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As Science Students Become Science Teachers: A Perspective on Learning Orientation

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Science teacher preparation needs to engage students in pedagogical praxis, i.e., in a reflexive way of thinking and acting intent on achieving learning outcomes. The paradox of such an endeavor is that "[students] cannot at first understand what [they need] to learn, can only learn it by educating [themselves], and can educate [themselves] only by beginning to do what [they do] not yet understand" (Schön, 1987, p. 93). This requires a dramatic shift in learning orientation for many science students. Undergraduate science instruction typically promotes a learning orientation that assumes something like the following--there are right answers; science has reliable problem-solving algorithms for yielding those answers; science learners need to master these algorithms. Unfortunately, this learning orientation has limited utility for learning to teach science in schools. In this article, we explore the structure of a teacher preparation program and how a preservice science teacher thinks about teaching and learning (what we call his learning orientation). In doing so, we point to the need for a research agenda focused on learning more about the interaction between the structure of teacher education programs and how novices think about learning to teach.

In arguing for the insufficiency of novice teachers' reliance on the familiar authorities of position (of professors and textbooks) and reason (in

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the arguments presented as justification for knowledge claims), Munby and Russell (1994) articulated a concept of the authority of experience:

> *In their many years of schooling preservice teachers have seen two basic concepts of authority at work: the authority of reason, and the authority of position . . . . Unfortunately, schools' preoccupation with the authority of reason and of position can cause teachers and students to ignore a type of authority lying at the heart of action and performance: the authority of experience. (p. 92)*

The knowledge-in-action of the competent professional (Schön, 1983) is rooted in the authority of experience. Novice teachers need to be able to interrogate their classroom experiences, in particular the responses of their students, in order to be able to learn from experience. Because knowledge-in-action is not reducible to a set of propositions, it does not rest on the authority of acknowledged experts or on the adequacy of rational argument, it resides instead in having the experience. Coursework in teacher education can unintentionally contribute to novice teachers' confusion about how to approach learning to teach. Some courses on the history of education, educational psychology, or school law, for instance, are presented in the familiar university mode which relies almost exclusively on the authority of position and reason. In methods courses and practice teaching, however, it is much more difficult to exclude the authority of experience. In a study of the ways in which student teachers make sense of teacher education experiences, Rodriguez (1993) pointed out the ineffectiveness of straightforward attempts to persuade novices to accept theoretical orientations not supported by their experience. He suggested that "teacher education programs may be inadvertently widening the gap between theory and practice from the students' point of view" (p. 221).

What all of this suggests is that, in teacher preparation programs, the novice has to shuttle back and forth between two learning orientations, without necessarily having the metacognitive awareness to decide when one or the other is more appropriate. "Education courses and field experiences offer distinct occasions for learning how to teach. They represent commitments to ways of knowing and coming to know--formal knowledge and first hand experience--that are typically not articulated and often compete with each other" (Feiman-Nemser, 1983, p. 154). There would appear to be, however, little research directed at understanding how teacher preparation programs might help student teachers come to grips with these different learning orientations.

The approach presented in this article draws heavily on one preservice

science teacher's reflections on his experience during teacher preparation. The point of the inquiry is to contribute to a conceptualization of learning orientations in beginning science teachers and of how these orientations interact with the structure of teacher education programs. The setting is one of collaboration between two science teacher educators--Art, who taught in this particular program, and Doug, who taught in a similar program at a different university and had the luxury of observing Art's teaching.

Background for the Inquiry

This inquiry grew out of a broader study of the physics education component of a program at the University of Western Ontario known as PEMSTEP (Physical Education, Mathematics, and Science Teacher Education Program). Among the many post-degree programs in the Canadian province of Ontario, PEMSTEP was unusual in that it provided an extended 16-week practicum experience in a single secondary school. Preservice teachers had an intensive two-week orientation in the Faculty of Education in late August to prepare them to begin their practicum on the first day of school. Following the practicum, they returned to campus for the final four months of professional coursework. The broader study focused on the 16 students who had elected physics as one of their two teaching subjects. Art Geddis was the instructor of the physics methods course which accounted for 25% of their coursework. Doug Roberts acted as an observer both of a variety of large and small group sessions during the orientation and of a number of physics methods classes throughout the year. Doug also conducted a variety of intensive interviews with two preservice teachers over the span of the entire academic year. It is the transcripts from the interviews with one of these teachers, Kevin, that we draw upon heavily for our inquiry. Kevin is quite open about what he learned in the practicum and how his on-campus coursework facilitated, augmented, or otherwise connected with what he learned in the schools.

The study was undertaken at a time of some dissatisfaction about PEMSTEP within the faculty. Some professors saw the program as elitist and found the students arrogant, opinionated, and less than willing to submit to instruction. They attributed these undesirable characteristics to the socialization of the 16-week practicum in which, it was asserted, students all too willingly accepted the norms and practices of schools as they presently exist. Many of the voices raised against the program were from professors who taught the foundation subjects--School and Society, Educational Psychology, and Educational Philosophy. These subjects were delivered in large lectures, supplemented in the case of School and Society by smaller

seminars of approximately 20 students, and were evaluated formally by examination, which in the case of Educational Psychology was totally multiple choice. In Educational Philosophy, students were also required to write one or more papers, while in School and Society, they wrote a major case study.

The upshot of this dissatisfaction was that PEMSTEP was to be severely restructured for the next year, shortening the length of the practicum to ten weeks by requiring students to spend five weeks on campus before going into the schools. This restructuring was being undertaken in spite of the objection of the PEMSTEP faculty members, the PEMSTEP students, and the cooperating teachers in the schools who had worked with the program. As a consequence, there emerged an extreme polarization of views within the faculty. Critics of PEMSTEP saw a need to protect preservice teachers from a narrow instrumental approach to education that they attributed to school personnel. They saw PEMSTEP as an apprenticeship model of teacher education in which preservice teachers learned techniques without questioning the broader aims and intentions of schooling. Supporters of PEMSTEP saw the extended practicum both as providing opportunities for developing the skills and techniques that beginning teachers needed to survive their first few years in the profession and as providing the experiences against which they could test the theoretical perspectives provided by their professional coursework.

This polarized situation cries out for a conceptualization of the learning orientations expected of the PEMSTEP students in their two different learning sites. That is, we think that a large part of the explanation for this familiar impasse in teacher education lies in the nature of the learning tasks we set for novices and how they approach those tasks. We also see some different views of the practice/theory relationships in the situation. These matters will be revisited later in this article. For now, let us listen to Kevin. The first section is based on his perceptions two weeks into the practicum. The second and third sections summarize his views of the practicum and its relationship to his coursework as he came to the end of the program.

Kevin
Keeping Respectable Physics on the Table

Kevin, like most of the students in PEMSTEP, had done graduate work in science. He holds a bachelor's degree in astronomy and a master's degree in physics. During graduate study, he worked as a laboratory demonstrator and as a guide for Saturday night public tours of the small astronomical observatory on campus. Perhaps as a consequence, he seemed confident that

teaching was something he would enjoy and do well. During the two-week orientation that preceded his practicum, Kevin was involved, but did not assume a leading role, in class sessions or in the students' organization of out-of-class activities. Kevin, Andrea, and Maureen were all assigned to Eastwood Secondary School for their 16-week practicum where they had the opportunity to work with a variety of cooperating teachers.

Early Days in the Practicum

Doug visited Eastwood Secondary School near the end of the second week of the practicum to get a sense of how Kevin was coping with his early practicum experiences. When he entered the science office, Kevin, Andrea, and Maureen were discussing classroom management. Doug's notes, which follow, provide a flavor of the tensions and anxieties faced by the beginning teachers.

> *Kevin was responding to Maureen's point that she was "having troubles" [with discipline], especially with the "bright ones." Kevin allowed that his trouble wasn't with the bright ones but with the others in the class. The trouble, I take it, is the tendency of kids to chat with one another while [the PEMSTEP preservice teachers] are trying to teach. Kevin told of telling his group, "I really would like it if you would pay attention, since this is really important material," or words to that effect. He expressed some consternation that his admonition was not very effective. Students were allowed to sit wherever they pleased, but Kevin didn't seem to connect this fact with the chatting and giggling.*
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> *What was most on [Kevin's] mind, though, was that the students in his class would not treat position as a vector. "They don't put on units; they don't use a vector sign." And he has told them "over and over" . . . . In an effort to suggest a reason for this thickheadedness on the part of his students, I asked Kevin if he recalled Art's discussion to the effect that a lot of physics is counter-intuitive. He recalled that but disagreed. I indicated that the students had no reason in their everyday world, or everyday language, to think of position as a vector (I gather they do okay with distance) and that it is only in the specialized realm of physics that such a construal is necessary. Kevin didn't respond one way or the other. If this constituted for him a reason for the behavior of the students, he did not give me any indication*

I asked how his students compared to Arnold's. (Arnold Kent was Kevin's cooperating teacher who taught a parallel physics class.) Kevin indicated that "[Arnold] allows more chatter than I do." Also, Kevin noted that Arnold didn't 'jump in' to correct students as quickly. He also said that Arnold's group is having trouble with position as a vector as well. (Frankly, I found myself wondering why that is such a big deal.)

At this point, I suggested that we wind up [our interview] to give him time to plan [for his next class]. Kevin's response was that "mechanics is etched into me, so that it isn't a big deal to plan for this afternoon's class." I asked if the textbook treatment was pretty much like he remembers mechanics. He said that he is more comfortable with a more advanced mathematical treatment--the calculus treatment. I then returned to [my earlier] point about this stuff being counter-intuitive, pressing the idea that there needs to be a reason to shift into the physics framework from the ordinary language one. I asked him if all of his students would be taking the OAC physics course, and he estimated about 12 or 13 out of 22 based on this year's enrollments of 40 in grade 12 and 18 in OAC.

(There are two sequential physics courses in the Ontario program. OAC is the second course, intended for university preparation. At the time of this interview, the first course was taken in grade 12, the second in grade 13. Kevin is predicting that about half of his students in grade 12 will take the second OAC course.) I then asked why those not going on to OAC should bother to learn the stuff. He replied that it was a required course for graduation. (??I'm at a bit of a loss on that since I'm out of touch with the graduation recruitments for Ontario schools. Kevin wasn't snarky or anything, just matter-of-fact. That's Kevin.)

Finally, I asked Kevin about what he had found the most and least useful/interesting/relevant from the two-week orientation that had proceeded the practicum. He responded (thoughtfully) that the systematic work on lesson planning was very helpful. On the other hand, some of Art's "philosophical stuff" was "not very practical."

In many ways, Doug's picture of Kevin after two weeks of practicum is not surprising. Kevin is concerned with the issue of getting and holding

students' attention. While he has found that exhorting students to pay attention is not very effective, he does not appear to be ready to engage in reflective inquiry into why students might be chatting in an effort to devise a strategy for holding their attention. Similarly, he sees the subject matter of physics as unproblematic--something that students have to learn. While he is aware that students are having difficulties coming to grips with position as a vector, both in his and Arnold's classes, he does not show any inclination to engage Doug's proposal that this might be rooted in the everyday preconceptions that students bring with them to the physics classroom. Finally, Kevin displays no inclination to reflect on the rationale for teaching this subject matter to those students in this context. The point is not that he dismisses the issue by claiming (incorrectly) that physics is a required course for graduation, but rather that in doing so, he displays a reluctance to see this as an issue about which he has some responsibility.

Kevin's identification of the most and least useful aspects of his two-week orientation can be seen as consistent with his reaction to problematic events related to classroom management, subject matter, and curriculum saliency. While lesson planning had been presented as a complex and problematic process that would unfold differently in different contexts, students had also been provided with a generic framework that they might employ where they found it useful. Kevin's perception, however, was that he had been provided with the equivalent of an algorithm for lesson planning and he proceeded to employ it rather directly. On the other hand, a central aspect of Art's program had been the introduction of constructivist perspectives on science learning and teaching using Osborne and Freyberg's (1985) *Learning in Science*. Apparently Kevin, as he stated, "disagreed" with this perspective and found it "not very practical." While Art saw the introduction of constructivist perspective on learning and teaching as an important part of his methods course, he had also attempted to locate these perspectives within a broader framework of perspectives. Students had read Scardamalia and Bereiter's (1989) "Conceptions of Teaching and Approaches to Core Problems," and Art had made an effort to use their four conceptions of teaching--cultural transmission, training of skills, fostering natural development, and promoting conceptual change--as lenses that could provide different perspectives on actual instances of teaching practice. What is of interest here is not just that Kevin "disagreed" with the constructivist perspective (Scardamalia & Bereiter, 1989), but that he conceptualized teaching in an essentialist way that precluded his using the four conceptions of teaching as lenses that might reveal something about the difficulties that students were experiencing with the vector nature of position. The fact that he "disagreed" with this perspective would appear to have constituted

sufficient reason to him for not employing it.

We should not be surprised at the lack of efficacy of PEMSTEP's two-week orientation. Given the short period of time and the novices' impatience to get on with the real task of learning to teach in the practicum, Kevin's unproblematic and essentialist views of subject matter and teaching are to be expected. In fact, Kevin's extensive subject matter preparation may itself be a contributing factor. Practicing physical scientists usually adopt a realist, if not naive realist, philosophy of science (Hacking, 1975), and the explication of the epistemological underpinnings of science are seldom addressed in undergraduate instruction. Consequently, science graduates, while they may have had considerable experience in solving subject matter problems, have likely had little experience in thinking about how they solve such problems or, even more broadly, how they think in their subject field. Like the proverbial fish who is unaware of the water, undergraduate science majors have little awareness of how they think or that there might be alternative ways of thinking. Such habits of mind are freely transferred to their thinking about the classroom where they focus on finding solutions in the same technical-rationalist manner in which they would go about solving their weekly set of physics problems. Unfortunately, precious few of the real world problems of the classroom yield to such strategies.

An argument can certainly be made that these habits of mind are, in fact, an artifact of undergraduate instruction where students confront not the real problems of the physicist but textbook problems for which not only are the answers, but also the preferred algorithmic solutions, preordained. Tobias (1990) provided an insightful look at undergraduate instruction in science.

Looking Back: Thoughts at the End of the Preservice Year

Doug's final interview with Kevin occurred in the last week of the program. Classes were speedily coming to an end, and most students' thoughts were on job hunting in a less than promising market. Kevin's thoughts about his teacher preparation year still focused, to a high degree, on the problematic issues that he had confronted in his practicum--classroom management, students' prior preparation, respectable physics, and his own preparedness to face the challenges of teaching high school.

Coming to grips with essential views of students and subject matter. Kevin had fairly clear views of both respectable physics and good students. In general, he was less than happy with the quality of many of the students he had encountered at Eastwood Secondary School and with the adequacy

of the physics being presented there. These views are succinctly expressed in his comments about the two grade 12 physics classes he taught.

Kevin: I had two different classes. I taught the one class for about five weeks, switched into the other one for three weeks, and then went back for a couple more weeks to the first class. The first one was a *really good class*, more bright people, outgoing people, a relatively polite class, and they were more willing to listen. They were willing to give responses and to talk to you about physics. They actually thought about physics. The third period class was dead in comparison. There were a couple of really bright people, but they weren't really willing to interact in the classroom, and the rest just didn't want to think during class. They just went there, took their notes, and sometimes studied at home, sometimes didn't. It was a completely different situation. It was a little bit disappointing. I figure that if you're taking 12A Physics, you're not just taking it for the credit, you are taking it for a reason, at least a little bit of interest. But it seemed like a lot of them were just doing it to get their diploma.

Doug: And that is really funny because in the Ontario scheme of things, these kids are really self-selected. I mean, they don't need that credit to graduate. It is totally optional for them. (This is an important point because of Kevin's apparent misunderstanding in the very first interview about the optional nature of physics as a subject. Now that he realizes that physics is optional, he appears even more at a loss to explain why some students are taking it.)

Kevin: I'm not sure why a lot of them took it. A lot of them were deficient in mathematics. It was frightening. Rearranging an equation with four or five terms in it was just impossible for some of them. Rearranging $V = d/t$ was even hard for a couple.

This dichotomization of students into prepared/unprepared, while understandable as a coping mechanism, left Kevin with nowhere to go. For Kevin, the ability to manipulate algebraic expressions was a prerequisite for solving physics problems, and it was hard to see what he was going to do with grade 12 students lacking these skills. Such a perspective would likely have been shared by undergraduate physics instructors with a strong focus on algorithmic problem solving and a relatively weak focus on conceptual understanding.

Interestingly enough, Kevin's memories of teaching general level grade 10 students did not display the same strong framing. General level courses

are offered in Ontario for students who are not university bound. While some of these students might go on to a community college, the majority of them will enter the work force after secondary school. Kilbourn and Roberts (1984) described an extended study of the complexities of teaching these students.

In talking about these less academic students, Kevin seemed to be able to adopt a more flexible stance.

Kevin: I had [the general level grade 10 students] for three weeks, right at the end of November. I taught them a unit on electricity and magnetism. It was a learning experience. It gave me an opportunity to interact with students who aren't all that motivated about science. They are not necessarily bad kids or terribly stupid, but a lot of them were just motivated about other things. [Having taught] the advanced classes until then, I just expected people to behave like I behaved [when I was a high school student], which just didn't happen. There were situations of people getting out of control that I handled [adequately], but looking back, I'd probably do things differently [now]. The things that I did controlled the situation, but they didn't promote cooperation. They weren't really a solution. One of the most important things that I learned was that rather than coming down on kids, you've got to get them going along with you. I had to get control because they would get out of hand once in a while. It was hard. I came in after they'd been in that class for three months, and their teachers are much more comfortable with a higher noise level than I am. The first period class during morning announcements [over the public address system], maybe two people were listening to the announcements, the rest were chattering. I can't handle that. But there was not a lot I could do about it after they had been allowed to do it for three months. I would have liked to have had them from the beginning [of the year]. They would have been more comfortable with me. They might have responded a little bit more favorably. I would usually go into a class and not have much time to think about what was happening until I got out of the class.

Doug: A pretty hectic pace in there.

Kevin: It was pretty, well, one step [immediately] to the next. Boom, boom, boom. Do it, do it, do it. I didn't often have time to sit and think, "Okay, what should I do next? and why?" I gather

that some teachers have the ability to do that, but they are very experienced.

Classroom management is a central task for the beginning teacher that engenders a great deal of tension and anxiety. With grade 10 generals, Kevin seems to have been able to modify some of his fairly restricted conceptions of learners and what constitutes legitimate motivations and behavior in the classroom. This is paired with an emerging understanding of the complexity of the ways in which teachers can influence students and of the unintended consequences that can emerge from classroom management strategies. At the same time, Kevin is acutely aware of the lack of authenticity in his practicum situation, and this allows him to attribute much of his management problems to the classroom context already established by his cooperating teacher. While such explanations certainly enable beginning teachers to cope, they do not engage them in the inquiry necessary for finding solutions to the problematic dynamics of the classroom.

Classroom management and the anxiety of being evaluated. Like most preservice teachers, Kevin had his share of war stories related to issues of classroom management. Often such stories can be a very formative influence on preservice teachers in that they establish behaviors that they are determined not to repeat. For Kevin, one of these critical incidents occurred with the class of grade 9 English as a Second Language (ESL) students to which he taught mathematics during the first two months of his practicum. He related:

There were a couple of kids in the grade 9 ESL that liked to push it. They were a struggle. You could get them under control for a while, and then they would be gone. Occasionally, I had to raise my voice or take them aside and just talk to them sternly. This one kid, whenever you did [admonish him], it was like he started to feel really hard done by, like "I'm not doing anything wrong here." There was one time where, as I looked back on it later, I thought, "I shouldn't have done that because I could get in a lot of trouble." He was teasing this girl rather unfairly about something--I don't know what it was. He was jabbing away at her so I said, "Stephen! Stephen, stop that please. Stephen!" But he was not paying any attention to me. Like I'm having no effect, and he is just verbal, verbal. This girl is defenseless, and he is not paying any attention to me. So I had this bunch of papers in my hand, and I just went "boom" over the top of his head. It was a number of pieces of paper

so it was like a good smack, and he is like "sorry." But when I went home, I thought "I could be in a lot of trouble." It was just a reflex reaction. I couldn't get the guy's attention, couldn't get him to do anything, so "boom." But he came back the next day, and he said, "Mr. Butler, I'd like to thank you for hitting me with the paper. I was not being nice to her."

Kevin's account of this incident clearly displays its emotional impact. While it is not possible to draw a direct link between his memory and his subsequent behavior, there is every expectation that such a powerful memory will influence his teaching behavior. At the same time, Kevin's account projects a concern that he has done something wrong and might be found out. No doubt, this is a consequence of the ambiguity of his position as a student teacher where, on the one hand, he is expected to teach the class on his own and yet is subject to evaluation of what he does.

Going it alone: Really learning to teach. As Britzman (1986, 1991) made clear, one of the dominant myths of teacher education is that "teachers are self-made." This view dominates the thinking of both practicing professionals and of novices like Kevin. PEMSTEP worked within and helped sustain this myth. Once preservice teachers had proven themselves capable of maintaining the instructional agenda, they were given substantial opportunity to go it alone. During the final three weeks of his practicum, Kevin designed, organized, and taught an electricity and magnetism unit for the two classes of grade 10 general level students. As there was no textbook for these students, Kevin had to work directly from the Ministry Guideline which provided topics, a rough time line, objectives, suggested activities, and a variety of resource books.

Kevin: I went from the Guideline, broke all of the objectives down into segments, made a time line, and designed a whole bunch of little activity sheets. It was very lab based. [There was] a little bit of lecturing, note-taking--a lot more than they liked. They really hated writing notes. I don't think I was doing it excessively, maybe 15 to 20 minutes average out of a 75 minute class. They complained a lot about that. The activities were good. They liked those for the most part. There was one activity where they were just constructing simple circuits, series and parallel, and some of them had a great time. They were seeing how many light bulbs they could string together [and still have the bulbs light] and how many batteries they would have to put together to

make them light or before they blew a light bulb. They were putting switches [in the circuit], going well beyond the activity, so I was really happy. They did things that were totally amazing. And then, two days later, total mood change. None of the other teachers who were regularly with that class could explain why this happened. Just boom. "Two days ago, you guys were so great what's the matter today?"

[The cooperating teachers] just turned me loose. They had enough confidence in me from the fact that I had been teaching for two months, and I was getting good reports from [my cooperating teachers]. They said, "Well, here are some reference books if you want them." They implied that their notes were available, but I didn't want to use them. I wanted to go from scratch and see what I could do. They observed the first few days. Actually, they observed the first day, and then for a couple of days, they were in the back room listening. After that, they said, "There is no problem here." And they went off and did their own thing.

Doug: Seventy-five minutes is a pretty long class. Did they have an activity each day?

Kevin: Pretty well. There was the occasional day when it just wasn't possible. I had to give them some reading assignment. There were quizzes fairly regularly, every couple of days. I wanted them to keep up. It was pretty much intensive. I marked all of the labs, all of the quizzes, until right near the end. I got tired of marking.

Doug: How did you get them through the theory?

Kevin: Basically, I dragged them through the theory. I didn't have any great insights into how to motivate them in that respect. Basically, they were writing it down in order to get the marks.

Doug: And they were tuned in enough to marks that they were willing to go along with what you were doing?

Kevin: Just enough. I mean there are the few that just don't care, and then there are those that get their marks by using other people's [work]. Those are the easy ones to spot because they are always doing nothing during the lab, but then they hand a [complete] lab in. I tried--but not too hard--to get their interest in the theoretical parts. Maybe with experience, I'll see more ways to. The Guideline is not [particularly] helpful. There are lots of books available with neat activities and demos and things which I plan to use when I get time. But I'd finish the [teaching] day at three

> o'clock and then go into the back room to start setting up the next day's lab. I'd look at all of the equipment that I had available, figure out what I needed, put it all together, and then I'd go home and type up the lab [sheet] on my computer. Then I'd come in [the next day], photocopy [the lab sheet], and go into class. That was my cycle. I can see that, after a couple of years, I'd have a lot more time to think about what I was doing because I would have all of this. I'd know the equipment; I'd know the labs. Then, I'd have a little bit of time to think about how I could vary it.

Although Kevin's learning to teach science subject matter doesn't make the subject matter itself problematic, we see a lot of attention to being sure the subject matter is mastered. For science teachers, this seems to be a prior condition to learning anything else about teaching.

With respect to more general matters about Kevin's experience, it is apparent that both he and his cooperating teachers hold a view of learning to teach that is highly individualistic. In many ways, Kevin's experiences in the final weeks of his practicum are commendable. In allowing him to go it alone, Kevin's cooperating teacher had provided him with an experience of what real teaching would be like. A strong argument can be made for the inclusion of such an experience in teacher preparation where there is a more accessible safety net than is typically the case in the first years of teaching. It would appear that Kevin was ready for the experience and learned from it. He worked hard to provide students with interesting learning activities which kept them engaged and which they appeared to enjoy. He experienced the dilemma of students needing to learn theory but not want to take notes and worked out one way of managing it while staying aware of the limitations of ". . . [dragging] them through the theory. . . . Basically, they were writing it down in order to get the marks." What would appear to be unfortunate is the lack of opportunity to talk with another teacher about what he was doing and why. Certainly, this problem is not unique to teacher preparation. The culture of schooling provides little encouragement for professional dialogue, nor are teachers noted for the ability to talk about the pedagogical expertise, much of their knowledge being tacit. The practicum would appear to be an ideal context within which to attempt to modify the excessively individualistic norms of professional culture. Given the design-like practice of pedagogy and the centrality of coaching, rather than didactic instruction, to learning such a practice, the explicit use of a variety of coaching strategies would appear to hold considerable promise. Schön's (1983) coaching models--follow me, joint experimentation, and hall of

mirrors provide three different examples of how the coaching might occur. Joint experimentation, in dialogue with the cooperating teacher, would appear to provide a particularly appropriate model for the kind of going it alone that Kevin experienced.

Thinking About Connections Between Coursework and Practicum

After his 16 weeks at Eastwood Secondary School, Kevin returned to the Faculty of Education for the final 16 weeks of professional coursework. This entailed three foundation courses (Educational Psychology, Educational Philosophy, and School and Society), two methods courses (Physics and Mathematics), and two electives. After attaining a certain degree of independence at Eastwood, Kevin found his re-entry into the Faculty less than satisfying.

> *It took me about two weeks to get really sick and tired of this place. I found a lot of what we were doing was utterly useless. I'd have rather been back [at Eastwood]. I fought it, resisted it. I was one of the first people in the class to get sick and tired of it, but eventually, everybody was sick and tired of it. I think I fought a lot harder than most. Grumbling and complaining, "This is a stupid exercise, why are we doing this?" However, eventually I decided to just do it. "You've got two more months, just do the work." And actually, after that point, I started to learn things. Now that I'm doing it, I'm not fighting any more, and I'm actually learning. A lot of it is useless. I don't see the point, but I am picking up more things. It might be that we are now starting to do some different subject material, and it is more useful than the stuff we did the first month or two.*

It is likely that attitudes of this sort from other students like Kevin are at the root of the reaction of many Faculty members to PEMSTEP students who they found arrogant, elitist, and contemptuous of what the Faculty had to offer. The demise of PEMSTEP, however, cannot really deal with this issue in more than a cosmetic manner. As numerous researchers have pointed out, teachers often perceive little relevance between their preservice coursework and professional practice (Lortie, 1975; Munby & Russell, 1994; Rodriguez, 1993; Smylie, 1989). By depriving preservice students of an extended meaningful experience of the very phenomena that their teacher preparation program is purporting to address, we do not prevent the

development of such dichotomous views of theory/practice but merely postpone their expression to later, at a time when education professors do not have to face them. At the same time, it is apparent that the view that an initial 16-week practicum will provide preservice teachers with the experience that will make their professional coursework more meaningful does not do justice to the complex interplay of coursework and practicum experience in learning to teach.

In discussing some of what he was beginning to find meaningful in his more recent coursework, Kevin referred to a demonstration devised by Leonard, another student in his physics methods class, in which Leonard had built a mock-up of a stud wall including a light switch, light, and electrical outlet. The class discussion that resulted about how this equipment could be used when adopting an "everyday coping emphasis" (Roberts, 1998) was very specifically connected to the immediacies of how electrical circuits might be taught but was also grounded in a critical examination of why students might learn this content, the role of schooling in perpetuating social inequality, and the inequalities of class, race, and gender. Now, the degree to which these broader issues will become part of Kevin's teaching is an open question; however, it was significant that he had raised them earlier in an interview when discussing his struggles to construct an electricity and magnetism unit for the general level grade 10 classes.

> *The scientific knowledge and understanding that is the [emphasis] that I immediately go to because I want those kids that are going to go beyond high school to be able to do it, but that's focusing mainly on the university types. And the reality is that the majority don't go to university. So for them, it would be much more useful to bring in societal implications and scientific literacy [of the everyday coping emphasis]. Just to be able to understand the decisions that are being made with regards to science and society. I think that is extremely important, so that's one [emphasis] that I would focus on. but I desperately want to do it without harming the learning that those university-bound students get in terms of their ability to do the science and to cover the curriculum.*

This issue of keeping legitimate physics on the table was a very central concern for Kevin. Roberts (1998) called this curriculum emphasis "solid foundation." As a result, in Art's methods course, he was often the one to point out errors in curriculum materials or in his fellow students' knowledge. At the same time, this concern made it difficult for Kevin to allow others to adopt perspectives of limited adequacy so as to work through a rationale for

moving on to more adequate perspectives. Kevin had commented earlier on his own tendency to jump in to correct students more quickly than his cooperating teacher. He also had some real anxiety about his fellow student teachers' grasp of fundamental physics concepts.

> *On Monday, George did a short demonstration on centripetal force, and both the discussion and the demonstration itself left me really worried. I thought, "These people don't really understand centripetal force. They don't understand circular motion and centripetal acceleration." Thankfully, Peter and Tom's seminar on Wednesday dealt very nicely with some of these problems. And by the end of it, I was thinking, "Hey, this class knows what it is doing now. At least a lot more than they did."*

It is quite possible that Kevin's very strong framing of legitimate physics was one of the factors that made it difficult for him to explore the usefulness of constructivist perspectives on teaching and learning. Given that few physics students are provided with philosophical or historical (not to mention sociological) perspectives on the nature of their discipline, Kevin's static and unproblematic view of physics knowledge is not surprising.

Kevin's major concern with his professional coursework centered on its theoretical rather than practical character. At the same time, he could see that there were severe limitations on what had been possible during the initial two-week orientation.

> *We were just antsy to get out. They didn't have time to give us a lot of really useful information. But we were also thinking, "They aren't trying to give us anything useful. They are just giving us a lot of theory which isn't going to--and I don't think a lot of it did--apply in the practicum." I think they should have spent more time dealing with the practical issue of classroom management and rules and regulations about teaching, what we are responsible for doing. They are doing that now in School and Society, but it would have been better to have it before we went into the schools so that we knew what our responsibilities were, so that we could avoid getting into trouble.*

While this dichotomization of theory and practice by preservice teachers has been well-documented (Rodriguez, 1993), it is not always clear what novices mean when they express a desire for coursework that is practical or useful. Kevin's comments might be interpreted as implying that what he was

looking for was something that was immediately and transparently useful. His conception of theory being applied in practice would appear to mirror the view of many in academe (including many of the severest critics of PEMSTEP) that somehow the application of theory is relatively straightforward and unproblematic. Likely, this teacher preparation year has been Kevin's first real opportunity to wrestle with the problems of employing theory in a practical endeavor and facing the inadequacies of the applied science view of practice. At the same time, his coursework has not provided him with much in the way of guidance for dealing with these problems. Although there had been an attempt in the physics methods course to employ Scardamalia and Bereiter's (1989) four conceptions of teaching in parallel with a developmental concept of learning to teach, it would appear that Kevin had had considerable difficulty in employing multiple perspectives to reveal and explore possible new avenues for action. Instead, his focus was on finding the definitive, almost algorithmic knowledge, about pedagogy, parallel to what he sees as his definitive subject matter knowledge, that would enable him to "avoid getting into trouble."

Kevin is not so much angry with his course instructors as he is perplexed.

> *The [methods] professors that we had, had a lot of experience teaching, and they did impart a lot of that, although not as much as we hoped they would. Occasionally, Art will come forward with something, some very specific thing that he has done, and that's great. But a lot of the time, he will talk very theoretically. The same with math class. Glen has had a lot of experience. He's got a lot of ideas, but the thing is, he wants us to come up with all of these ideas on our own, which is a fair tactic, but we are not coming up with as many as we could get out of the course, and they're not as refined as they cold be if he gave us a little bit more input about what he knows.*

Perhaps Kevin is simply expressing his frustration at finding teaching to be difficult. If this is the case, we should feel satisfied, for the awareness of the complexity of the enterprise is essential for a teacher to take his or her profession seriously; however, there is likely more to it than this.

Conclusions

Learning to teach is a complex process that has only begun to be understood. The issues that Kevin found to be problematic--classroom management, teaching proper subject matter, the shortcomings of students,

his own need to quickly correct student mistakes, finding connections between theory and practice--are familiar to most science teacher educators. Seen in terms of an algorithmic learning orientation possibly rooted in undergraduate science education, however, there are commonalities among issues. Kevin's essentialist views of subject matter link both his concern for presenting legitimate physics and his desire for fail-safe strategies to help avoid "getting into trouble." Such views of subject matter link readily to transmission views of teaching and, at the same time, contribute to anxiety about getting it right. Consequently, when telling is unsuccessful, in terms of classroom management and conceptual understanding, this experience is attributed to inadequacies in learner character and preparation. Interestingly, it is Kevin's experiences with the less academically inclined general level students that leads him to ameliorate some of the limitations of his learning orientation. As he works with the generals, he begins to see that "They are not necessarily bad kids or terribly stupid, but a lot of them were just motivated about other things." Similarly, commenting on Leonard's class presentation on the electricity of house wiring, he begins to see the utility of employing different curriculum emphases to accommodate the needs and interests of different learners; however, when it came to university-bound students, Kevin is still committed to transmitting what he saw as legitimate physics--the physics of a university physics major. Such a strong commitment leaves little room for consideration of learners as meaning makers or of subject matter transformations that might facilitate the development of learners' understandings (Geddis, 1993).

Kevin's experiences make it clear that the way in which practicum experiences and on-campus coursework is structured is an important factor in determining what novices take with them from teacher preparation. There are problems and limitations associated with learning in both arenas. A variety of researchers have focused on what Feiman-Nemser and Buchmann (1985) called the pitfalls of learning from experience in teachers education or on the conservative pressures of professional socialization in schools (Zeichner & Gore, 1990). Novices' experiences are constructed through the sets of preconceptions that they bring to professional preparation. Typically, these views of learning, teaching, and subject matter are limited (Aguirre, Haggerty, & Linder, 1990) and tend to restrict what can be learned. Less attention has been directed at the pitfalls of trying to learn a design practice, such as teaching, within the typical university structuring of lectures, seminars, term papers, and written examinations. Here, again, novices' preconceptions tend to limit what can be learned from instruction. As Grossman and Richert (1988) suggested, "theoretical discussions of student diversity, the multiplicity of capacities for learning in a diverse group of

students, may be premature for novice teachers who have not yet had classroom experience, and therefore, whose reference for student understanding is their own learning style" (p. 61). The key issue would appear to be how coursework and field experience together can most effectively challenge novices' preconceptions about learning, teaching, and subject matter for dealing with the complexities of professional practice.

Central to this endeavor is the need for explicit attention to perspectives on how theory informs practice in professional coursework. The inadequacies of the theory-independence of practice and applied science perspectives have been well-documented. Zeichner and Gore (1990), in their review of the teacher socialization literature, set out many of the inadequacies of the theory-independent view while Schön (1993) provided a compelling critique of the applied science view. Professional coursework needs to help novices see the manner in which particular theories provide limited, though often insightful, perspectives on practical situations (Schwab, 1978). It needs to actively engage novices in reflecting on past experiences and in engaging in new experiences with the potential to buttress the rational and traditional authority of instruction with their own authority of experience. Instruction that fails to engage novices' pedagogical experience runs the danger of being dismissed as irrelevant. At the same time, teacher preparation based narrowly in the authority of experience of novices runs the parallel risk of superficiality. Explicit attention to the complexities of how theory can inform experience not only can enrich novices' pedagogical repertoires but also can engage them in exploring the limitations of the preconceptions that they bring to teacher education.

Clearly, there is a need for more research into the learning orientations of novice science teachers and how they interact with coursework and field experiences in teacher education. In retrospect, the view that the 16-week PEMSTEP practicum would automatically provide preservice teachers with the experience necessary to make their coursework meaningful was an oversimplification. At the same time, Kevin's practicum, with all its limitations, provided an extended experience within which he began to challenge his initial ideas about students, teaching, and subject matter. What we need at this point is more research into the complexities of how coursework and field experiences interact in the preparation of novice teachers. In particular, we need to learn more about how coursework and field experiences together can function to help expand the algorithmic learning orientation of science students into the reflective learning orientation of the competent professional. Some exploratory beginnings to such a research agenda in the area of mathematics teacher education can be found in Geddis and Wood (1997) and Wood and Geddis (in press).

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