

Using Action Research for Large-scale Teacher Professional Development:  
Research in Science and Technology Education  
(Ph.D. Thesis Proposal)

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In an effort to explain why I have settled on exploring the use of action research (a definition of action research will be detailed later in the paper) as a mechanism to promote the professional development of teachers (again, this term will be defined later in this paper), I will tell you the story of my own teaching experiences and my own attempts to develop my pedagogical understandings and skills. The story goes something like this:

## **Early Experiences**

Following the completion of an undergraduate degree in Marine Biology at the University of Guelph (Guelph, ON) and nine months of field work as a biological (primarily limnological, oceanographic and ecological work) consultant for a private firm in Sidney, B.C., I found myself back in an academic environment, the University of Victoria (Victoria, B.C.), in the Post-Degree Professional Teaching Program. This year long program was designed for those who had completed a degree and wanted to gain teacher certification in B.C. An additional half year of courses was required for a second, B.Ed., degree . I decided not to follow this second option. While enrolled in the program at U.Vic, I was exposed to my first professional development program. Even though I was required to attend and pass the usual types of courses (History of Education in Canada, Reading and Writing, Assessment and Evaluation, Psychology of Adolescents, and Science Methods), I experienced the greatest satisfaction and the greatest growth in teacher development in the classrooms of Victoria schools. Already at that time, I instinctively suspected that the transmission of theoretical elements in the university classroom would never match the learning opportunities for teachers that were available when interacting with ‘real’ students in ‘real’ classroom situations.

For the next four years I taught Science and Mathematics courses (among others such as

Introductory Computers, Vocal Music to forty junior high students and Introductory Accounting) in a private school in Calgary, AB. While endeavouring to ‘find my feet’ in the application of classroom management techniques, develop appropriate lesson plans and struggle to complete all of the administrative tasks as the lone science teacher in a small school, I found very little time to work on my development as a ‘reflective practitioner.’ In fact, I had a few opportunities to begin moving in new directions. I attended a professional development course that was offered by the University of Calgary and was introduced to ‘The Learning Cycle’ (Bernie, 1981), similar to other theories that I was exposed to later. This initial exposure, while not immediately fruitful (I could not determine how to use the theory in my classroom at the time and had no support inside or outside of the school to do so), would act as a catalyst for some of the changes I would make in my teaching later.

During my tenure in Calgary, I had the pleasure of working with an OISE Master’s Student. This student worked with me for a few weeks, offering her insights and suggestions as to how to improve my teaching. This, in effect, was an action research program designed for one, me. I was able to take some of the suggestions of this consultant and try them out in my classroom and then share my experiences. The main drawbacks, as I saw them, to this experience were several: short time span leading to limited opportunities for improvement and sharing, the imposed nature of the situation since working with the consultant was a requirement of my working conditions, and the experiences of the consultant as she was not a science teacher and therefore I had to improvise many of the suggestions into a science environment. However, the interactions between myself and the consultant instilled in me a desire to work with teachers in similar situations in a collaborative way so as to improve all of our practices.

For family reasons I left the school in Calgary and took a position as science department head in a private high school in Chatham (Chatham, ON) for the next three years. The ‘head’ position was somewhat euphemistic in that I was the only full-time science teacher (with some responsibilities for Mathematics). Other teachers would pick up individual science courses as required by the time table. I was responsible, though, for setting the science ‘tone’ (the

philosophical tact used for all the science courses) and all administrative tasks (ordering supplies, inventory, etc.). While in Chatham, there were few opportunities for professional development. Annual conferences, offered yearly for and by teachers employed in the same school and other similar private schools in Ontario, were of the one hour workshop course type. There was no follow-up to any of these sessions and application by individual teachers was left strictly to the individual teachers.

In retrospect, it occurred to me that the weekly full-staff (8-10 teachers) review sessions that occurred in this school were professional development sessions. In some ways they were also of an action research nature, although not formalized in any way. We would sit around and discuss how the week had gone, what the joys and sorrows had been, which students were having difficulties and usually what type of interventions could be devised in order to address the concerns that were perceived. The collaborative nature of these discussions and the resulting decision making was a precursor to my interests in this type of methodology.

Transferring to the public system in the Toronto area opened possibilities to me that had not been previously available. This move occurred when the provincial government was in the process of rewriting the entire curriculum in order to make it 'objective' oriented, *The Common Curriculum* (Ministry of Education, 1993). The school that I joined was the site of a designated 'pilot project' and I participated in the collaborative production of curriculum materials that would be used in the Gr. 9 Science program for the following year. The materials combined 'hands-on' problem solving activities in an integrated mathematics-science program. Only three individuals from a large staff were involved in this curriculum development project and, at the end of the school year, I was transferred to another school. The entire science and math departments were not involved in the development of the pilot program and as a result it was difficult to make substantial changes to teacher understanding and pedagogy. I heard few comments about the fate of the project and with a change in government the direction of public education was about to change again.

In my new school I marked time over the next few years taking a few additional qualification courses in Mathematics and Honours Specialist Science-Biology but generally attempted to hone my skills as an Intermediate-Senior Science teacher in the public system. This entailed getting to know the new curriculum, building rapport with students and staff and generally finding my niche in a new school and a new system.

It was during the Honours Specialist program that I heard an invitation by a doctoral candidate from OISE to become involved in an action research project centring on project work in science. For the next four or five years, in conjunction with the action research team (consisting of five or six individuals from public and separate boards in the area, and the in-school team, consisting of all teachers who had teaching responsibilities for Gr. 9 and the department heads), we worked at developing a science program that centred itself on student designed project work. The program was based on a model designed by the external action research team. Due to the extraordinary conditions that existed in the school in which I was placed and the willingness of those involved to change teacher and student attitudes and practices, the program thrived. Students who were previously self-described as mediocre started to encounter success. Similar changes were subsequently made to the Grade 10 program and changes in structure and methodologies could be seen in senior level courses. The number of students enrolling in science courses past those required increased and classrooms were converted from other subjects. The most noticeable changes which occurred were among the science department staff. Although the weekly or bi-weekly (we did both) meetings were referred to in (derogatory) ways by many of the staff, the business of planning out the curriculum and interventions for the students was heady and many, if not all, of the staff were changed substantially. For a more detailed report of this project see the unpublished doctoral thesis of J.L. Bencze (Bencze, 1995).

I was subsequently promoted to department head in this same school and, in less than half a year, I became the Curriculum Coordinator of Science (K-12) for the school board and, after the amalgamation of this board with several others in the area, continued in this role for the next two years. While I had the responsibility to support the science teaching staff in, initially,

approximately one hundred and sixty schools, and then, following amalgamation, over five hundred schools, I found that there was no effective way of communicating with all of those teachers, let alone to try to effect changes in their practice. The Instruction/Program department had the ability to send information out to the teaching staff but no way to determine if the communication was read or followed. Typical teacher support consisted of providing stand-alone workshops and, if time permitted, some contact with individual teachers in their classrooms. This was very frustrating and highly ineffective for both the teachers and myself.

As a consequence of further curriculum changes by the provincial government, science teachers in elementary grades (almost all elementary teachers for Grades 1-6 since these teachers are responsible for teaching their particular group of students most subjects, including science) had to cope with a brand new set of 'expectations' which included many topics taken from higher grades and the subject of technology which was integrated with science (Ministry of Education, 1998). Many teachers felt that they did not have the content knowledge nor the pedagogical background required to address the new expectations. As a result, I, with the support of the rest of the S&T curriculum support team, embarked on the production of sixty curriculum units. Twenty-two of these units were eventually produced and prepared for distribution, both electronically and in hard copy form, to the teachers of the system. A more detailed description can be found in the unpublished account of the project (van Oostveen, 2000).

Each of these curriculum documents were written by a team of teachers (pairs of classroom teachers who were invited to participate) and then edited by a central team of non-classroom teachers. The teachers involved grew in their knowledge and understanding of the curriculum in ways of presenting the material to students, however again, there was no way to ensure that the recipients of the materials (classroom teachers in any of the more than 500 schools) would understand or be able to use the materials in any more than a superficial way. Since the function of these units was only to be an initial introduction to some new methodologies for classroom use and also to give teachers a much needed assurance to work through the first few attempts at teaching certain topics, I feel that the curriculum units would have been a success if they had

been released. However, as a means of professional development, they were a spectacular flop. This was an example of a top-down initiative at its worst. In addition to the imposed curriculum directives from the government, here were new imposed curriculum units outlining the ‘how to do it in the classroom’ from the teachers’ own school board. Teachers generally were not given the opportunity for ownership of the new materials, nor were they given the required support (although series of rotating workshops were offered and attended by many teachers), and finally teachers believed that they had to follow the pedagogical directions in the units and were not able to modify the materials for their own uses in their own classrooms.

Following this experience and another refresher course on action research at OISE/UT, I was prepared to have another shot at professional development for teachers in my school board using action research as the primary methodology since, in my experience, this is the mechanism that seems to have the best chance for success in allowing teachers to come to grips with the issues confronting them.

The remainder of this paper will be devoted to exploring the literature regarding professional development for teachers and action research and why these are suited to be used in conjunction with each other. I will also outline the methodology that I intend to use to study a group of teachers as they proceed through cycles of action research in an attempt to improve their own teaching.

## **Professional Teacher Development**

Professional Teacher Development would seem to imply an improvement or, perhaps, a maturing in the arts that define teaching. Susan Noffke (1997) suggests that this development can be in two different areas. Noffke, in this paper which summarizes and analyzes much of the work around action research into the 1990's, talks about developing the ‘knowledge base’ of educational research, which would not only include the theoretical understandings but also the methodologies needed to put those theories to work, as well as “creating a form of social inquiry responsive to

the process of education.” The development of the knowledge base has been done through the contributions of teachers in the form of curriculum theorizing and through the production of data upon which further reflection and theorizing can be done. The process of changing the practices of teaching through the inclusion of teacher research is used by Noffke to illustrate the social inquiry side of her equation. Types of research that have an impact on changing the working conditions of teachers and consequently on student learning conditions are reported to contribute to the development of this social inquiry. Another positive aspect that is reported here is that of partnerships that have been created between academic researchers, and institutions and teachers.

Sagor (1992) adds to these definitions when he states that the teaching profession differs from that of other services in several notable ways. These factors give clues as to how Sagor defines a profession. Sagor suggests that other professionals interact with each other as well as their clients on a daily basis. The “interactions with other professionals stimulate and push these people to new levels of performance in both the art and the craft of their profession.” He goes on to suggest that teachers, due to the structure of the school day and other pressures, rarely interact with each other except perhaps at staff meetings and then these meetings are rarely held to talk about advancing the teaching profession. He also argues that teaching does not have a certain and finite knowledge base but that generalized solutions to the problems of teaching, which tend to be very context sensitive, are not usually easily, if at all, found. Experiential learning is very important and if the experiences cannot be discussed on a regular basis then the problems will not be solved and most likely will be compounded instead.

A second factor that Sagor identifies as part of the teaching profession deals with contributions to the knowledge base. While he holds that the teaching profession is informed by a knowledge base, Sagor contends that the teaching profession does not interact with and contribute to the development of this knowledge base. School teachers’ work is not generally found in the literature, instead the educational journals tend to be the domain of educational researchers, professors and others in academic circles but not in the classroom. Professional workers, according to Sagor, need to not only access a body of knowledge but also must be giving the

opportunity to add to that knowledge.

The final factor that Sagor identifies as part of the definition of the teaching profession has to do with the 'separation of quality control.' According to Sagor, most professions involve self-assessment as measured against a standard established inside the profession itself. This does not seem to be the case with teachers. Much of the assessment that occurs within teaching is in the hands of the administration (principals and other designates) and, with the changes the government is instituting in Ontario, increasingly lies in the political arena.

## **Action Research**

Traditional educational research can be viewed as 'process-product research', according to Cochran-Smith and Lytle (1990). The processes involved are those used by the teacher and students reaction (hopefully while learning) becomes the product. This view of education research is very much linear and abstracts from classroom reality to a large extent. This view creates time lags between the research and the implementation of the intervention as well as other problems when attempting to improve teaching using the research results (Tarachnick and Zeichner, 1999). One of the worst problems caused by this type of research is that it relegates the teacher to the position of 'technician'. Teaching becomes a matter of using the correct technique at the appropriate time to achieve the highest possible scores on standardized tests (Cochran-Smith and Lytle, 1990), where the relationship between teaching and learning is inherently confounded (DiGisi et al., 1999) This way of thinking suggests that it doesn't make sense to isolate factors and abstract from the complex mess that is the classroom, but rather focus on acting within the complexity and endeavour to make some sense of the result through reflection. This, in essence, is action research.

Action research has been defined by many writers over the past few decades. DiGisi et al. (1999) talk about collaborative research which "seeks to increase the likelihood of research being utilized by including practitioners as partners in the research." Davis (1996) focusses on the

processes of self discovery and realization (presumably the process of accommodating changes in pedagogical style and understanding into a teacher's thought structures and practices) through the practice of having teachers take on the role of researchers within their own classrooms. van Zee (1998) uses Richardson's (1994) definition, in which teacher research is said to be practical in nature. Teachers undertake this research in order to help them understand the teaching situations in which they find themselves and to, as a result, change their practice or, perhaps, just increase their understanding.

Other writers define action research as 'collaborative self-reflective inquiry' (Tabachnik and Zeichner, 1999; Hewson et al., 1999; Zeichner, 1993). This definition emphasizes the collaborative nature of the reflection including the teachers' sharing of their experience, listening to other's thoughts, making suggestions in response to other's and trying to apply other teachers ideas to your own situation. Tabachnik and Zeichner also focus on the notion of strategic action. This notion calls for teachers to plan and carry out interventions in their classroom so as to bring about desired change. The document prepared by the PEEL project team in Australia recount successive waves of this type of strategic action (Mitchell et al., 1995; Baird and Mitchell, Eds., 1987; Baird and Northfield, Eds., 1992). Pedretti's (Pedretti, 1996; Pedretti and Hodson, 1995) definition seems to be in this some vein - take action.

Feldman and Atkin (1995) and Feldman (1994) suggest that action research incorporates four distinct characteristics: 1) Action research is collaborative; 2) Teachers focus on their own practice; 3) It is self-developmental and; 4) These is a significant moral component to the process.

Action Research is designed to improve "practice by developing the practitioner's capacity for discrimination and judgement in particular, complex, human situations" according to Elliott (1992). Elliott states that "the improvement of teaching is not so much a matter of becoming better at implementing an externally designed curriculum, but of developing one: whether it is self-initiated or initiated by outsiders."

Noffke (1997) takes a more philosophic view of action research when she suggests, in a review of the action research literature compiled to date, that action research should be seen to include a variety of dimensions, namely the historical, professional, personal and political. Much of this work seems to follow from the earlier discourse of Grundy (1987) in which three cognitive interests of curriculum are noted, the technical, the practical and the emancipatory.

The technical interest deals primarily with “controlling and managing the environment” or “controlling the environment through rule-following action based upon empirically grounded laws” (Grundy, 1987). Essentially this dimension refers to the use of ‘experimental’ research in order to produce ‘positivist’ knowledge of teaching grounded in observations and experiences of the world, i.e. the ‘process-product’ type of knowledge suggested by Cochran-Smith and Lytle.

The practical interest is focussed on understanding; “understanding the environment so that one is able to interact with it” or “ understanding the environment through interaction based upon a consensual interpretation of meaning” (Grundy, 1987). According to Grundy, this interest includes understanding the environment in such a way as to know something of the best thing to do in circumstances, that is to include moral and rational judgements. This understanding is developed only in agreement with other practitioners.

Perhaps the most important interest is the final one - emancipatory. Grundy expresses the emancipatory interest as being individualistic using self-reflection as a primary mechanism. The notions of justice and equality are included into emancipation. Grundy (1987) defines the emancipation interest as “a fundamental interest in emancipation and empowerment to engage in autonomous action arising out of authentic, critical insights into the social construction of human society.” The emancipatory interest draws teachers and, through them, their students to change their learning environment in ways that allow for “social and political ideas of freedom, equality and justice” (Grundy, 1987)

While this list is by not means comprehensive, it outlines many of the issues that this particular

proposal is meant to address. This action research project is designed to be collaborative (groups of teachers working together), practical (designing interventions for immediate use in the classroom), informed (accessing information outside of their own sphere through the facilitation of a university researcher), and focussing on self-discovery of and by the teachers. The project will take action in the classroom and beyond. It will be developmental, professional and emancipatory.

## **Intent of Action Research as Professional Development Project**

The project is designed to encourage elementary and secondary teachers in the a school board to undertake collaborative action research, focussing on exemplary science and technology education. The objectives of the project will include:

- A. Understanding the nature of collaborative action research in the context of elementary or secondary school science (and technology) education;
- B. Establishing traditions of reflective practice, professional development and collaborative professional growth with teachers;
- C. Developing curriculum materials to encourage and support exemplary practice in science (and technology) teaching and learning; and,
- D. Illuminating the nature of professional alliances through a university-district school board collaboration.

## **Methodology**

In consultation with the large school board to which I am associated, it was decided to proceed with an action research project involving small groups of teacher volunteers from a family of schools working collaboratively with a facilitator over several months. The teachers will work together through a process designed to identify issues of significance in their own teaching, attempt to make changes in their teaching, and then discuss their experiences before trying the next change. This process is action research in essence. McNiff (1988) , Sagor (1992), Sagor

(2000), Hoepfl (1997) and Maykut and Morehouse (1994) were used in the design of the processes and data collection techniques described below.

## **Recruitment of Teachers**

Teachers, in consultation with their school principals, will be recruited using an invitation issued using the board's electronic bulletin-board to the entire system. The teachers will be asked to volunteer using the following selection criteria as a guide to their suitability:

- curriculum leadership potential
- project loyalty
- strong commitment to professional development
- willingness to reflect on experience, try their ideas out in the classroom and critique those ideas afterwards
- willingness to participate in an educational research project
- willingness to participate in collaborative group work
- experience in curriculum development

All volunteers will be accepted to the project and no attempt will be made to select any particular participant. In order to ensure the maximum randomization, teachers in schools across most of the district will participate. The teacher volunteers will come from a wide variety of schools; some adjacent, some within the same school, and some from schools that are widely separated. Some of these scenarios will allow the teachers to rely upon the support of teachers within their own school. Some teachers will be able to contact and rely upon other teachers within their own family of schools and still others will not have immediate contact with other participating teachers outside of team meetings. This spectrum should ensure that variation within the support structure can be studied in order to determine the most effective means of carrying out this type of professional development program.

While the researcher will focus on one group only, additional data will be collected from the

other groups simultaneously in order to have data coming from different sources. The data from the different sources can then be used to support any conclusions that are drawn and therefore minimize the distortions that may occur (Hoepfl, 1997).

The participating teachers will be brought together as a large group at the beginning of the project. This meeting will be used for a variety of purposes. The initial use will be as an orientation to the project and action research. Each teacher will be given a copy of a text (Sagor, 2000) which will be used as a means of introducing the teachers to the intentions and methods of action research. This meeting will be used for an initial team meeting with teachers determining their areas of interest for the focus of the action research and an attempt to formulate a problem statement for their group (Sagor, 1992). Finally, the meeting will be used to collect some of the data, described below, needed at the beginning of the project from each teacher.

## **Data Collection Methods**

The following methods of will be used to collect data:

- Participant Observation of group meetings using audio recordings  
Audio recordings of teacher contributions and sharing will occur on a weekly basis. In addition, anecdotal participant observations of general involvement of the teachers will be noted. (Maykut and Morehouse, 1994) Essentially these observations will serve as a record of those items of interest which will not be apparent on the audio recordings, such as the level of interest expressed by the teachers. The recordings and observations will be used as available as a record of all the action research project in process. Teacher planning of interventions, their accounts of their experiences will carrying out the interventions, their perceptions of the impact of their impact and their critique of their efforts will all be present in the recordings. It is hoped that the progress of the teachers as they become more skilled in their use of the research techniques will be readily apparent.
- Interviews of all participants

All participants will be interviewed and audio recorded by the researcher both at the outset and the conclusion of the study. The interview will use a semi-structured format with the questions focussing on the perspective of the teachers with regards to their own feelings about science, science education and professional development. It is hoped that evidence of professional growth will be displayed when the two interviews are compared (Hoepfl, 1997; McNiff, 1988)

- Journal entries by participants

Teachers will be asked to keep a journal of their activities and thoughts while participating in the project. The entries will be primarily meta-cognitive in nature (thoughts about their thinking) so that the researcher will be able to approximate changes in attitude and understanding throughout the project. It is expected that these journals will be brief and incomplete due to the finite amount of the time the teachers will have to work on them. A total of 2-3 paragraphs per week per teacher are expected. Facilitators will be expected to keep a journal of their experiences as well. (Maykut and Morehouse, 1994)

- Quantitative Methods (Nature of Science Profile and Repertory Grids)

‘Nature of Science Profile’ (Nott and Wellington, 1993)

This survey is designed to encourage teachers to critically examine their understanding of the nature of science. The survey is primarily numerical and graphical in nature. It will also be used as a method of determining if a shift in the teacher’s understanding of the nature of science has occurred through the course of the project as the survey will be administered at the beginning of the project and again towards the end.

‘Repertory Grids’ (<http://gigi.cpsc.ucalgary.ca/WebGrid/>)

A repertory grid is a graphic and number way of illustrating associations between various ‘constructs’ and between various ‘elements.’ It can be used by teachers to make their understanding and beliefs regarding the various ‘elements’ explicit to themselves and

others (Bencze, 1995). Again, it is expected that changes in the repertory grids between the beginning and ends of the project will be interpretable as growth in the understanding and skills of the teachers.

- **Documentary Materials** (including material produced by the participating teachers, as well as samples of students' work, as identified and collected by the teachers)  
This type of documentation will add credibility to the sharing of teachers experiences in the main meetings and will be used in conjunction with the audio recordings and the anecdotal observations made during the meetings.
- **On-line dialogue using First Class or Web Knowledge Forum** (open conversations between participating teachers on topics of their choice)  
In an attempt to create a community of 'knowledge builders' (Bereiter et al., 1997), an on-line dialogue forum will be used for communication between participant teachers and will include the facilitators. This will give additional opportunities for all involved to build new understandings in the 'third world' of Bereiter and Popper (Bereiter, in press). Teachers will be encouraged to interact with each other for a minimum of 10 min per day using this forum throughout the project.

It is expected that this project will add to the professional development of the school board teachers who will be participating. In addition to the data collection for the purposes of the thesis development that will follow this paper, it is hoped that a report of the feasibility of using this type of process can be used produced using the same data. However, most importantly it is hoped that the teachers will grow in professional development using action research as main modus operandus.

## References

- Baird, J.R. and I.J. Mitchell (Eds.) (1987). *Improving the Quality of Teaching and Learning: An Australian Case Study - The Peel Project*. Melbourne, Australia, Monash University Printery.
- Baird, J.R. and J.R. Northfield (Eds.) (1992). *Learning from the Peel Experience*. Melbourne, Australia, Monash Print Services.
- Bencze, J.L. (1995) *Towards A More Authentic and Feasible Science Curriculum for Secondary Schools*. Unpublished Doctoral Thesis, OISE/UT
- Bereiter, C. (in press). *Education and Mind in the Knowledge Age*.
- Bereiter, C., M. Scardamalia, C. Cassells, and J. Hewitt (1997). Postmoderism, Knowledge Building, and Elementary Science. *The Elementary School Journal*, 97(4): 329-340.
- Birnie, H.H. (1981). *An Introduction to the Learning Cycle*. University of Saskatchewan, Saskatoon, Saskatchewan.
- Cochran-Smith, M. and S.L. Lytle (1990). Research on Teaching and Teacher Research: The Issues That Divide. *Educational Researcher*, 19(2): 2-11.
- Davis, N.T. (1996). Looking in the Mirror: Teachers' Use of Autobiography and Action Research to Improve Practice. *Research in Science Education*, 26(1): 23-32.
- DiGisi, L.L., A. Nix, K. Daniels, L. Kramer, and S. Cyr (1999). Embracing the Complexity of Inclusive Science Classrooms: Professional Development Through Collaboration. *Research in Science Education*, 29(2): 247-268.
- Elliott, J. (1992). The fundamental characteristics of action research. In Elliott, J. (1992). *Action Research for Education Change*. Philadelphia: Open University Press. (pp. 49-56).
- Feldman, A. (1994). Erzberger's Dilemma: Validity in Action Research and Science Teachers' Need to Know. *Science Education*, 78(1): 83-101.
- Feldman, A. and J.M. Atkin (1995). Embedding Action Research in Professional Practice. In Noffke, S., and R. Stevenson (Eds.) (1995). *Education Action Research: Becoming Practically Critical*. New York: Teachers College Press.
- Grundy. S. (1987). *Curriculum: Product or Praxis*. London: The Falmer Press.

- Hewson, P.W., B.R. Tabachnick, K.M. Zeichner, K.B. Blomker, H. Meyer, J. Lemberger, R. Marion, H. Park, and R. Toolin (1999). Educating Prospective Teachers of Biology: Introduction and Research Methods. *Science Education*, 83: 247-273.
- Hoepfl, M.C. (1997). Choosing Qualitative Research: A Primer for Technology Education Researchers. *Journal of Technology Education*. 9(1): 47-63.
- Maykut, P. and R. Morehouse (1994). *Beginning Qualitative Research: A Philosophic and Practical Guide*. London: Falmer Press.
- McNiff, J. (1988). *Action Research: Principles and Practice*. London: Macmillan.
- Ministry of Education and Training, Ontario (1995). The Common Curriculum: Policies and Outcomes, Grades 1-9. Queen's Printer for Ontario.
- Ministry of Education and Training, Ontario (1999). The Ontario Curriculum: Science and Technology, Grades 1-8. Queen's Printer for Ontario.
- Mitchell, J., L. Rijnveld, and I. Mitchell (1995). About Peel: The Project for Enhancing Effective Learning. Melbourne, Australia. Monash Education Faculty.
- Noffke, S.E. (1997). Professional, Personal, and Political Dimensions of Action Research. In Apple, M. (Ed.) *Review of Research in Education*, 22, Washington, D.C, American Educational Research Association.
- Nott, M. and J. Wellington (1993). Your nature of science profile: an activity for science teachers. *School Science Review*, 75(270): 109-112.
- Pedretti, E. (1996). Learning about science, technology, and society (STS) through an action research project: Co-constructing an issues-based model for STS education. *School Science and Mathematics*, 96(8): 432-440.
- Pedretti, E. and D. Hodson (1995). From Rhetoric to Action: Implementing STS Education through Action Research. *Journal of Research in Science Teaching*, 32(5): 463-485.
- Repertory Grids found at <http://gigi.cpsc.ucalgary.ca/WebGrid/>
- Sagor, R. (1992). *How to Conduct Collaborative Action Research*. Alexandria, Virginia: Association for Supervision and Curriculum Development.
- Sagor, R. (2000). *Guiding School Improvement with Action Research*. Alexandria, Virginia: Association for Supervision and Curriculum Development.

Tabachnick, R.R. and K.M. Zeichner (1999). Idea and Action: Action Research and the Development of Conceptual Teaching of Science. *Science Education*, 83: 309-322.

van Oostveen, R.H. (2000). Resource Packs: Views from the Field. Unpublished doctoral course paper. OISE/UT

van Zee, E.H. (1998). Preparing Teachers as Researchers in Courses on Methods of Teaching Science. *Journal of Research in Science Teaching*, 35(7): 791-809.

Zeichner, K.M. (1993). Action Research: personal renewal and social reconstruction. *Educational Action Research*, 1(2): 199-219.