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RESPONSE

Gender issues and constructivism: Reflections on praxis

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Introduction

Constructivism, a theoretical perspective currently under debate in New Zealand, is worthy of a considered reflection. Johanne McComish considers constructivist theory with respect to the gendered view of science and the gendered nature of science teaching. Her argument is that there is need to develop an approach to science education that takes account of fundamental feminist critiques of the gendered nature of science and education. She suggests that a theoretical research agenda is the next major project for constructivist researchers. As a feminist science educator-researcher I would like to explore this notion from a different perspective.

In science education we are interested in understanding what happens in the classroom during the interaction between the learner, the teacher and the curriculum. How do the teacher and learner each modify, adapt, select, implement and reflect upon the curriculum? Some research, much of it initiated at the University of Waikato, has thrown light on these issues. We are also interested in the interaction between research, and theory and practice for teachers. The exploration of this nexus has aspects that could well provide further directions for future research.

Theory, research and practice are often regarded as separate entities but it could be argued that they can have an overlap or nexus which can further inform debate. Connected knowing articulated by Belenky et. al. (1986) makes this nexus one end to be achieved by feminist science educators who wish to ensure positive learning experiences which marry all three crucial aspects of education. Whitehead" s (1989: 41) following statement suggests a way forward is for those of us who are teacher-researchers in a tertiary setting to seriously consider and reflect upon how they are positioned in terms of the nexus of these aspects.

> I am attempting to make an acknowledged and scholarly contribution to knowledge of my subject, education. This purpose is part of my contract of employment as a university academic. I have chosen the field of educational theory because I am committed to the profession of education and believe it needs a theory which can adequately describe and explain the development of individuals. I am writing as a professional in education .... I am saying that educationalists, through studying their own attempts to answer such questions as "How do I improve my practice?", are constructing a living educational theory.

The above quote sets the parameters for my response to Johanne McComish's paper. I have chosen to respond to it by telling a story; an account of my professional journeying in trying to answer the question "How can I improve my practice?" as a means towards developing a living educational theory; exploring the interconnection of theory, research and practice. It is very easy for us as educators to put on our researcher - theoretician hats and divorce our work in these arenas from the reality of the day-to-day educational practice we experience. This response records the attempts to develop meaning out of efforts to integrate all three aspects by myself as one feminist science educator over a decade of life in tertiary institutions. I will begin with an account of myself as training to be a female secondary teacher of science and go on to describing a variety of practical projects and programmes using elements of constructivism and directed towards addressing gender bias. It

is a journeying that, at times, has been excruciatingly painful, and at other times has been wonderfully joyful. During it I have constructed robust understandings that have stood the test of working with teachers in three cities in two countries. This paper briefly outlines some of the experiences that have had crucial personal impact within the past decade. I reflect on the important threads, developed largely as a result of these particular experiences. This reflection on my herstory leads me to the suggestion that the development of other case studies as well as classroom-based investigations of the theory, research and practice nexus may also bear fruit for future directions in science education.

Learning in science project (LISP)

My deep interest in science education research, or any education research for that matter, began in 1980, after completing a B.Sc., a B.A. majoring in Education, and a Diploma of Teaching in which there was a substantial Education component. As a secondary teacher I was restless after thirteen years of teaching and about to embark upon a year of professional development by doing an M.Sc. in Chemical Education at Reading University. In preparation for this I took advantage of living in the capital city and asked the then national curriculum officer for science, Lyall Perris, for information about science education research in New Zealand. He gave me the first eighteen working papers from the first Leaming in Science Project (LISP) from the Science Education Research Unit (SERU) at the University of Waikato (Osborne and Freyberg, 1985). I vividly remember one Sunday afternoon sitting in a sand dune at Pukerua Bay, Wellington reading them and being astounded to find out that there was education research that was relevant and valuable to teachers in classrooms. For the first time I saw connections between my classroom practice and research that had never been evident during the many previous years of educational study. The knowledge gained from that seminal experience turned out to be of no value to the work I was subsequently to do at Reading, where the three aspects of theory, research and practice were taught as disconnected, isolated bubbles of information. Nevertheless the Pukerua Bay experience provided me with an excitement about investigating learning and teaching in the classroom. This is still with me and this is why I am sitting at my computer on a grey, windy, Wellington day writing this, so that I can share with you this challenging journeying from a *positivist* secondary teacher of science, chemistry and mathematics to a *constructivist* teacher educator.

On my return from Reading I maintained an interest in what was happening at the University of Waikato by attending conferences and workshops and reading papers. Little did I know then that I would become the Project Officer for the third LISP (Energy).

During the three years as Project Officer for LISP(Energy), the most challenging experience for me was sitting in the back of classrooms being taught by selected, competent teachers and seeing myself as the teacher I had been for nearly twenty years. This challenged me to the core. I had to come to terms with the importance of experiencing alternative ways of teaching that incorporated recent research findings about learning. It was not enough to have good intentions. I came to realise in a deeply significant way that my previous years of teaching in science which had been carried out with sincere commitment was not good enough anymore. I also came to realise that teachers come to the classroom with different ideas about teaching, learning, the nature of science and scientific concepts such as energy. These impact on what choices and experiences are provided to learners in the classroom as well as the interpretations put upon these experiences. From that point on I decided to develop coherent and consistent views about learning and teaching that I could. The richness from the involvement in the research, the reading of research, the constant interaction with overseas 'experts', scientists on campus, local teachers and teacher educators helped dramatically in this process.

After much reading, and talking with people I began to understand that practice and research were only part of a trio of aspects. The third of the trio theory underpinned much of ~he other two.

It was here that I was first introduced to the constructivist learning theory. Whilst I had experienced much theory in my educational studies, never before had theory impacted upon me as crucial to the classroom in which I was teaching. This new theory excited me as for the first time I was able to see an overlap between my teaching in the classroom, the research I was involved with and a theoretical framework that made sense of it all. Hewson and Hewson's (1987) conditions of plausibility, intelligibility and fruitfulness for a new idea to be taken on board were fulfilled.

During this research I also learnt about concepts of validity in educational research different from the usual statistical validity. This has informed my actions ever since. It relates back to my reading of the first LISP papers in the sand dunes. The information in those papers had such validity for me that I went back into my classroom the next day and thought differently about the process of learning and teaching. Not one bit of the mass of educational research I had read all the previous years, although steeped in statistical validity, had any impact on me. Research that was to be meaningful to teachers had to be valid for them in their classrooms.

In becoming the Project Officer for LISP(Energy) I succeeded Fred Biddulph who had been the Project Officer of LISP(Primary). Fred, out of the preliminary research, and along with SERU Director Roger Osborne and visiting academics David Symington (Symington, 1980) and Wynne Harlen (Harlen and Osborne, 1985), constructed an interactive teaching approach (ITA) (Biddulph and Osborne, 1984) for teaching science in primary schools.

The ITA developed in LISP(Primary) project was embedded in the findings of the first LISP project. These were that children come along to classrooms with understandings about the world they live in, that teachers rarely know about these understandings children have, that teaching rarely interacts with them, and that the understandings are often not those which scientists have. The approach also took into account that science is about asking questions and investigating to find answers, in logical and creative ways, to make better sense of the natural and technological worlds we live in. Thirdly, the approach took into account that many primary teachers, often women, had been turned off science in their schooling because it was presented as an overwhelming body of knowledge. The IT A gave them an entirely different view of science enabling them to some extent to learn along with the learners. This approach was to be invaluable for me in my next position as it was to become integral to my teaching.

Primary and early childhood science and technology education project (PECSTEP)

Following the completion of LISP(Energy) I had a year's contract at Canberra College of Advanced Education (now The University of Canberra) in 1989. The job was to develop, teach and evaluate gender-sensitive science and technology education programmes for primary and early childhood teachers, both at preservice and inservice levels. This Primary and Early Childhood Science and Technology Education Project (PECSTEP) with codirectors Margaret Bearlin and Tim Hardy was set up to provide a third model of teacher education. Bearlin, et. al. (1990) as a result of surveying primary and early childhood teacher education found two models in current practice. One model was subject-centred and the other learner-centred. The authors did not think that either of these models would break the disaffected pupil, disaffected student teacher, disaffected teacher cycle. They proposed a third model integrating teaching on science with teaching on gender. They suggested this would have more prospects of breaking the cycle because:

> attitudes are changed by changing both what science and science teaching and learning are, and are perceived to be, and by what gender is perceived to be. It is both knowledge and person-centred. Both knowledge and persons, both teachers and children, are seen from a gender perspective. Both knowledge and gender are seen to be constructed. It is similar to Model 2 (learner-centred) but with a gender perspective integral to every aspect. (Bearlin et al, p94)

When considering the possibilities for the construction of the year-long programme I chose, for the first semester, to role-model the interactive teaching approach (Biddulph and Osborne, 1984). As an

outcome of research it seemed to me to be a way of providing an alternative teaching approach that teachers would otherwise not experience. It was also developed as an approach that took into account the fear of science that many people, and particularly women who are the bulk of primary and early childhood teachers, bring with them. Often over the years I have continued to hear comments like the following:

> Science is a structural subject similar to Maths in that is usually has right and wrong answers. My feelings are very negative. I liked science until about Year 8 then I had a teacher for 3 years who seemed to think females weren't worth teaching science to. (PECSTEP data 1989, Lyndall, Year 2 primary student teacher)

> I was always frightened of the word science, let alone what was involved in science. (PECSTEP data 1989, Janelle, experienced primary teacher)

The interactive approach, by getting them to ask questions after a focus activity, was one that enabled teachers as learners to find out more about the natural and technological worlds they lived in; and to use a process very different from what they had previously experienced during their schooling. Often professional development providers (as with teachers of secondary science before them) had treated them as vessels to be filled up with the *right* knowledge so that they could pass it onto their students; a deficit model. The IT A took the teachers from where they were *at* and provided them with strategies and experiences that enabled them to further develop in their understandings. I also chose to role-model the approach twice so that by the second time around teachers may be feeling more confident to try things out in their classroom.

The focus of the first IT A was toasters, as work done at Hamilton Teachers' College (Cosgrove et. al., 1989; Faire and Cosgrove, 1990) had shown it to be a fruitful context to get into electricity, a much feared topic in primary schools. We followed up the first IT A on toasters with one on bread which got us into biology and chemistry and more, and different technology. As a woman I also saw the advantages of using a familiar piece of household technology to access this, forbidding for many, area. I was concerned that teachers were able to see technology as something familiar and everyday. Challenging the idea of technology as *high tech,* for example, computers (Eckersley, 1988), very gendered (Stanley, 1983) and remote from the world of the classroom is therefore important within this framework. For this reason there was a focus activity getting teachers to categorise a list of things (Symington, 1987) as either technology or not. The responses highlighted the very different understandings people had of technology and led to a discussion of just what is science and what is technology which was to be an ongoing debate underlying the workshops. People's individual theorising followed by small group and whole class discussions provided opportunities to reflect on the nature of science and its theories. The recognition that theories change as new information comes to light enabled people to re-evaluate science as a static body of knowledge and begin to consider other aspects.

Connecting this activity with everyday life was done through the use of metacognitive learning strategies such as concept maps (Novak and Gowin, 1984 ; Fensham et. al., 1981), and journal/diary keeping (Holly and McLaughlin, 1986; Swan, 1988; Swan and White, 1990). However, early on in this semester-length programme, there arose a need for the teachers to share their experiences of the previous week. What appeared to be needed was the opportunity for teachers to feel free to comment on aspects of the previous workshop that had given them food for thought and things they had tried in the classroom; to link to parts of their everyday life that had not been linked in that way before; to comment upon science/technology things they had heard, seen, read, and resources they had discovered and found useful; and to try out new vocabulary. Thus began an important part of each workshop - the sharing session which facilitates connected knowing (Belenky et. al., 1986). Such sharing can only happen if teachers feel comfortable and relaxed. Many things can help people in their transition from the teaching, parenting and other roles to the learning role: getting to know each other's names, backgrounds and reasons for being at the workshops, sitting in a circle so that we could each interact with the whole person with total communication including body language (not the backs of people as often happens in our row-based laboratory classroom designs). Such

aspects cannot be lightly dismissed, as teachers articulated in their evaluations (Kirkwood et. al., 1989).

The gender implications of the introductory experience of pulling apart a toaster surfaced as men in the group replicated what research has shown boys do in classrooms. They tended to take over the *doing* or in this case the *undoing.* It provided an opportunity to confront an issue prevalent in many classrooms and links from the workshop back to school situations. It provided an ideal opportunity for female teachers' often negative early learning experiences with technology, to be aired. This we did during the sharing sessions. It provided everyone, and particularly the male teachers, with an exposure to the reality of science learning for many girls. It also enabled some men to provide links to their own experiences. For example one father-teacher commented on how his daughter perceived herself to be regarded as a piece of furniture rather than as a person in her science classroom. He had not understood what this meant until he heard his female colleagues, the teachers in the professional development programme, talk about their learning experiences in science with such feeling.

Even in all female groups the gendered nature of their science learning surfaced. Women, when confronted with the ease of making an electrical circuit at the age of, say forty five, are challenged to reflect on their schooling and they wonder why it has taken them so long to do something so simple. They often get angry and perceive themselves to have been cheated out of useful knowledge for a large part of their lives. Readings that focus on research done into the gendered nature of classrooms (Alton-Lee et. al., 1990; Bell, 1988; Clark, 1990; Davies, 1988;) and the gendered nature of technology (Stanley, 1983) provided the teachers with alternative ways of looking at aspects of the world. Other readings (Lewis and Davies, 1988; McClintock Collective, 1988) provided them with further strategies to try in classrooms. The ruminations from these experiences, in tum, got linked to their own classrooms and they started wondering about the gendered nature of experiences they do or do not provide for the children in their classrooms. More than anything else I saw this impacting on their decisions to ensure that the girls in their classes are provided with experiences that enhance their making sense of the natural and technological worlds they live in.

During the second semester of PECSTEP at Canberra the teachers were developing, teaching, evaluating, and writing curriculum units based on their understandings from the first semester (Kirkwood et. al., 1990; Kirkwood, 1991). The surveys, interviews and evaluations completed by the teachers (Kirkwood et. al., 1989; Hardy et. al., 1990; Bearlin and Lendon, 1991) indicated that the form of professional development provided led to teachers who perceived themselves to be more confident and competent in science and technology teaching in primary classrooms across a range of topic areas. Other interesting findings were that teachers changed in their perceptions of girls in the classroom. After the professional development programme girls were perceived to be more actively involved in science, more interested in science, more frequently asking questions and more communicative.

Waikato university

My return to the University of Waikato, in 1990, enabled me to further explore these four teaching approaches, with Tim Hardy, within a third year university subject taken by teachers and teachers-to-be from primary and secondary sectors (Kirkwood and Hardy, 1991). This strategy provided students with thought-provoking challenges to reflect on the views of science, teaching, learning and knowledge that each of the alternative teaching approaches conveyed to the learner. In turn this appeared to enable them to reflect on their ideas and practice in a way they had not experienced previously. This experience raised the difficulty that tutors have in working through the very different issues that are surfaced by learners when providing constructivist programmes (Hardy and Kirkwood, 1994). It also challenged the writers to surface, articulate and debate their own assumptions that underpinned their teaching. This exploration led to a recognition of the

multiplicity of theoretical perspectives and research findings that contribute to praxis, thus challenging Matthews' (1995) simplistic assumptions of the role of constructivism. The nexus of practice, research and theory was enlarging and consolidating with each new professional experience.

The experiences of PECSTEP provided a basis for the writer within the fourth Learning in Science Project (LISP - Teacher Development). This project (Bell, 1993) involved investigating professional development experiences for primary and secondary teachers that enabled them to implement recent findings in science education research; particularly those of the Learning in Science Projects (Osborne and Freyberg, 1985; Biddulph & Osborne, 1984; Kirkwood, 1988; LISP(Energy), 1989) in their teaching. In the first year one facilitator (Dr Beverley Bell) worked with four teachers from a local high school and another (myself) worked with a group of twenty primary and secondary teachers from a variety of schools. In the latter programme I attempted, within a shorter time frame, to model a similar approach to PECSTEP using irons, instead of toasters, as the familiar household technology context (Bell, et. al., 1990). Once again opportunities and readings were provided to explore the gendered nature of science teaching and learning and the nature of science and technology. Working with teachers from different schooling sectors enabled me to explore differences I had perceived in views of science, teaching and learning (Kirkwood and Symington, 1995).

The University of Melbourne

In 1992 I took up a position at the University of Melbourne with a responsibility to develop and extend primary science. Building on my previous experiences I initiated a professional development/research project with teachers in the local inner city area. Again I role-modelled four teaching approaches with the first initial experience being an interactive teaching approach using toasters. This time I focussed on one conceptual science thread throughout the programme, that of electricity. Although focussing on one conceptual area did not reflect the richness of the natural and technological worlds we live in, it did enable more depth to be explored in a topic that presents many concerns for teachers.

During semester 2 we set out to explore what difficulties teachers perceive themselves to confront within the classroom situation as they are attempting to put the research findings experienced within professional development components into practice. The research aim was to further understand the process of implementing gender-sensitive science and technology education in primary and early childhood settings. The research questions were: "What questions/problems do teachers have as they seek to implement science and technology teaching in educational settings?", and "Can their experiences help and support other primary and early childhood teachers implement science and technology teaching?". The data gathered during these two years is still being analysed.

In 1994 University of Melbourne's Department of Science and Mathematics Education with the Australian Department of Employment, Education and Training (DEET) developed a programme to involve both practising teachers with a strength in primary science in the role of consulting teachers, and scientists and engineers from other faculties on campus as consulting scientists. This was to ensure that there was a blend between pedagogically meaningful classroom practice and cutting edge science. This professional development programme further extended the models I had previously used, not only incorporating a range of teaching approaches, a range a teaching strategies and a range of metacognitive learning strategies, but also involving a range of personnel, made possible with funding. The evaluation (Symington, 1995) clearly indicates the successful nature of such richness of people and experiences.

Reflection

In ten years since I left secondary teaching I have had a variety of experiences from which I have constructed understandings about teaching science to teachers, and in particular primary teachers. Some of these, such as using a constructivist base and implementing a conceptual change approach (Shuell, 1985; Hewson and Hewson, 1987) have been widely written about by others. I would like to focus on aspects that are less discussed.

The crux of the whole programme I think is the respect for teachers, not only as "thinking professionals" (Fennema, 1993) but also as feeling beings who are striving to make better sense of the worlds they live in by developing a "connected knowledge" (Belenky et. al., 1986). Women with whom I have spent a great deal of time with over the past few years know a great deal about the natural and technological worlds. Unfortunately this is not usually recognised or accepted nor is it used as a jumping off base for further learning. More often science teaching and learning is perceived in a constrained perspective.

> By science we mean the systematic study of that hard-won knowledge which enables us to comprehend the beautiful and useful natural and technological worlds. (Opat, 1993)

Academics who say that all that is needed to teach science well is a body of knowledge are giving no value to the nexus of practice, research, and theory in educational settings. Academics who convey to the public that teaching and learning of science in classrooms is based on one theoretical perspective (Matthews, 1995) also devalue the complexity of the teaching/learning experience and the professionalism of the teachers who are taking seriously the need to explore this nexus in a constantly ongoing manner. The role of teachers as reflective practitioners (Schon, 1983, 1987) has overtaken outmoded models of teaching. A view of teaching which takes into account the multiplicity of research findings, not only from science education but from education in general, and underpinned by meaningful and coherent theoretical models is able to bring together, in the experiences provided by an informed teacher, a learning experience which has a richness. This enables science to be experienced as a way of knowing about and living in the world, science as yet another pair of spectacles to be put on to interpret the world. Once people are provided with experiences that enable them to link past schooling experiences in science, everyday living experiences, and professional experiences with current learning they are empowered to ask more questions. If at the same time they also have access to the skills required for them to seek the answers to those questions then they have access to all spheres of knowledge; science has been demystified.

Using common household technologies as a context for science learning is another focus for enabling people to access science and provide them with skills to live in their world in a more informed way. While some teachers are reluctant starters most get captured by the empowering situation of beginning to understand a previously inaccessible part of their everyday life. Somehow the initial dismantling of the toaster or iron enables people to take risks in developing their understandings of other technological things. Pulling apart the toaster is solely responsible for this empowerment. The asking of questions and the investigation of them to find the answers also develops a confidence in the process of being able to problem solve. It may be they already had this skill in everyday life, but had never thought it transferable to a part of their world they considered inaccessible.

Experienced teachers talk about listening to their children, as if for the first time, and being stunned by how much they know and the depth of what they know. It appears that the focus on personal learning to be collectively shared enables teachers, through the variety of learning strategies they have experienced (concept maps, before and after statements, drawings, thinking books, sharing sessions, cooperative group work, etc), to hear and see what children think about things in ways not previously accessible.

Johanne McComish raises issues for further development associated with (1) the nature of science, (2) the purposes of education, (3) the nature of individuals, (4) how students learn, (5) the role of teachers. I suggest that some innovative things are already happening in classrooms. Teachers have increasingly less time to focus on the core business of the classroom, less time to read widely, less time to incorporate their learnings into classroom practice, more constraints to teach in a particular direction. As teacher educators part of our job description is to explore this arena. As we seek to push theoretical ideas to their limits and beyond let us not forget the implications they have for classroom practice. Let us not forget the contributions theoretical perspectives and challenges make to inform our practice. We need to examine our practice in teaching and learning in light of current theory and research. May those of us interested in the question "How can I improve my practice?" be enabled to find time, to write about our work so that the nexus of practice, research, and theory are brought to the forefront. Perhaps it is a responsibility we have as professionals with time and accessibility to ask and investigate the question ourselves about how we construct the research/theory/practice nexus. This way we can build up a body knowledge to reflect upon and write about so that theory building can begin. It is then more likely that challenges made against particular aspects of our educational system (Matthews, 1995) can be addressed by a greater number of people.

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