Teachers and Curriculum

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

KAIAKO ME TE MARAUTANGA

VOLUME 10 2007

Teachers and Curriculum

Editorial correspondence and manuscripts submitted for publication should be addressed to:

Greg Lee
School of Education
The University of Waikato
Private Bag 3105, Hamilton
New Zealand
email: educgdl@waikato.ac.nz

Website:
http://education.waikato.ac.nz/research/publication/

Books for review should be sent to the editor.

Business correspondence:
orders, back orders, subscriptions, payments and other enquiries should be sent to:

Teachers and Curriculum
Hamilton Education Resource Centre
PO Box 1387
Hamilton
email: janh@waikato.ac.nz

Subscriptions:
within New Zealand $22 (includespostage)\
overseas $40 (includes postage)

Volume 10 2007

Contents

Teachers and Curriculum is an annual publication of the School of Education, The University of Waikato, Hamilton, New Zealand.

It includes articles about curriculum issues, research in the area of curriculum and informed curriculum practice. Reviews of curriculum related books may also be included.

The Opinion item is contributed by a leading New Zealand educationalist.

ISSN 1174-2208

Notes for Contributors

Teachers and Curriculum provides an avenue for the publication of papers that:

- raise important issues to do with the curriculum
- report on research in the area of curriculum
- provide examples of informed curriculum practice
- review books that have a curriculum focus.

This peer reviewed journal welcomes papers on any of these from tertiary staff and students, teachers and other educators who have a special interest in curriculum matters. Papers on research may be full papers, or if time or space is at a premium, research notes, that is a 2,000 word summary.

Submitting articles for publication

The editorial committee encourages contributors to ask colleagues to comment on their manuscripts, from an editorial point of view, before submission for publication.

Length

Manuscripts should not normally exceed 7,000 words, includng references and appendices. An abstract must be provided. Abstracts should not be more than 100 words.

Method of submitting a paper

Please provide copy in 12 point type in a font compatible with the use of macrons (preferably Helvetica Maori or Times Maori) with line and a half spacing for the main text, and with 20 mm margins on all edges. Word files are preferred. Please do not include running headers or footers, Follow the style of referencing in the Publication Manual of the American Psychological Association (APA), 5th edition with references in a reference list at the end of the manuscript, rather than footnotes. Manuscripts not submitted in accordance with the above guidelines will be returned to authors for amendment.

Covering Letter

When submitting a manuscript to *Teachers and Curriculum*, authors must, for ethical and copyright reasons, include in a covering letter a statement confirming that (a) the material has not been published elsewhere, and (b) the manuscript is not currently under consideration with any other publisher.

Date for Submission

Manuscripts may be submitted at any time.

Copyright

Acknowledgement of Reviewers

We wish to thank the following people who reviewed for this edition of *Teachers and Curriculum*. Asterisks indicate reviewers who contributed more than one review.

Guy Broadley
Ken Carr
Wendy Carss
Gail Cawkwell
Linda Daniell
Colin Gibbs*
Ted Glynn
Paul Keown
Catherine Lang*
Greg Lee*
Peggy Lee
Clive McGee*
Colleen McMurchy-Pilkington
Ally Sewell
Gordon Suddaby

Scholarship in the design of curriculum and the professional practice of tertiary teaching – a personal perspective

Anne Hume
School of Education,
The University of Waikato

Abstract

This paper traces the development of a tertiary teacher's philosophy and approach to teaching a post-graduate paper for pre-service secondary teachers in science.

In her narrative, the teacher, a recent appointment to the university system, reveals the important roles past experiences and scholarship play in informing and shaping her practice as she familiarises herself with a new community of practice and the requirements of tertiary students.

Influences on the curriculum she is developing for her student teachers include her own teaching and learning experiences; her doctoral research; the needs of her students; involvement in further personal academic study; and a growing interest and awareness in the value of reflection in improving professional practice.

She identifies the potential of action research for providing valuable insights into the nature and extent of student learning and the pedagogical strategies required to improve outcomes for students.

Introduction

In this paper I intend to identify and reflect critically, in narrative form, on a teaching and learning plan I have progressively developed and delivered over the past three years. This is an evolving plan, hence the narrative, as I familiarise myself with methods of teaching and learning in a tertiary education institution and adapt to the learning needs of mature students learning to be teachers.

The plan relates to a post-graduate paper for students with science degrees, and contributes towards a one-year programme in secondary teacher initial teacher education. Graduates of this programme enter into the secondary education sector where they serve as provisionally registered teachers for two years before becoming fully registered secondary teachers. Participants in this class come from a wide range of backgrounds in terms of age, gender, ethnicity, country of origin, religion, family and work experience, and science qualifications. Not surprisingly, they arrive with a wide range of experiences and views on the teaching and learning of science, and diverse learning needs in terms of developing the capacity to perform successfully as a teacher of science. Many of these students may be experiencing for the first time an educational programme with a vocational orientation that prepares them for a professional role, rather than mastery of a knowledge domain. Such a course places requirements on students that are quite different to those of a traditional academic course, and may create tensions for many of these novice teachers. For example, adapting to a pedagogical role in classrooms where their students are unmotivated and struggle with science can be difficult for novice teachers to accomplish if they themselves have been successful learners in science. Such experiences may challenge their long held views about learners, and teaching and learning in science, and need to be addressed if they are to become effective teachers of all students in science.

I took on responsibility for this paper three years ago and, accustomed to detailed programme documentation as an experienced teacher in the pre-tertiary sector, I was most disconcerted to be given a course outline that contained very generic guidelines and little by way of guidance about the specific content of the paper. It transpired that within these guidelines I was expected to develop my own paper including teaching and learning content, pedagogical approaches and materials and assessment. The guidelines indicated that I needed to familiarise students with the structure and requirements of the *Science in the New Zealand Curriculum* (SiNZC) (MoE, 1993), including how to use the document to plan effective classroom science lessons and units of work. There were indications that constructivist views of teaching and learning were promoted in the paper, that recognition should be given to the diverse learning needs of all students, and that reflection and evaluation of teaching and learning processes be practised. Safe laboratory practice and management were also emphasised.

As I was new to the University system, this lack of clear direction in the paper guidelines was worrisome, and the task of paper design initially seemed daunting. However, I was soon to discover that this challenge proved to be a blessing in disguise since the lack of constraints on paper structure gave me the freedom to develop a programme more aligned with my own views and experiences from many years of teaching (and learning). Prior to my university teaching career, I had been a science teacher in primary and secondary schools for over 25 years, and four years as an evaluator of pre-tertiary education programmes with the Education Review Office. I had extensive first-hand experience of science teaching and evaluation of science teaching programme in terms of the quality of teaching and student learning outcomes. During this time I had also been on national curriculum writing and examining teams in science, including the National Certificate of Educational Achievement (NCEA) Expert Panel in Science. In addition I gained a Masters degree in science education ten years ago and at the end of my first year of university teaching I completed a science education doctorate. My doctoral study allowed me the opportunity to integrate my personal experience of science teaching and learning as a practitioner with findings from both my own research work and the wider science education research community. From these experiences have crystallised some key concepts of teaching and learning that are important to me and which have consequently strongly influenced the pedagogical approach I have taken in developing my pre-service science education paper. These concepts came together for me when reading a seminal paper by Graeme Nuthall (1997) called "Understanding student thinking and learning in the classroom".

In this paper, Nuthall brought together three closely inter-related perspectives on learning that were having a strong influence on educational thinking and development in the late twentieth century in the hope that this amalgamation would facilitate advances in pedagogy and learning outcomes for students. In the view of Nuthall, these three perspectives on learning – constructivist, socio-cultural and linguistic – have a synergy that encapsulates classroom life and if considered together have the potential for improved classroom practice. I explored these views of learning in greater depth with other authors and began to build up a picture not just on learning but also of the implications for pedagogy if these perspectives on learning were accepted. The following paragraphs summarise the understanding of these perspectives on learning that I gained from my research. These constructs sit comfortably with my own insights into science teaching and learning gained from my professional teaching and evaluative experience, and ultimately influenced the manner in which I developed and delivered the paper.

In the *constructivist* view of learning, students experience changes in what Leach and Scott (2003, p. 92) term the "mental structures" of individuals, that is, their concepts, schema or mental models. Individual learners construct their own knowledge motivated by the need to make sense of experience in light of their existing understandings. In constructivist terms, what a student learns during particular teaching and learning episodes are those concepts, skills and understandings he/she has actively, personally constructed as a result of the classroom experiences (McMillan, 1995; Skamp, 2004). The science teacher's role is to provide learning experiences that enable students to construct knowledge as close to accepted science knowledge as possible. Research in this field indicates that students often hold views that are contrary to scientific views and these alternative ideas (sometimes called misconceptions) are often strongly held and can persist, even years later, despite students having experienced many teaching and learning episodes that promote the scientific view (Osborne & Freyberg, 1985). To change such views, learners need to experience situations where their existing understandings are challenged in ways that cause them to reassess the usefulness of their ideas and form new concepts that are closer to those of scientists.

Since learning is seen as an active process where the learner makes links between their existing ideas and new information, an implicit feature of any pedagogy that seeks to facilitate learning of science involves ascertaining what existing ideas students may have on particular science phenomena. Strategies that reveal prior knowledge include brainstorming, concept mapping and the post-box technique, and all three strategies were used in my course. For example, I used the post-box strategy to probe students' understanding of the nature of science by eliciting their comments on statements about aspects of scientific practice such as "scientists work in teams", "scientific knowledge is tentative" and "science requires creativity and intuition". Through subsequent discussion I was able to identify the type and range of existing views in the class and challenge and extend their thinking, which I supplemented with targeted academic readings on the nature of science. A final concept mapping exercise enabled me to both assess the understanding each student had of the nature of science and gauge the extent to which class members' thinking had changed from their post-box comments.

The *socio-cultural* stance on learning takes constructivism a step further by emphasizing the role of social interaction in building knowledge constructs. In the socio-cultural view "thinking and learning are not seen as an activity of the mind in isolation, but rather as part of, or constituted by, the visible social interaction that takes place between members of a community" (Nuthall, 1997, p. 701). What counts as knowledge is situated in the practice of that particular community and defined in social interactions (Barnett & Hodson, 2001; Black, 2001). For example, scientific concepts are cultural products that have been validated through rigorous and complex empirical investigation and social processes performed by members of the scientific community (Leach & Scott, 2003). Individuals could rarely discover or perceive such concepts without social interactions. Even the reading and interpreting of text (also considered cultural products) requires an individual learner to function in a social context in order to learn. Thus, from a socio-cultural perspective, learning is a process of enculturation where an individual develops the capacity to interact with other members of the community and participate effectively in its activities. Through social and cultural processes, students in science classrooms learn by co-constructing understanding with their more expert teachers (Haigh, 2001), and fellow students come to learn viable science concepts through social reinforcement (Leach & Scott, 2003). In this view, *what* students are learning in science could be the concepts, skills and practices that an expert scientist possesses, if the

student as novice works in partnership with the teacher as expert (Hodson, 1996; Nuthall, 1997; Tytler, 2003). This view of learning is closely linked to the concept of situated cognition (Hennessey, 1993; Brown, Collins, & Duguid, 1989) which recognises that ways of knowing differ from one community of practice to another, and that learning is a process of enculturation into the ways of thinking of members of that community.

Pedagogies based on this view of learning seek to promote social interaction with group tasks involving discussion, debate, negotiation, and shared problem-solving high on the list of appropriate strategies. I made frequent use of group work in solution-seeking sessions where the students role-played in scenarios depicting problematic situations they could well encounter in their future science teaching practice. To encourage involvement, there was an expectation that groups report findings to the whole class and that all group members participate in that report. Group membership was randomly chosen for each of the tasks, so students regularly worked with different class members and experienced a greater range and variety of interactions. While these sessions often produced positive learning outcomes for students, they were not always as successful as I had hoped. I realised that for some tasks students generally lacked the required experience and knowledge, such that even the collective group wisdom was inadequate to solve certain problems. I needed to take care that the students had the capacity to solve such problems, and I found that setting relevant science education readings as professional tasks prior to the workshop sessions had positive spin-offs in terms of the contributions individual students could make to the group learning.

Mentoring was also a strategy I utilised in two different ways. To help enculturate my students further into the science community of practice, I invited a panel of scientists to speak to the class about the nature of work they did and to discuss how they operated within their community. My students commented later (verbally and in reflective journals) how the points raised by scientists in the conversation provided valuable insights into the nature of authentic scientific inquiry. I also utilised reflective journals as a means of providing mentoring for my students as novice teachers. Students kept these journals while out on teaching practice in schools and often recounted issues or difficulties they faced in classes. Acting as an expert teacher, I provided written feedback and, where appropriate, comments designed to suggest possible next steps in their learning. The journals were only partially successful in this function because I believe students were not prepared or skilled enough in reflective writing to provide the necessary information, and to provide the support these novice teachers needed to make productive next steps my comments needed to be far more targeted. My most successful mentoring occurred during discussions I held with the students in schools after observing them teach in classes. In these discussions I felt confident that I was able to provide pertinent feedback in a manner that was constructive and forward-looking. Similarly the two individual half hour conferences I held with each student during the paper also enabled valuable mentoring opportunities. These conferences, which were held after each teaching practicum (two practica each lasting six weeks), will remain an important component of the paper's structure.

The *linguistic* perspective acknowledges the acquisition of language as a semiotic process (one of making meaning) that is central to all learning. Language is the means by which concepts are introduced and discussed by learners on the social plane, and the tool for individual thinking once concepts are internalised. There is "continuity between language and thought" (Leach & Scott, 2003, p. .99). Linguistically then, science learning includes the acquiring of the scientific social language and speech genres that are the way of communicating and thinking within a scientific community, and using them appropriately in various situations. In my science education research I did not often encounter the term 'linguistic' as such. However, 'scientific literacy' is considered an important curriculum goal for students in science education and in discussions of this goal the ability to read, write and understand science as a form of systematized human knowledge appears as an important component (Laugksch, 2000). In simple terms, being scientifically literate involves both an understanding of science and of what it means to think and work scientifically (Feasey, 2004). Thus 'literacy' may be a more appropriate term that 'linguistic' in the context of enculturation of students into the science community. The science education literature does refer to 'literacy tools' such as concept cartoons, Venn diagrams, and Think-Pair-Share for aiding extraction of information and understanding from text and for helping concept development (King & Mattox, 2007; Naylor & Keogh, 2000). I have progressively introduced these tools into the paper content by modelling in workshop sessions, both to improve my students' understanding of science education concepts and to broaden their pedagogical repertoire of teaching and learning strategies.

Nuthall's paper had provided me with a more holistic understanding of how science learning occurs, and consequently, when beginning work on my own design of the science education paper I realised some of the existing learning outcomes needed rethinking. In particular, the learning outcome promoting constructivist approaches in the paper needed to be more inclusive of the other perspectives that were underpinning my philosophy on the teaching and learning of science. Thus, I modified this outcome to read that on completion of this paper students will be able to "apply constructivist and sociocultural approaches to the teaching and learning of science". I chose not to formally include the linguistic perspective at this stage simply because of my own fledging knowledge in this field. I believed I could introduce elements of this view within the other two approaches where and when I felt it appropriate, for example, as a component of scientific literacy, and as an integral feature of my pedagogy. Linguistics is a fascinating field, particularly the idea that without language you cannot think! When I introduced this notion into one of the paper sessions it generated much interest and debate. As an aside, I introduced a series of small professional tasks into the paper (about eight in total) that are assessed on a three-point scale of achieved, merit and excellence. These tasks usually involve analysis and interpretation of professional readings related to various topics in the paper. For example, in one task the students were to locate a research paper dealing with the teaching of scientific inquiry and share the major message of the paper with others in small groups in class. Key emerging ideas were in turn shared with the whole class in report backs, and students commented on how worthwhile they found this activity for raising their awareness of particular issues in this area of teaching and learning. A similar literature search activity, this time in the field of linguistics and science education, could well prove beneficial for lecturer and students alike – after all 'two heads are better than one!'

Another reading that was to have a strong influence on the nature of the paper outcomes and design was again a seminal paper, this time concerning a foundation for teaching reform. The paper "Knowledge and teaching: foundations of the new reform" (Shulman, 1987) was informed by philosophy, psychology and a growing body of knowledge gained from case studies of the practice of young and experienced teachers. In seeking to promote teaching that emphasises comprehension and reasoning, transformation and reflection, Shulman observed that good teachers utilise a complex knowledge base gained from a range of sources or "domains of scholarship and experience" (p.5) for understanding. To deal with the complexity of the knowledge base good teachers draw upon, Shulman proposed a number of categories. These categories include:

content knowledge;

general pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organisation that appear to transcend subject matter;

curriculum knowledge, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers;

pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their special form of professional understanding;

knowledge of learners and their characteristics;

knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures; and

knowledge of educational ends, purposes, and values, and their philosophical and historical grounds. (p.8)

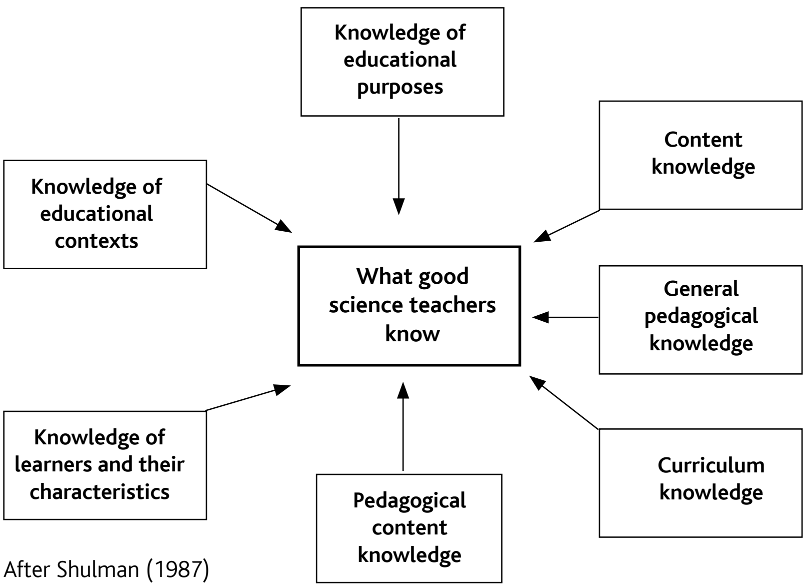
I first introduced Shulman's paper to the class after a workshop activity early in the paper when I was trying to give students some direction for the paper. It occurred to me that the students taking this paper were beginning a process of enculturation into the practice of teaching, rather like embarking on a journey of discovery. On this journey, they would be progressively learning and filling their kete of knowledge as defined above. In the workshop activity I presented students with the following scenario:

*You have just arrived at your first teaching position and learned that as the first topic of the teaching and learning programme for the year 10 Science class you have been assigned you are required to teach the topic "chemical reactions". In pairs **discuss** and **record** what steps you imagine you'll have to take in order to begin teaching this topic e.g. what will you need to do? - how will you go about tackling this task? –what information will you need? resources? etc (what, how, when, where, why etc).*

This task was done in groups, and ideas shared in a whole class feedback session. In conclusion, to help highlight the many facets of knowledge, skills and experience teachers require to actually perform this task in a real classroom, I presented Shulmans' knowledge categories of good teachers in a framework form (see Figure 1).

Figure 1.

Shulman's Framework



After Shulman (1987)

I subsequently decided to use this Shulman framework both as a planning tool for designing the paper content and structure and as a reflection tool for monitoring students' learning progress in the paper.

In terms of planning the paper, and the knowledge base I wanted students to develop by the end of the paper, I surveyed the existing paper outcomes and content to determine what match there was with Shulman's framework. As a result I introduced two new learning outcomes for the paper. The first of the new outcomes related to students' content and curriculum knowledge categories by requiring them to "describe key aspects of the nature of science and science education". During my literature review for the doctoral thesis, I had become aware of new goals and purposes for science education. Internationally, the call for scientific literacy for all citizens in society is growing as world communities realise that science and scientific issues are exerting an ever-increasing impact on their peoples' daily lives (American Association for the Advancement of Science [AAAS], 1989; Jenkin, 2002; Lederman, 1999; Millar & Osborne, 1998; Ryder, 2001). Progressive science educators recognise the importance of education in the public understanding of and about science, and support scientific literacy goals in new science curricula (Carr et al., 2001; Driver et al., 1996; Duggan & Gott, 2002; Hurd, 1997; Mayer & Kumano, 1999; Millar & Osborne, 1998; Ryder, 2001). Since scientific literacy involves both an understanding of science and of what it means to think and work scientifically (Feasey, 2004), Shulman's content category for science teaching therefore needs to go beyond traditional notions of science concepts and skills to understanding how the scientific community of practice generates and validates knowledge. It also needs to include the possession of "cognitive capacities for utilizing science/technology information in human affairs and for social and economic progress" (Hurd, 1997, p. 411).

In the draft *Science in the New Zealand Curriculum* statement released in February, 2006, the reasons for learning science are clearly and strongly linked to the need for a scientific perspective in many decision–making processes that occur in society. By studying science, students will, for example, "learn that science involves particular processes and ways of developing and organizing knowledge, and these continue to evolve … and use scientific knowledge and skills to make informed decisions about the application and implications of science with regard to their own lives and the environment." (MoE, 2006, p. 1). It is proposed that the nature of science strand takes centre stage.

The nature of science is the over-arching, unifying strand. Through it, students learn what science is and develop the skills, attitudes and values that build a foundation for further study. They come to appreciate that scientific knowledge is at the same time durable and tentative; they learn how science workers carry out investigations, and come to see science as socially valuable knowledge system. They learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions. (MoE, 2006, p.1)

To achieve such goals, inquiry-based inquiry has re-emerged as an important component of these new curricula (Atkin & Black, 2003) but with the emphasis on "authentic scientific inquiry" where "learners can investigate the natural world, propose ideas, and explain and justify assertions based upon evidence and, in the process, sense the spirit of science" (Hofstein & Lunetta, 2003, p. 30). The justification is that students become enculturated into science in a manner that ultimately helps them develop an understanding and appreciation of the nature of science (Collins, 2004; Driver, Leach, Millar & Scott. 1996; Duschl & Hamilton, 1998; Powell & Anderson, 2002; Weinburgh, 2003).

To address this new learning outcome, I developed workshops in the paper to explore the nature of science and the need for scientific literacy in everyday life and the role of investigative work. Activities included the post box strategy to gauge and challenge students' views on the nature of science; forums of scientists talking about their work; professional readings about the need for scientific literacy, modelling of strategies to scaffold learning about scientific investigation; and engagement in open-ended science investigation.

The second of the new outcomes required students to "reflect critically on their practice to promote professional growth and help develop a personal philosophy of teaching" using Shulman's categories of knowledge as a reflective tool. Shulman's categorization of a 'good teacher's' knowledge base was to be used by students as a framework for reflecting on the nature and extent of their own knowledge development. Students were encouraged to reflect as part of activities in workshops, but to meet university assessment guidelines I needed a means by which I could have written records of such reflections. I recalled from my earlier experience as a teacher participant in an action research project (Bell & Gilbert, 1996) the use of journals to record our reflections on experiences, and decided to use journals in a similar manner for this paper. As things eventuated, not only did the journals serve as reflective and assessment tools, they also served other valuable functions by informing my planning and assisting in my mentoring role. The paper for the pre-service secondary science teachers is rather fragmented in the sense that workshops do not run continuously over a semester. To meet teaching practice requirements of the qualification, students must attend blocks of semester time in schools. The journals became an important means of communication between the students and me during our long periods of separation. For example, the students' writings identified for me aspects of their experiences that were going well and aspects that could be addressed by further work in classes on campus. Of particular value, was the realisation that the students were keeping to very traditional forms of pedagogy and seemed loathe to experiment with different strategies. Thus on their return to university, I placed a fresh emphasis in my workshops on exploring a variety of ways to teach the same material. Interestingly, students do not use Shulman's framework very effectively as a reflective tool and I suspect that part of the reason may be that I do not scaffold the reflective process sufficiently for students – I make assumptions that they can do this, when in fact this is an acquired skill that needs support and practice.

Concluding Thoughts

In my academic reading for my doctorate, and more latterly for formulating a proposal for an education research bid, I became increasingly aware of the potential of a research paradigm known as critical theory (Cohen, Manion & Morrison, 2000) for informing my teaching practice. Exponents of critical theory believe in emancipatory research that is deliberately political and transformative in its intent (Harding, 1987; Lather, 1992; Walshaw, 2001). A methodology suited to critical theory investigations is action research, which involves participants in a form of disciplined self-reflective inquiry that is collaborative and designed to enable them to understand, improve and reform their educational practice (Engstrom, Engstrom & Sunito, 2002; Kemmis & McTaggart, 1988). Such inquiry is said to promote an appreciation by participant researchers of the relevance of research for their practice (Kennedy, 1997) and builds their capacity to improve practice through their own research (Keeves, 1998). This methodology seems highly appropriate to my situation, and remembering insights I gained through personal experience as a teacher-researcher in the Learning in Science [Teacher Change] Project (Bell & Gilbert, 1996) convinces me it is an opportune time to introduce this research approach to my tertiary classroom practice. Of particular interest to me, is a form of action research design known as *practical action research* as outlined by Cresswell (2005). The action research component involves a dynamic, flexible and iterative methodology, allowing the researcher to move back and forth between reflections about a problem, data collection and action. The methodology comprises a general spiral of generic steps that lets the action researcher pursue solutions to his/her identified problems in collaboration with other researchers or mentors, and to enter the spiral at any point appropriate to the particular action research project. The nature of this form of action research would enable me to make use of my findings to date from my first informal attempts at problem solving, and move forward, utilising the full potential of the methodology for improving my practice.

I would like to bring this narrative to a close at this stage by signalling my intent in my plan to explore student journals further as reflective and planning tools in follow-up action research. Already, in the literature about teacher education, I have found reflective practice is widely advocated as an important attribute to promote, develop and foster participants of pre-service programmes. Thinking about their experiences is believed to enhance professional learning and growth by helping students to develop an educational philosophy that will guide and improve their teaching practice in classrooms (Moon, 1999; Shireen Deouza & Czerniak, 2003; Wallace & Louden, 2000). Bain, Mills, Ballantyne and Packer (2002), in support of journal use in pre-service teacher education, report that many researchers and theorists maintain that reflective skills can be taught and learned, despite early difficulties. My personal experience and research into formative assessment practice suggests that perhaps if these skills are made explicit then improved learning is likely to result (Clarke, 2001). Exemplars that illustrate good reflective journal writing, as suggested by Moon (1999), could be an appropriate pedagogical strategy. Bain et al. (2002) investigated the role of feedback in improving journal writing and found that "feedback focusing on the reflective writing process –giving guidelines and a suggested framework for moving into higher levels of cognitive activity – is both more effective and more easily generalised than feedback focusing on the *teaching issues* raised by teachers" (p. 193). Thus, providing students with feedback in relation to exemplars seems a promising strategy to employ in my action plan. Moore (2005) encouraged her trainee teachers in mathematics to use reflective journals to learn how to learn mathematics. In their journals, she required students to critically assess their own learning experiences in workshops and then apply that experience when creating learning opportunities for their students. Moore reviewed their journals periodically and found this structure for reflection very effective in helping students develop personal knowledge in relation to the development of their content knowledge. Again, such a strategy appears compatible with other components of my plan and worth inclusion.

As with student journals, there are many similar avenues in the literature about pre-service teacher education in science that I would like to explore more before devising new approaches, and I look forward to introducing innovations into my programmes that are informed through research and evidence-based reasoning.

Anne Hume is a senior lecturer in science education in the School of Education at the University of Waikato. She may be contacted at annehume@waikato.ac.nz

References

American Association for the Advancement of Science. (1990). *Science for all Americans*. New York: Oxford University Press.

Atkin, J.M., & Black, P. (2003). *Inside science education reform: A history of curricular and policy change*. New York: Teachers College Press.

Bain, J.D., Mills, C., Ballantyne, R., & Packer, J. (2002). Developing reflection on practice through journal writing: Impacts of variations in the focus and level of feedback. *Teachers and Teaching: Theory and Practice, 8*(2), 171-196.

Barnett, J., & Hodson, D. (2001). Pedagogical context knowledge: Toward a fuller understanding of what good science teachers know. *Science Education, 85*(4), 426-453.

Bell, B., & Gilbert, J. (1996). *Teacher development: A model from science education*. London: Falmer.

Black, P. (2001). Dreams, strategies and systems: Portraits of assessment past, present and future. *Assessment in Education*, *8*(1), 65-85.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Clarke, S. (2001). *Unlocking formative assessment. Practical strategies for enhancing pupils' learning in the primary classroom*. London: Hodder & Stoughton.

Cohen, L., Manion, L. & Morrison, K. (2000). *Research methods in education* (5th ed.) London: Routledge.

Collins, N. (2004). Scientific research and school students. *School Science Review*, *85*(312), 77-86.

Creswell, J.W. (2005). *Educational research. Planning, conducting, and evaluating quantitative and qualitative research*. New Jersey: Pearson Education Inc.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham: Open University Press.

Duschl, R.A., & Hamilton, R.J. (1998). Conceptual change in science and in the learning of science. In B.J. Fraser & K.G. Tobin (Eds.), *International handbook of science education* (pp. 1047-1065). Dordrecht: Kluwer.

Engstrom, Y., Engstrom, R., & Sunito, A. (2002). Can a school community learn to master its own future? An activity-theoretical study of expansive learning among middle school teachers. In G. Wells & G. Claxton (Eds.), *Learning for life in the 21st century. Sociocultural perspectives on the future of education* (pp. 211-224). Oxford: Blackwell.

Feasey, R. (2004). Thinking and working scientifically. In K. Stamp (Ed.), *Teaching primary science constructively* (pp. 44-87). Victoria, Australia: Thomson.

Haigh, M. (2001). Supporting student investigations. *New Zealand Science Teacher, 96*, 39-41.

Harding, S. (Ed.). (1987). *Feminism and methodology*. Bloomington, Indiana: Indiana University Press.

Hennessey, S. (1993). Situated cognition and cognitive apprenticeship: Implications for classroom learning. *Studies in Science Education, 22,* 1-41.

Hodson, D. (1996). Laboratory work as scientific method: Three decades of confusion and distortion. *Journal of Curriculum Studies, 28*(2), 115-135.

Hofstein, A., & Lunetta, V. (2003). The laboratory in science education: Foundations for the twenty-first century. *Science Education, 88*(1), 28-54.

Hurd, P. (1997). Scientific literacy: New minds for a changing world. *Science Education*, *82*(3), 407-416.

Jenkin, J. (2002). The drive for scientific literacy. *School Science Review 83*(304), 21-25.

Keeves, J.P. (1998). Methods and processes in research in science education. In B. Fraser & K. Tobin. (Eds.), *International handbook of science education* (pp. 1127-1153). Dordrecht: Kluwer.

Kennedy, M. (1997). The connection between research and practice. *Educational Researcher, 26*(7), 4-12.

Kemmis, S., & McTaggart, R. (Eds.). (1988). *The action research planner* (3rd ed.). Victoria, Australia: Deakin University Press.

King, C.M., & Mattox, S.R. (2007). *Learning through inquiry: Weaving science with thinking and literature*. Norwood, Massachusetts: Christopher-Gordon Publishers, Inc.

Laughksch, R.C. (2000). Scientific literacy: A conceptual overview. *Science Education, 84*, 71-94.

Lather, P. (1992). Critical frames in educational research: Feminist and post-structural perspectives. *Theories into Practice, 13*(2), 87-99.

Leach, J., & Scott, P. (2003). Individual and sociocultural views of learning in science education. *Science & Education, 12*, 91-113.

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916-929.

McMillan, B. (1995). Making sense of the debate about the science curriculum. In A. Jones, A. Begg, B. Bell, F. Biddulph, M.Carr, M. Carr, J. McChesney, E.

McKinley & J. Young-Loveridge (Eds.), *SAMEpapers* (pp. 95-111). Hamilton, New Zealand: Centre for Science, Mathematics and Technology Education Research, University of Waikato.

Millar, R. & Osborne, J. (Eds.). (1998). *Beyond 2000: Science education for the future*. London: School of Education, King's College, London.

Ministry of Education. (1993). *Science in the New Zealand curriculum*. Wellington, New Zealand: Learning Media.

Ministry of Education (2006). Science essence statement (working document). Retrieved 2 April, 2006 from Ministry of Education website: www.tki.org.nz/r/nzcurriculum

Moon, J.A. (1999). *Learning journals*. *A handbook for academics, students and professional development*. London: Kogan Page.

Moore, J. (2005). Transformative mathematics pedagogy: From theory to practice, research and beyond. In A. Rodriqez & R.S. Kitchen (Eds.), *Preparing mathematics and science teachers for diverse classrooms*. *Promising strategies for transformative pedagogy* (pp. 183-202). London: Lawrence Erlbaum Associates.

Naylor, S., & Keogh, B. (2000). *Concept cartoons in science education*. Sandbach, Cheshire: Millgate House.

Nuthall, G. (1997). Understanding student thinking and learning in the classroom. In B. Biddle, T. Good, & I. Goodson (Eds.), *The international handbook of teachers and teaching* (pp. 1-90). Dortrecht: Kluwer.

Osborne, R., & Freyberg, P. (1985). *Learning in science*. *The implications of children's science*. Hong Kong: Heinemann.

Powell, C.P., & Anderson, R.D. (2002). Changing teachers' practice: Curriculum materials and science education reform in the USA. *Studies in Science Education, 37*, 107-136.

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 36,* 1-44.

Shireen Desouza, J.M. & Czerniak, C.M. (2003). Study of science teachers' attitudes towards and beliefs about collaborative reflective practice. *Journal of Science Teacher Education, 15*(2), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Skamp, K. (2004). *Teaching primary science constructively* (2nd ed.). Victoria, Australia: Thomson.

Tytler, R. (2003). A window for a purpose: Developing a framework for describing effective science teaching and learning. *Research in Science Education, 33*, 273-298.

Wallace, J., & Louden, W. (2000). Interests and forms: Johanna. In J. Wallace & W. Louden (Eds.), *Teachers' learning*. *Stories of science education* (pp. 99-125). Dordrecht: Kluwer.

Walshaw, M. (2001). Engaging postpositivist perspectives in mathematics education. In R. K. Coll (Ed.), *SAMEpapers* (pp. 19-33). Hamilton, New Zealand: Centre for Science, Mathematics and Technology Education Research, University of Waikato.

Weinburgh, M. (2003). Confronting and changing middle school teachers' perceptions of scientific methodology. *School Science and Mathematics, 103*(5), 222-232.