [tell candidates how to teach] and that it wouldn’t do anything.” After several comments back and forth about the challenges of articulating what they learned from physics course, the following exchange occurred:

> *Participant 1*: I feel like what Tom’s doing is pretty subtle . . . I find that it’s just like he is really doing what he wants to do and that is what he’s teaching . . . the way that he’s teaching is just doing it.
>
> *Participants 2 & 3*: Yes.
>
> *Participant 1*: As opposed to saying “This is what I’m doing” and “Now I’m going to do this and watch.”
>
> *Participant 4*: So the way we teach is the method?
>
> *Participant 1*: Yes. He actually does that, you know? It’s shocking but he does.

The teacher candidates who participated in this research had, by this point, reached the conclusion that *how* Tom taught them about teaching physics was more important than *what* he taught. This conclusion had profound implications for how the candidates reframed their ideas about teaching and learning physics.

Reframed Ideas about Teaching and Learning Physics

We convened as a group for a final time in late April, after a final 2-month practicum and all but one of the methods classes in the final month of the program. The participants were a much closer group then they were at the beginning of the research, and the mood of the final focus group interview was quite positive. In stark contrast to the first focus group, where participants worked to find common ground by commiserating on past learning experiences in secondary and tertiary physics classrooms, the final focus group featured lengthy discussions about the new ideas about teaching and learning candidates had developed as a result of learning experiences in the physics methods course.

Participants used the term *active learning* to label the pedagogical approach used by Tom in the methods course. They frequently contrasted *active learning* with *traditional learning*, which they associated with their early metaphors of “repeating the textbook” and transmission-based instruction. The labels emerged as a result of the group discussions and should not be confused with other definitions found in the research. For example, the participants had high praise for a recent class in which all of the candidates in the methods course collaboratively created a concept map of “big ideas for teaching physics.” Again, the participants felt that *how* Tom taught the “review class” was the message. They made comments such as “It’s the sort of thing [making a concept map] that I’ve heard of . . . but I hadn’t had the opportunity to try it” and “Because we’ve done it in physics class, it’s given me a push to try it when I get out there [in the teaching profession].” One candidate seemed to sum up the general feeling of the group by stating that “Tom’s already done all of the big things, no one is going to accomplish anything new in April . . . [but he provided an experience] so we’ll remember some of those things in a couple of months.”

Each of the participants then took turns offering their opinions about how learning experiences in the physics course and, to a lesser extent, the entire teacher education program had challenged them to reframe their views about teaching and learning. As one person said, “My perceptions of teaching now are totally different than they were in September.” The following is a sample of comments, from all five participants, during an extended dialogue about what was learned by attending to and interpreting the way the physics class was taught:

> *Participant 1*: Tom modelled what he thought was good teaching . . . it’s OK to be calm as a teacher . . . everything we’ve done in physics class is about how to be a good teacher.
>
> *Participant 2*: The big thing about physics class for me is that we’re encouraged to focus on the big picture.
>
> *Participant 3*: Physics class is less about the content, the assumption is that you know it, or that you know enough to know what you don’t know and you can figure it out over the summer . . . [instead] let’s focus on big ideas.
>
> *Participant 4* (in reference to an in-class activity): A defining moment [in physics class] was planning our first day and week [for the beginning of a teaching career]. I was thinking about how I can actually do all of these things!
>
> *Participant 5* (in reference to the same activity): Everything that we did in physics class, I thought, well I am going to do this, this, and this in my first week!

The representative comments listed above are much different from the initial metaphors used by the candidates to talk about teaching and learning physics. Instead of focusing on how to transmit information in an engaging way, the teacher candidates who participated in this study moved beyond a discussion of content toward big picture issues in teaching and learning. Encouraged by their professor’s focus on the importance of building relationships and his reluctance to “tell” them how to teach, the participants instead focused on how they could incorporate “active-learning” approaches in their future classrooms. The excitement surrounding the activity that required candidates to develop an “action plan” for the first week of school was, in part, due to a shared realization that they could name what they had learned from experiences. For example, the participants unanimously wanted to use Predict-Observe-Explain pedagogy on the first day of school to set a similar tone to what Tom created at the beginning of the year in the methods course. There was very little mention of physics content, rather, candidates chose to theorize about how they would establish productive relationships with their students and find ways to avoid lecturing wherever possible. At the same time, however, the candidates realized that the first few years of teaching would be stressful and that they would likely fall back on “default” methods of instruction. Here again, they drew inspiration from Tom: “He finally said, ‘Your first year, you're just trying to survive. Don't feel the pressure to try all of the stuff that you think is useful, in time you will have the opportunity to try everything.'" Participants in the study had developed a wider notion of the teaching and learning possibilities in a physics classroom.

Conclusions

One important finding from the data is that the participants unanimously agreed that they became better physics teachers as a result of completing a teacher education program. This finding is significant given that teacher education programs are often heavily criticized for having little impact on teacher candidates' development (e.g., Levine, 2006). One participant stated that he felt as though he "got a leg up because now I have some specific goals to think about that have given me real ways to think about, real ways to critically analyze what it is I'm doing [in the classroom]." Participants felt like they were "treading water" through the extended time on practicum, with little time to think about the bigger issues in teaching and learning. Another participant reported that despite some of his frustration with certain aspects of the program, looking back he believes that the B.Ed. program "really changed the way I feel about teaching and it also hammered home the importance of reflection and professional development. And I don't think I would have understood the importance of those two concepts if I didn't go to a Faculty of Education."

The data also indicate that teacher candidates experienced major changes in the way they understand teaching and learning as a result of pedagogies they experienced in the physics methods course. One participant reported that for him "teaching has become not giving answers and hoping they'll [students] think about it . . . .teaching is teaching kids how to learn." The physics methods course encouraged the candidates to think about different approaches to teaching:

> When I came to the program I thought there was pretty much just one way to teach. I didn't really realize teaching was so complex and there's so many different ways to teach, and you can't really— There is no "right way" to teach. You've really got to go in there and find out what your class is like. Find out what their interests are, what their strengths are, and you've got to kind of tailor your lessons and your assignments and things like that to meet the needs of your students.

As the participant indicates, coursework at a Faculty of Education need not be perceived by teacher candidates as irrelevant to their development as teachers. Powerful pedagogies of teacher education can help candidates to reframe their understandings of how to teach and how to think about their development as teachers. The comments made by participants toward the end of the B.Ed. program were a long way from their earlier characterization of physics teaching as "repeating the textbook in an engaging way" or "solving problems on the board so students can do practice problems."

The data also indicate that practicum experiences, which are almost universally lauded by candidates as the most significant part of a teacher education program (LeCornu & Ewing, 2008), often tend to reinforce traditional assumptions about the way science should be taught. Participants saw the practicum as a place to "practise basic teaching skills" before moving on to using "discovery, active-learning based strategies" if they had both the time and the permission of their associate teachers. One participant felt overwhelming pressure to lecture during each of her Grade 12 physics classes because of the expectations of her associate teacher. This pressure resulted in considerable internal conflict because she perceived that the Faculty of Education would not approve of how she taught on practicum. Another participant characterized his practicum as an “artificial” learning environment, even though he was given considerable freedom by his associate teacher.

Finally, the data indicate that the effects of the apprenticeship of observation have a powerful influence on what candidates expect from coursework and the practicum during a teacher education program. All five of the participants came to the B.Ed. program with the expectation that they would learn the most efficient ways to enact pedagogies they had witnessed during their lives as students. They were surprised to learn that there are alternatives to traditional pedagogy that they were encouraged to attempt during their practicum experiences and, to different extents, they appreciated and embraced the active-learning alternatives that were modelled in the physics methods course.

Zeichner and Tabachnik (1981) argued that the effects of teacher education programs are so insignificant that they are “washed out” by school experiences. The effects of teacher education are likely to remain invisible unless we make listening to teacher candidates an explicit focus of coursework throughout teacher education programs. This research suggests that experiences in a science methods course can have a significant impact on how physics teacher candidates think about teaching and learning.

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