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MISCONCEPTIONS IN LEARNING TO TEACH SCIENCE: STUDENT TEACHERS' STORIES OF UNFULFILLED EXPECTATIONS

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ABSTRACT

This paper suggests that Hawkins' concept of "critical barriers" can be applied to the experiences of individuals learning to teach. Data are drawn from mid-year interviews and end-of-year personal stories by students in a physics method class in a post-degree preservice teacher education program. Student teachers' assumptions and expectations are seen as barriers to the intended learning processes of the preservice program. Seven barriers are identified and illustrated. These barriers may be particularly high for science, math and engineering graduates, whose undergraduate programs implicitly reject the value of personal voice and experience.

INTRODUCTION This paper reports and interprets data from end-of-year stories by students in the physics method course at Queen's University. This eight-month course spanning the entire B.Ed. program is one of two curriculum or "method" courses taken by students preparing to teach at the secondary level in Ontario. Most of those enrolled in physics are also enrolled in mathematics. Practice teaching assignments of two- and three-weeks duration are spaced at intervals through the program, beginning after five weeks of course work and ending with three final weeks of

on-campus course work. The proportion of B.Ed. students who come straight from university to pre-service teacher education has declined in recent years as our admissions criteria give increased weight to personal experience statements. Almost half of the students in physics/mathematics have engineering degrees and some have worked as engineers for several years before turning to teaching.

I have taught this course every year for the last 16 years, with the exception of two years when I was away on sabbatical leave. In my earliest years at Queen's, the course included students in all secondary science subjects; since 1988 it has been devoted solely to physics. In 1991-92 and again in 1992-93, I arranged with a physics teacher in Kingston to teach Grade 12 physics to one class (76 minutes daily) for a full semester (September through January); in return, he taught one of my twice-weekly two-hour method classes during the same period. The exchange was mutually beneficial and generated a positive working relationship that we hope to continue. The physics method students found it “interesting and unusual” that their methods professor was actively involved in teaching at the secondary-school level while he also taught them.

In the last two years I have required my students to prepare as the final assignment in the method course a paper that I describe as “the story of your year learning to teach.” Students are asked to keep journal entries and teaching records that will permit them to revisit the many different stages of their eight-month program to establish a synthesis to which they can return after one and two years of teaching to gauge their initial progress as teachers. They are also asked to prepare drafts of their stories before their final four weeks of practice teaching so that I can suggest additional themes and approaches to interpretation. Two basic features of my teaching seem to be consistent from year to year: (1) Some of the students report that I spend too much time encouraging reflection and too little time telling them exactly how to teach physics, and (2) almost all of the students speak very candidly to me about the course and program features that they like and dislike. While I have not succeeded to their satisfaction, or to my own, in convincing them of the importance of reflection as a strategy for learning from experience, I do

seem to have succeeded in gaining their trust that they will not be penalized for speaking critically about the B.Ed. program in which they are enrolled.

AUTHORITIES FOR LEARNING TO TEACH My dual teaching responsibilities in the high school and at the university have heightened and developed my continuing attention to the familiar teacher education tensions between “theory” at the university and “practice” in the schools. By teaching secondary physics as I teach others to teach secondary physics, my interest in and “feel” for the process of learning to teach has been heightened. Hugh Munby and I have recently argued from a related data base that the competing authorities of REASON (embodied in theory and research in university courses) and of POSITION (embodied in cooperating teachers who have many years of experience) will not be resolved successfully for those learning to teach until teacher education programs help new teachers to recognize and respond to a third authority, the contrasting authority of personal EXPERIENCE (Munby & Russell, 1993; Russell, 1993).

In suggesting that beginning teachers need to develop a personal perspective from their earliest teaching experiences, we follow Richert's (1992) comments about the importance of developing a sense of voice. We take this to include listening both to one's own ideas and experiences and also to reactions of students to one's teaching.

Listening to yourself as an authority on your own experience . . . is an important part of learning. In fact listening to your own words and attempted explanations is fundamental to reflective practice that results in learning to teach. While the power of speaking lies in part in the fact of being heard, being heard is not something that can be taken for granted in teaching. For one thing, being heard implies that someone is listening and there is no norm for listening to teachers within the professional community of schools. Beyond the norms of the profession, the demands on teachers' time preclude much reciprocal conversation among colleagues; teachers are too busy to listen to themselves let alone listen to one another. (p. 193)

By listening to people learning to teach in order to better understand how individuals learn to teach, we have concluded that beginning teachers are trained very well by school and other experiences to take very seriously the claims made about experienced teachers (who are in a position of authority by virtue of extensive experience) and (b) by those who teach their preservice courses (who can speak with the authority of reason familiar to all university students). Yet in their first year of teaching, new teachers will be “on their own” most of the time, in the classroom with one or more groups of students. We believe that two essential points can be addressed by urging new teachers to listen also to their own personal reactions to their teaching and to the reactions of their students. (1) Casting learning to teach as a process involving listening to educational arguments, to the experiences of those who have taught for significant periods, and also to their own personal experiences, may reduce the long-standing tension between schools and universities that often leads new teachers to feel forced to choose between “theory” and the wisdom of “practice.” (2) Learning to listen to self and students may be of great value to teachers in their earliest years of experience, reducing the tendency to interpret the preservice program as inadequate preparation because the first year of teaching was so overwhelming.

It seems clear, in hindsight, that my daily attention to my own voice and to the unexpected reactions of students, captured in journal entries about each day's Grade 12 physics class, helped me to recognize a feature of learning to teach that may help beginning teachers reduce the initial and predictable tension between what is recommended in university courses and what is asserted in schools as the best strategies based on years of experience. In 1992-93 I became aware of an additional feature that I had not considered carefully in previous years: it seems possible that those who enter preservice teacher education programs have predispositions that work against the features we would like to develop in teacher education. Others have reached similar conclusions; Holt-Reynolds (1991) has written about preservice teachers' initial assumptions:

Preservice teachers are not internally silent, waiting on professional points of view to “tell” them what to believe and

how to act as teachers. They are vibrant, active, meaning-making thinkers with a long-standing conversation about “teaching” already in progress when we first meet them. Our assumption that they will come to their professional study of teaching eager to adopt our points of view about classrooms, ready to question their past experiences, and able to reinterpret those experiences has not proved to be true. Preservice teachers' assumptions that their study of teaching will be a series of courses where they learn how to be interesting, caring, interactive adults have not been true either.

Hawkins' (1978) phrase “critical barriers” seemed particularly relevant; it captures my sense that preservice teacher education candidates will not have a positive and constructive stance toward their program until they overcome such barriers. In the main body of this paper, I identify and illustrate stances that appear to act as significant barriers to learning to teach.

BARRIERS TO LEARNING TO TEACH Following Hawkins (1978) and the language of student misconceptions in learning science, I offer the following as misconceptions about learning to teach that are displayed in varying degrees by those who enter a post-degree program of preservice teacher education. I believe that these conceptions are soundly rooted in commonsense knowledge and previous experience. Because the study of sciences and mathematics traditionally gives little attention to the “subjective, personal voice,” those learning to teach science may be particularly predisposed to regarding the reactions of self and students to their earliest teaching experiences as lacking authority in the process of learning to teach.

I am increasingly convinced that these “barriers” to the recognition of the authority of personal experience must be overcome if those learning to teach are to look back on their preservice program with any sense of satisfaction and comprehension of the type of learning that occurred during the program. I see these barriers as ones that restrict our best efforts to develop issues associated with students' misconceptions about concepts in mathematics and science. I also believe that it is virtually impossible to address these misconceptions in productive ways before the first practice teaching assignment or, at any time, by “direct telling.” Rather, these barriers

become "frames to listen for," to address with individuals as they express particular issues in journals or written assignments and to address collectively when most members of a class seem ready to explore one or more barriers at the experiential level as well as in speech.

BARRIER 1: Teaching can be told

“I expect to be told how to teach. I take it for granted that it is possible for those who have teaching experience to convey that experience to me in ways that I will comprehend fully and be able to express in my actions when I begin to teach.”

BARRIER 2: Learning to teach is passive

“Learning to teach is just like all my previous learning in various disciplines: the teacher talks, I listen and take notes, and I respond to the teachers' various assessment tasks. If I do what the teacher asks of me, I will learn to teach without further effort or responsibility on my part.”

BARRIER 3: Discussion and opinion are irrelevant

“Personal opinions have rarely mattered in previous courses, and there is no reason they should be significant in learning to teach. I did not enter this program to engage in discussions that are little more than 'pooling of ignorance'.”

BARRIER 4: Personal reactions to teaching are irrelevant

“My own reactions to my first teaching experiences are unimportant. It is only important for professors and cooperating teachers to tell me how to teach. I have no teaching experience, and so my own reactions are largely irrelevant. So are the reactions of those I teach.”

BARRIER 5: Goals for future students do not apply personally

“I want to teach students to learn independently, but it is not appropriate for me to learn independently during a preservice teacher education program.”

BARRIER 6: “Theory” is largely irrelevant

“Anything that does not seem to be directly relevant to success in the classroom is best termed 'theory' because that term is the one I use to describe anything that I cannot find meaning in or see how to apply in 'practice.' 'Theory' in education is not useful to beginning or experienced teachers.”

BARRIER 7: Experience cannot be analyzed or understood

“Most of my learning to teach occurs in classrooms during practice teaching, even though I cannot describe how I learn from experience. I know that I did learn from practice teaching experiences, and that's what really matters. Understanding how professional knowledge of teaching develops is not relevant to my learning to teach.”

In the terminology of the Project to Enhance Effective Learning (Baird & Mitchell, 1986; Baird & Northfield, 1992), what I have termed barriers to learning to teach might be compared to “poor learning tendencies” often apparent in students. A willingness to explore and challenge these barriers could be seen as a “good learning behaviour” in classes in a preservice teaching education program. I may well have overstated the seven barriers, yet they have been expressed in so many ways over the last 16 years that I believe the risk of overstatement is worth taking to call attention to an unexplored feature of preservice teacher education--the tendency to avoid program integration activities and discussion of tensions between those in schools and those in universities. Just as I was intrigued, in my early years as a teacher educator, by student statements such as “Why didn't you tell us you weren't going to tell us [how to teach]?” and “I paid \$25 tuition for this class and I didn't get my money's worth,” so I am also intrigued by experienced teachers who speak as though the university is the place where one learns to teach and the schools are places where one practices what one has learned. My sense of intrigue rises when these assumptions that teaching can be “told” are countered by some teachers who welcome student teachers with the statement, “Forget everything they told you at Queen's.” (It was reassuring to hear an identical statement reported by student teachers in a school in Australia.)

STUDENT TEACHERS' COMMENTS ILLUSTRATING BARRIERS TO LEARNING TO TEACH

The barriers listed above summarize a range of strong tendencies expressed in various subtle and direct ways by those who appear in my physics method course each year. Many would probably reject them if presented with the very explicit list of seven barriers, yet their comments and actions through the year support the barriers to learning to teach. As comments from three recent student teachers illustrate, some express the barriers directly while others report them as positions taken by others in the program but not held by the authors. Certainly, many student teachers make significant progress in overcoming these barriers during the preservice program, and I am also pleased to be told that my classes have contributed to that process. My broader concern is that more could be done sooner and across the various courses within a preservice program so that the transition from preservice to inservice development would not seem so stark, and preservice programs would not seem so disconnected from the process of learning to teach.

The following comments by a student teacher designated “Edward” suggest most directly the barriers to learning to teach:

EDWARD: By far, most of the actual learning that I experienced came during the teaching rounds, both in terms of pedagogy and of the professional lot of the teacher. When I arrived at Queen's, I had no real idea how the year would go but I did expect that we would learn about the school system and how students learn, as well as about different ways of approaching education. One of the most common phrases I think I heard was, “Oh, you've discussed small group cooperative learning in your other classes, haven't you?” when we've done no such thing. This seems symptomatic of a program that is greatly lacking in cohesion. Aside from a few cursory discussions in class about the structure of lesson plans and questioning techniques there seemed to be no great desire, in fact one might say there was an aversion to teach us anything about the mechanics of teaching.

EDWARD: The emphasis on one's teaching in the first few weeks of our course was useful, but when that turned into reflection on the process of learning to teach, I found the classes became aimless and nobody really understood what was going on. For myself, I think it was because I felt I was here, paying to be here actually, to undergo the process of learning to teach, not reflect on it. That would be appropriate at a later time once I've done it.

EDWARD: I hope to be able to make science relevant to students. By this I mean that I want them to know that science is more than a collection of facts with a bunch of arbitrary laws that they have to memorize. I want them to realize that it is a rational way of understanding the world around us and that it is predicated on the assumption that the human intellect has the singularly remarkable capability to understand it.... I want them to realize that even if they don't become scientists they have the ability to deal rationally with the world around them, and they don't have to be afraid of things they don't understand right away. I also hope to infuse them with a healthy sense of scepticism about scientific aims and a desire to have the tools to assess critically these claims on their own. I would like the students to realize that what they do in the science classes is related to their everyday lives.

EDWARD: In the final analysis, I don't think my time at Queen's has added up to much. Somebody could have handed me the curriculum guidelines 8 months ago and said, "Go teach this physics/science course," and I probably could have done a fairly good job of it. I don't think I'm any more prepared for life in the schools now than I was when I got here. Not that I'm unprepared, but I don't think I've actually learned anything really new. It seems as if I've spent most of the time here giving voice to things I already knew. In that sense I've been disappointed in the lack of rigorous intellectual discussion about education

methodology and about the content and philosophy behind the content in the curriculum.

A student here referred to as “Larry” is much more able to see a role for “theory” and alternative ideas in education. At the same time, he would prefer more time in schools gaining experience and less time in classes at Queen's.

LARRY: Many of the courses have been saying a lot without really saying much. I feel that the time spent at the faculty could easily be reduced to a few months of studies. There seems to be a lot of little unnecessary assignments that mean nothing to many. All they are is a source of aggravation. Our time in the field should be increased. That is not to say that every course was a waste of time. The curriculum courses, for the most part, were extremely helpful. I actually enjoyed the media lab assignments. But there really isn't a whole lot else out there to compliment. I may be a little off, but this is how I feel at the present time.

LARRY: I've been told on more than one occasion that the theory doesn't work, out in the field. I think it is more a question of do you try to make it work? It's easy to say, “Oh it doesn't work,” but was a real attempt made? Did you believe it would fail before you started? I guess I have become a little disillusioned with the attitude of some of the know-it-all teachers out there. The theory doesn't work because it's not applied. Teachers are not supposed to scream at their students to the point of making them cry. Teachers are supposed to be open to new ideas, like destreaming, and not crucify the idea before attempting to see if the theory will work. Teachers are not supposed to centre out students, make them feel small, talk about them behind their backs. But I have observed all of these, on more than one occasion. Teachers aren't perfect, but that should be their ultimate goal. They are role models, holding important positions in the public's eyes, and should act accordingly.

A student identified by the name “David” speaks to the issue of willingness to assume personal responsibility for learning. His comments about my teaching are interesting because he speaks speculatively about my intentions, which he has captured quite well:

DAVID: One point which I would like to address in this paper is that negative attitude which is carried by a number of students at Queen's. People often complain that there is not enough structure to the program and that they are getting very little from this year at Queen's. I think this is a very poor attitude. What did these people expect? Did they want everything to be laid out on a silver platter for them? At this stage in our careers as teachers if someone has to hold our hands and lead us through the program, telling us what to study and what not to study, then we should not be here as teachers. Is anyone going to stand beside us next year saying what to do and what not to do? Not very likely. Almost every professor here gives a large list of extra materials and resources. If the people that feel they are not getting enough from this year have been through that list then they may have an argument but I find it hard to believe that they have. I think you get out what you put into this year and no one should be holding our hands through the process. If we have come this far, and plan on educating others, we should be mature enough to take care of ourselves.

DAVID: One last thing which I would like to comment on is what I think Tom tried to do with our Physics method class this year. (This is my interpretation, which may be wrong.) I think that Tom was trying to give us the freedom and responsibility to decide what we wanted to learn. It was left up to us to question things and to ask questions. Our fate with the course was put into our own hands. I think Tom was trying to get us to question what is being done and to explore different options, to come up with our own ideas. I think Tom was trying to get away from the typical “this is how it is, accept it and like it”

class. I think a lot of the students had a hard time adapting to this approach to teaching. We are so used to having all of the information spelled out for us and all we have to do is soak it up like a sponge. No one has taught the majority of us to question things. This is something which I feel is definitely lacking in the field of science. We tend to just accept things for what they are without any questioning. It took me a while to see it but I now appreciate what I think Tom was trying to do.

CONCLUSIONS In preparing this paper for a plenary session on teacher education, I was asked to respond to one or more of the following three questions:

1. What are the most significant problems and issues in teacher education?
2. What are the theoretical frameworks that should serve as a foundation for teacher education?
3. What do we know about teacher education, and how should that knowledge shape the focus of our future research?

The following responses to the three questions permit me to draw this paper to a close in the context of the ideas about barriers to learning to teach and about the importance of developing the “authority of personal experience” in relation to the very familiar authorities of reason (this is how theory and research say science should be taught) and position (this is how my extensive experience says science should be taught).

1. Over the course of 16 years of science method work in preservice teacher education, the one tension that simply will not go away is the tension between the university (courses) and the schools (practicum). The two sources offer radically different views of learning to teach--one stressing logic, research, and good theory and the other stressing the long history of apparently successful practices. Those learning to teach are “programmed” to expect “transmission teaching” (Barnes, 1976) of the techniques and maxims that work--the domain that the practicum can best address. Schools often assume that student teachers should have “learned” to teach at the university, with the practicum seen as a place to practice theory already learned. At the same time, the school may appear to reject theory as abstract

and irrelevant, just as the university decries the unwillingness of schools to innovate.

I grow weary of this “stone throwing by people who live in glass houses”; deep down, neither schools nor universities can claim with much evidence that there are no improvements possible in their services to their clients. I hope that seeing learning to teach from the additional view of “authority of experience”--a domain unrecognized by new teachers, schools, or universities--can begin to move me and my preservice students beyond this longstanding tension.

2. I believe that we still lack a coherent account of how people learn to teach--in general and with particular reference to teaching science. Our preservice teacher education activities in universities and in schools are built on decades-old traditions developed in “normal schools” that served to equip teachers (mostly female) with survival skills to teach for only a few years. Teaching now approaches the status of a profession and many teachers make it a career that spans their entire working life. I believe that frameworks that incorporate how teachers learn from the experiences of teaching, particularly in the pre-service program and the first two or three years of teaching, are necessary to move us forward. A perspective that sees preservice teachers having strong misconceptions about how they should learn to teach that then act as substantial barriers to learning to teach may be helpful in developing more satisfying preservice and mentoring programs.

3. We know that teacher education is famous for urging others to change their teaching practices, and we also know that teacher education is famous for not practicing what it preaches. In this paper I have suggested one way in which we can apply research on learning science to research on learning to teach science: by viewing our student teachers as having significant misconceptions about learning to teach that may be substantial barriers to developing coherent preservice teacher education programs. Both schools and universities will need to explore such implications, but universities must lead the way. The new AERA Special Interest Group, “Self-Study of Teacher Education Practices,” is one sign that teacher educators are beginning to recognize the importance of directing frameworks about

learning to the learning that occurs in teacher education programs. We have long ridiculed the lecture on the discovery method of teaching, but we have not moved far beyond it in the eyes of those we teach in preservice programs. This tension should be one focus of future research on the learning that occurs in teacher education classes.

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