Volume 20 • Issue 2 (2017)

Purposeful Action Research: Reconsidering Science and Technology Teacher Professional Development

Roland vanOostveen

Abstract

Initial plans for this project arose from a need to address issues of professional development of science and technology teachers that went beyond the norm available within school board settings. Two teams of 4 teachers responded to an invitation to participate in a collaborative action research project. Collaborative action research was chosen in order to address issues of

ROLAND VAN OOSTVEEN

Dr. Roland van Oostveen is Associate Professor at the Faculty of Education, UOIT and Director of the EILAB. He is author of the Fully Online Learning Community (FOLC)

inadequate teacher interaction around pedagogical structures and processes, insufficient opportunities to access and add to the professional knowledge base and a perceived lack of teacher control of the teaching environment enabling them to make decisions that they consider appropriate for their local classrooms, schools and students. Early in the project, it became apparent that the collaborative nature of the action research engaged in by the participating teachers needed to be modified. The modified collaboration, termed purposeful action research, allowed the teachers to grow in a number of dimensions of action research. The article concludes with a number of recommendations for those hoping to employ a similar methodology.

Keywords: science and technology education; teacher professional development; purposeful action research; collaborative; community of learners;

Introduction

The subject for this project grew out of frustration teachers were experiencing with methods of professional development available to them through district boards of education, professional organizations and the Ontario Ministry of Education and Training. Complicating this was the release of new provincial curriculum guidelines (Ministry of Education and Training, 1998) that were to be implemented by teachers who felt inadequate for the task. In my dual role as teacher in-service support for science and technology at a district school board and teacher-in-residence at a local university, I had access to a wide variety of resources to develop, implement and study action research as a form of teacher professional development. More importantly, I was in contact with a

model, and a proponent of technology-enriched, democratized learning. Current areas of research include problem-based learning, digital competencies, and socio-physiological facets of human interaction in online communities. With a view towards cross-cultural exploration of online learning, Professor van Oostveen collaborates with researchers at universities throughout Canada and around the world.
roland.vanoostveen@uoit.ca

number of teachers who were eager to explore alternate methods of professional development.

Collaborative action research was used as a means of providing authenticity to the teacher development process by: 1) giving teachers opportunities to improve their understanding of their subject matter, 2) giving teachers opportunities to improve their own practice, and 3) determining factors which may affect this type of professional development. It was anticipated that the collaborative process would help to inform the nature of teacher change. Part way through the project, it became apparent that collaborative action research would not be sufficient to provide a broad perspective for teachers to use as a basis for reflection on their practice. Consequently, the nature of the interactions within the team meetings changed and the entire group embarked upon a variation of collaboration, referred to as *purposeful action research*. A number of questions about teacher change laid the foundation for my investigations:

1. What is the nature of the reflection when teachers participate in *purposeful action research*?
2. In what ways did teachers' attitudes and understandings towards current issues in science and technology education (aims of science education, scientific literacy, constructivism, nature of science and technology) change after participating in *purposeful action research*?
3. What was the role of the facilitator? How did the facilitator support and foster change?
4. What are the elements of an effective relationship between professional development and teacher change? How can the relationship be fostered?

Background and Educational Context

Ontario teachers were given a formidable challenge in implementing the Elementary Science and Technology curriculum (Ministry of Education and Training, 1998) and the Secondary Science curriculum (Ministry of Education and Training, 1999, 2000). The curriculum requires both elementary and secondary levels teachers to have a deep conceptual understanding of: biology, chemistry, physics, geology, astronomy and a variety of technologies that complement these subjects. While the curriculum poses a problem for secondary school teachers due to the immense number of expectations given and the inclusion of topics such as geology and astronomy that few teachers have studied in great depth, the situation was even more desperate for elementary school teachers. In Ontario, secondary school teachers are generally specialists in one or more subject areas by virtue of an undergraduate degree in that subject or one that is related. Few intermediate (Grade 7 - 10) teachers have these qualifications and it is rare for teachers in the lower grades to have them. In addition, elementary teachers are expected to address all of the five strands that are present in the curriculum. Many of these strands include references to broad-based technologies such as pulleys, gears and levers, for example. Most elementary teachers do not have an adequate background to teach these strands effectively.

While the implementation of the curriculum took place over several years, school boards across the province scrambled to find ways to support their teachers during this transition phase. The Ministry of Education, with the assistance of ‘expert’ teachers, devised the curriculum and distributed it to the provincial school boards. The

Ministry traditionally disseminated curriculum instructions to school boards and teachers via directives, guidelines, advisory bulletins, and more recently, through 'train-the-trainer' sessions for centrally assigned consultants and lead teachers (Fullan, 1992, 1993; Olson, 1990). According to Fullan (1992, 1993), such approaches often fail, largely because no account is taken of the individual teacher's previous experiences, personal theories and values. No acknowledgement is made of the uniqueness of each educational environment, and there is seemingly little appreciation that teaching is a complex, fluid and uncertain enterprise. Simultaneously, teachers feel disenfranchised and oppressed since the curriculum is imposed upon them (Johnston, 1994). Consequently, the setting was ripe for an alternate form of professional development.

Action Research as Teacher Professional Development

It has proven difficult to define what teacher professional development means. This may partially be due to a broadly-based assumption that teachers are aware of the characteristics of effective, authentic professional development. For this study, the primary characteristics for authentic teacher professional development were drawn from sources which suggest that teaching is more like creation of an artisan than a technician (Hodson, 1998), where authentic teacher professional development would seem to imply an improvement, or perhaps a maturing in the arts that define teaching. Little (as cited in Burnaford, 1999) suggests that teacher professional development should include the following principles:

1. Offers meaningful intellectual, social, and emotional engagement with ideas, materials, and colleagues.

2. Takes explicit account of the contexts of teaching and the experience of teachers.
3. Offers support for informed dissent.
4. Places classroom practice in the larger contexts of school practice.
5. Prepares teachers (as well as students and parents) to employ the techniques and perspectives of inquiry.
6. Involves governance that ensures a balance between the interests of individuals and the interests of the institution.

Carr and Kemmis (1986) and Sagor (1992) examined the essential characteristics of authentic professional development comparing the teaching profession with other professions. Sagor (1992) indicates that most other professionals interact with each other as well as their clients on a daily basis and that these "interactions with other professionals stimulate and push these people to new levels of performance in both the art and the craft of their profession" (Sagor, 1992, p. 2). 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 these meetings are rarely held to talk about advancing the teaching profession. He also argues that the knowledge base for teaching is not as defined and certain as that found in other professions such as law and medicine. In addition, generalized solutions to the problems of teaching, which tend to be very context sensitive, are difficult to determine.

A second component that Sagor (1992) 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 teachers do not interact with and contribute to the development of this knowledge base. Teachers' work is not generally published in the academic literature. Rather, publishing in educational research journals tends to be the domain of educational researchers, professors and others in academic circles but not in the classroom. Carr and Kemmis (1986, p. 8) claim that "theory and research play a much less significant part in teaching than they do in other professions." Regardless of how teachers view theory, they must not only access the existing body of knowledge but also take advantage of the available opportunities to add to that knowledge. Teachers therefore need to interact with their academic colleagues in such a way that both groups are mutually supportive of each others' efforts, or as Carr and Kemmis suggest: "The attitudes and practices of teachers must become more firmly grounded in educational theory and research" (1986, p. 9).

The final component that Sagor (1992) identifies as part of the definition of the teaching profession entails the 'separation of quality control.' According to Sagor, most professions involve self-assessment as measured against a standard established within the profession itself. Most professions also subject their professionals to a far more extensive pre-service instruction schedule, including rigorous and constant in-service training. However, 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) through annual reviews. In contrast, authentic professional teacher education should allow teachers to regain control of the teaching environment enabling

them to make decisions, within the context of the learning community in which they work, that they consider are appropriate for their local classrooms and schools. Carr and Kemmis (1986) agree that teachers are severely limited in the autonomy that they possess. “Teachers operate within hierarchically arranged institutions and the part they play in making decisions about such things as overall educational policy, the selection and training of new members, accountability procedures, and the general structure of the organizations in which they work is negligible” (p. 39). Accordingly, in order to make teaching a more professional activity, teachers must take advantage of existing opportunities to participate much more widely in the decision-making process.

The challenge becomes one of attempting to engage teachers in authentic teacher professional development which reflects the characteristics noted earlier by Sagor (1992), with teachers interacting with each other in professional ways, accessing the academic literature, and reassuming quality control. In the estimation of this author, the most effective way of achieving this would be to have teachers meet in small groups where they could interact with each other and the established knowledge base, discussing which theory(ies) would be most appropriate to their given situations. They need to be given opportunities to construct plans, try some strategies out in their classroom, reflect on those experiences and then come back to the group and critique what happened. The teachers should take their reflections, the criticisms and ideas of their colleagues, and make new plans that they can take back into their classrooms for another cycle of action. I am, of course, describing collaborative action research (James, 2006;

Kemmis, 2006; McPherson & Nunes, 2004; Sagor, R., 1992)

In other settings collaborative action research has been used as a means of providing authenticity to the teacher development process by: 1) giving teachers opportunities to improve their understanding of their subject matter, 2) giving teachers opportunities to improve their own practice, and 3) determining factors which may affect this type of professional development (Pedretti et al., 2002). It was anticipated that the collaborative process would help to inform the nature of teacher change throughout this project. Part way through this project however, it became apparent that collaborative action research would not be sufficient to provide a broad perspective for teachers to use as a basis for reflection on their practice. It is my contention that teachers need to have access to theoretical and pedagogical issues and concerns that impinge on their practice but of which they may not be aware. Typically, in-service teachers seem to be overly concerned with the practical aspects of teaching, for example which activity should be used to address this specific expectation and how to respond to the unruly behaviour of a specific student. The issues of systematically planning and implementing a consistent science program that addresses topics such as critical scientific literacy seem to become lost in the business. Consequently, I intended to give teachers opportunities to build a deeper understanding of science and technology theoretical constructs while simultaneously exploring pedagogical strategies for classroom use. I felt that one way to do this would entail the establishment of a learning community of teachers complete with a facilitator who could intervene, as necessary, to provide this ‘outside’ perspective and to provide access to

additional resources. When this change was implemented in the project teams, the nature of the interactions within the team meetings changed and the entire group embarked upon a variation of collaboration, which was referred to as *purposeful action research*.

Research Design

Two teams of volunteer teachers (each ultimately with 4 teachers) were formed. One team, (termed the East Team due to the relative locale within the school board of the teachers) was the focus for much of the study. This particular team of teachers was chosen for close scrutiny because of its unique mix of experience and representation from both the elementary and secondary ranks. I facilitated this group. The second team, the North Team, carried on with another facilitator, and followed the same methodology as the East Team. All teachers proceeded to reflect on their practice and to modify it based on theoretical and practical considerations of their own choosing. Pseudonyms were assigned to all the teachers who participated in the project. All teachers, schools, students and school board officials are referred to anonymously throughout this article.

Qualitative methods were used almost exclusively in this study as a means of dealing with the multiple perspectives and situations expressed by the teachers (Bogdan & Biklen, 1992; Glaser & Strauss, 1970; Glesne & Peshkin, 1992; Stake, 1995; Strauss & Corbin, 1990;) to “seek illumination, understanding, and extrapolation to similar situations” (Hoepfl, 1997, p. 47).

Weekly Meetings

The four teachers in the East Team were studied using a

case study methodology. A description of the teachers' reflections and interactions through the team meetings and in the Web Knowledge Forum forms the basis of the case studies. Team meetings were held on a weekly basis. Each meeting lasted approximately 3 hours. Weekly group meetings were audio recorded. In addition, I collected anecdotal participant observations of the teachers during our discussions (Maykut & Morehouse, 1994). These observations served as a record of those items of interest which are not apparent on the audio recordings, such as the level of interest expressed by the teachers. The recordings and observations were used as a record of all the individual action research projects. Teacher planning of interventions, their accounts of their experiences while carrying out the interventions, their perceptions of the impact of their interventions and their critique of their efforts are present in the recordings. The recordings were transcribed later. All transcripts and notes were coded and hand-written notes were made on their contents.

Pre- and Post-Interviews

All participants were interviewed and audio recorded by the researcher both at the outset and the conclusion of the study. The interviews used a semi-structured format with the questions focusing on the perspective of the teachers with regard to their own feelings about science, science education and professional development. In several instances the semi-structured interview format provided opportunities to talk about an individual teacher's situation and test the ideas that were generated. This 'emergent' design is typical of naturalistic research approaches (Guba & Lincoln, 1988). Evidence of professional growth was displayed when the two

interviews were compared (Hoepfl, 1997; McNiff, 1988). The recordings were transcribed and coded later date into an electronic format and were placed into a data base using the coded themes as they emerged from the analysis process as field headings. This process allowed for efficient searching of the transcripts while also providing an easy method of reorganizing the data as the need arose.

Teacher Journals

Teachers were asked to keep a journal of their activities and thoughts while participating in the project. The entries were primarily meta-cognitive in nature (thoughts about their thinking) to enable the researcher to approximate changes in attitude and understanding throughout the project. For the most part, the journals were brief and incomplete due to the short amount of time the teachers had to work on them. A total of 2-3 paragraphs per week per teacher was expected. Complete journals were received from several of the teachers. The journals were transferred to an electronic format and coded using a similar methodology to that used for the meeting recordings.

Web Knowledge Forum

To create a community of 'knowledge builders' (Bereiter et al., 1997), an on-line dialogue forum was used for communication among participant teachers and facilitators between meetings. A web-enabled version of a computer application, Knowledge Forum (WebKF), was used for this purpose. The application is an enhanced asynchronous discussion board complete with tools to assist users to post their own ideas and to build on others' posts. In their most basic form, the Web

Knowledge Forum posts are conversations among the team members. As such, they were viewed as extensions to the team meetings. The use of this application, however, provides additional benefits in that members of both teams were free to interact with each other. Using WebKF also gave additional opportunities for the teachers to build new understandings of their experiences (Bereiter, 2002) without having to get together for a face to face meeting. There is an immediacy element that is added to the reflections when the conversations are mediated by a program such as this.

A single forum (or database) was used for both teams and was separated into several views or threads. A view was assigned to each week throughout the project to give the teachers some sense of structure for their posts. Teachers were encouraged to interact with each other for a minimum of 10 minutes per day by posting notes to each other using an asynchronous communication mode. The posts were coded and analyzed in similar fashion to that used for the team meetings and the journals.

Repertory Grids

To gain some insight into both the predispositions that teachers bring to bear on their conceptions of teaching and to determine if there had been any shift in the predispositions of the teachers regarding the relationships between the ‘constructs’-teacher beliefs about their practice and the ‘elements’-teaching techniques during the lifetime of the project, I employed the Repertory Grid technique. Repertory Grids are drawn from the Personal Construct Theory (PCT) of George Kelly (Bencze, 2000; Feixas & Alvarez, 2000). The technique used in this study is a graphical and numerical,

computer generated (web-based) grid, which can be accessed at http://webgrid.uvic.ca (Gaines & Shaw, 2003). It allows the user to illustrate relationships that exist in the user's mind between constructs and elements. Each of the teachers completed a repertory grid at the beginning and at the end of the project. The results were primarily used to corroborate the evidence of teacher growth as determined through the interviews, team meetings and WebKF postings.

Nature of Science Profile

Finally, I employed a 'Nature of Science Profile' based on a simple survey designed by Nott and Wellington (1993). The aim of the survey, per its authors, was "to encourage teachers to critically consider the image that they have of science" (Nott & Wellington, 1993, p. 109). The survey requires a participant to build their own profile of beliefs regarding how science works. By administering the survey at the beginning and end of the project, it was possible to ascertain whether a shift in the teacher's understanding of the nature of science had occurred through the course of the project. Any possible shifts were corroborated with data collected from interviews and team meetings. In addition, the teachers were invited to comment on the results of the survey and the Repertory Grids during the final project interview.

Results and Discussion

This project brought the first exposure to action research to most the participating teachers. The only individuals who had any experience with the process were the facilitators. Consequently, the teachers took some time warming to the task at hand. During the initial group meeting and to orient them to the processes that would be used, I asked the teachers to collaboratively identify a

global problem that could be addressed throughout the program. Following identification, the problems were to be expressed in a statement of approximately 100 words. Producing the problem statements was one of the techniques suggested in *How to Conduct Collaborative Action Research* (Sagor, 1992). The problem statement identification process, started in the initial meeting, continued to occupy much of the time and discussion during the next meeting (25Sep01). It became clear that the teachers wanted to talk about issues that were of utmost relevance to their own situations. Jennie, an elementary science, technology and computer teacher, talked about using computers into the science classroom.

> This is kind of my issue. I'm teaching science with integrated computers. I teaching science from [Grades] 1 to 6 and I'm teaching computers to the whole school [Grades] K to 8 and my challenge is to integrate computers into the science curriculum and I'm really loving doing that. I think that it's the way to teach for me, in conjunction with all of the other things that you do in science. My question is, is using the computers, having learned how to use a database, a wordprocessing or whatever, does that change the way students think? Because, I'm just speaking from my own experience, it's changed the way I think (Jennie, 25Sep01).

Katy, a grade 7 and 8 science and technology teachers, wondered whether playing music for students would allow them to be more interested in their school work. She questioned whether

> .... allowing students, once they are doing seat work

> and if they are quiet and nobody objects, to play music of their choice, assuming no objectionable lyrics, and seeing if that helps to motivate (Katy, 25Sep01).

Lana, another elementary science and technology teacher, was interested in a similar theme in that she wanted to explore the link between student motivation and the relevance of science to student's lives outside of the classroom. Finally, Sharon, who had not been able to attend the organizational meeting and who alone among all of the teachers was teaching in a secondary school, wanted to work on a number of issues, including working through new courses, an equipment shortage problem in her school and working on skill development with students. She also had a student who was physically challenged and was interested in modifying the program for this student.

At one point during the discussion, I mentioned briefly to Katy that problem based learning (PBL) activities, using a project oriented design orientation, might be effective in improving focused student attention and motivation. While this was the first intervention on my behalf, it was not premeditated but was merely a response to the experiences as related by Katy. The decision to investigate motivation was immediately acted upon by Katy as stated in a posting in WebKF the next day:

> Today with my science class my goals were to give the students practice with a triple beam balance and to help them understand the distinction between qualitative and quantitative measurement. ... I decided to pose a real-life question. We are manufacturing and distributing a soft drink .... We

> got into a lot of issues, including measuring specific amounts to make up our drink. Did my scenario aid understanding or muddy the waters? (Katy, 26Sep01)

During this meeting, I was given an opportunity to intervene and have a direct impact on the way a teacher decided to proceed with her teaching. Little did I know at the time that this would be a major factor in the way the project concluded.

Due to scheduling complications, the East Team did not meet together for 3 weeks and when the group next reconvened very little progress was evident. During the Week 4 meeting the discussion went off in a variety of directions. The teachers began by talking about curriculum development and the restrictions placed upon them by government agencies dealing with curriculum and evaluation. Quickly the discussion centred on a professional learning program as implemented by the provincial government. The teachers were quite adamant that “we (teachers) are very over-regulated and we’re not given that latitude that other professions (have) to develop our own programs” (Katy, 23Oct01). Some suggestions, such as viewing video programs on television, were given as alternative methods or sources of professional development. The meeting continued with teachers sharing their experiences from the past week but no substantial breakthroughs had been made.

Up to this point in the project, the teachers had been ‘on their own’ so to speak, in terms of setting the agenda for the team meetings and the focus of their interventions within their classrooms. Both facilitators essentially

responded to the concerns of the teachers and provided access to resources as requested. However, we did not espouse any particular direction to the program. In consultation with the other facilitator and the teachers in both teams, it was decided that Week 7 would begin with more direct interventions. This was a response in part to the level of attention being paid to the science content of their interventions by the teachers rather than to developing strategies to improve learning. Also, as suggested by Carr and Kemmis (1986), the teaching profession "has a special responsibility to promote critical reflection in society at large as well as a responsibility for critical self-reflection on the rationality and justice of its own self-educational processes" (pg. 222). To carry out this responsibility, I felt the teachers in this action research team needed familiarity with some issues surrounding educational theories that relate directly to their teaching practice. The deliberate interventions were an attempt to bring these teachers to an awareness of some of these issues.

Some of the interventions were presented as a result of a request or a question. For instance, early in the project Katy asked about techniques that could be used to motivate students. My response was the description of a number of problem-based learning activities of which I was aware. Following this exchange Katy implemented several activities which explored PBL usage throughout the remainder of the project. For example, Katy vigorously described her latest PBL, the Solar Oven in Week 7.

> I was so excited about this solar oven and I don't know why. I built my own solar oven and tried to do stuff with it and it didn't work that well.

> Anyway, but the kids are really excited at the thought. You know what, this school is always being disrupted by things like music and always being disrupted for assemblies and basketball games, why the h___ don't I disrupt it and we will have a cook off in the back yard? And we will have a big field day (Katy, 13Nov01).

Later in the project, I initiated some interventions about 'critical scientific literacy', 'nature of science' and 'constructivism' without waiting for the teachers to broach these subjects, in order to promote critical reflection by the teachers (Carr & Kemmis, 1986). While it is impossible to establish a causal relationship between changes in teacher practice and the interventions, it is interesting to note that some of the teachers, particularly Katy and Sharon began several new initiatives in the weeks following the interventions.

Sharon took several classes down to the creek that runs behind her school. There they studied stream characteristics, including stream velocity and volume. She stated

> ... that went really well. I didn't have a lot of questions from the kids after but overall it was really enjoyable and they really enjoyed it and they're going to be writing up their stuff and that's going to be handed in to me on Friday (Sharon, 06Nov01).

Sharon also began a new unit using an exploration of literature related to the content area of weather. This treatment is consistent with the central ideas of critical scientific literacy (Hodson, 1998a). Katy's use of PBL

techniques can be correlated with the features of situated cognition (Cognition and Technology Group at Vanderbilt, 1992).

One other teacher began to make small changes in her teaching practice. In Week 9 Jennie shared her work about ‘automata’ consisting of a figure affixed to a pole which had a cam at the bottom of the shaft. The ‘automata’ could be activated by rotating a connected crank. She had been able to turn this into a project for the Grade 6 classes.

> Okay, well, I am going to take you off topic with my holiday parade. So this is the one I am giving to my 6's. This is a follow up to Mr. M. who came in and showed his ‘mouseworks’ [automata]. You turn a crank and they open their mouths. And the kids really liked that.
>
> The first assignment I gave them was to send him an e-mail thanking him for coming and I told them in their letters they had to use some technical terms like cams, cranks, pulleys, whatever (Jennie, 20Nov01).

It was interesting to see how Jennie had interpreted the ‘open-ended’ project work discussion which had occurred following the intervention regarding constructivism and critical scientific literacy made in week 7. It seemed that Jennie felt that any time students are given choices (in this case the choice of computer produced versus hand drawn, or a choice of applications on the computer) this can be defined as open-ended work, having no pre-determined shape or form. To be fair, there are some elements of open-endedness in this project; however, the

presentation part of it is still just a presentation.

I was encouraged by the changes that occurred in the teaching practices of some of the teachers following these interventions. Sharon and Katy seemed to create new activities on a weekly basis. While they struggled with their students' reactions at times, it became apparent that the students were responding to the teachers' efforts. At the completion of the project, both of these teachers had significantly changed their views of the nature of science and the types of activities which they would attempt with their students. Lana and Jennie indicated that they too had changed, if somewhat less than their colleagues. There is evidence that the teachers in the 'North' team grew as a result of the interventions as well. However, since the data for the 'North' team were not analyzed to the same extent as the 'East' team teachers', it is not possible to make more definitive statements about the changes experienced by this group.

Purposeful Action Research Defined

While it is difficult to draw major generalizations, which would be valid for all types of action research studies on the basis of this project due to the small teacher population involved and the short time frame available (4 months through the fall of 2001), this project resulted in the development of a modification of collaborative action research when used as a means of professional development for science and technology teachers. This variation can be viewed as a *community of teachers* who engage in *professional development* using '*purposeful*' *action research as a means of progressive knowledge building* around *science (and technology) education* in collaboration with a *skilled and knowledgeable facilitator*.

Community of Teachers

It is my contention that teachers should work in collaborative groups. The teachers who participated in this project were diverse in terms of their experiences and roles. They engaged in mutual support while offering suggestions for improvement regarding each other's work. Equally important was the role that the teachers played in inspiring and empowering each other (Bell & Gilbert, 1996). This aspect of the project was commented on by the teachers in the final combined team meeting.

> The thing that benefited me the most was the networking. Just talking and bouncing ideas off other people (who) knew what you were talking about... (Jennie, 18Dec01).
>
> Yeah, I think the like-mindedness of the people in the group (is great) whereas I can't necessarily go back to my school and share what I did because it wouldn't necessarily be accepted. But here it is. Not only is it accepted but it is lauded too (Katy, 18Dec01).

Facilitator 2, the North Team facilitator, expanded on these thoughts as she added that

> school cultures often do not support...sharing or just a focus or an interest in talking about your academic program. You know the staff room at lunch certainly isn't (supportive). People would immediately leave you as though you were a pariah and go and sit somewhere else. It really is a shame but there isn't the culture for that. So this provides that time to sit down and talk about .... (Facilitator

> 2, 18Dec01).

This last statement speaks to the concept of teacher professional conduct raised by Carr and Kemmis (1986) and Sagor (1992). This action research project offered these teachers opportunities to discuss and critique their science and technology programs in professional ways. Katy built on the idea, saying that she felt “as a first-year teacher, I didn’t think I would have taken the chances, the things that I have done, go for it. What have you got to lose? Just my job.” The support and encouragement of the teachers in the group gave her a sense of acceptance and freedom to attempt some non-traditional teaching methods and techniques. Flores (2003) reiterates these thoughts as she lists the common traits of successful professional communities of learners; “the promotion of shared goals, a sense of self-efficacy and self-worth amongst (the learners), opportunities for authentic participation in the decision-making process, the centrality of personal values, and the ability to manage tensions and dilemmas” (p. 21). The community of learners that was established functioned in ways that are somewhat like the community of scientists. Among other things, scientists test their peers’ ideas and approaches, verifying and challenging as needed. The community of learners formed by these teachers engaged in this type of activity on a weekly basis during the team sharing sessions.

Professional Development

I want to focus for a moment on various aspects of professional development and discuss what was accomplished during the action research project: teacher change, school development, curriculum development,

and student change. Fullan and Stiegelbauer (1991) suggest that teacher education should be part of a life-long learning continuum. While this project was not designed to investigate the sustainability of the advocated reflective practices, there is considerable evidence that during the project each teacher grew in some of three dimensions as identified by Rearick & Feldman (1999): theoretical orientation, products and types of reflection.

The action research project provided the teachers with conditions (including resources and time) and opportunities to engage in sustained processes of reflection, collaboration and inquiry (Flores, 2003). While participating in the project the teachers changed. Bell & Gilbert (1996) state:

> Changing ideas and beliefs may involve the clarification of existing ideas and beliefs, evaluation of and dissatisfaction with existing ideas and beliefs, construction and consideration of new ideas, acceptance of new ideas and modification of existing ideas and beliefs. Reflection also involves this form of thinking and in connection with classroom practice (p. 105).

The central measures of teacher growth in this project focused on a variety of dimensions of reflection within action research. The teachers brought with them different starting points in the reflecting processes and they achieved different goals. Individual teacher's work within the action research project was analyzed to determine their growth as they participated in action research.

Lana stated that she was helped tremendously as she could keep track of techniques and activities that worked well or did not work well with her students. She hoped to be able to use the notes and plans as aids in future units and years. Jennie stated that reflection allowed her to analyze her motives and methodologies than what she had done prior to the project. Yvonne, a grade 7 and 8 science and technology teacher in the North Team, noted that action research has something to offer to teachers who have been in the classroom for longer periods as well. She states that action research brings a “lot of mothballs out” regarding:

> ...things that you already know. Now, this is an older teacher remember, (things) that (are) way back in the back of the head, that you have forgotten about and somebody tweaks your memory. You think, ‘oh, now that’s what they meant.’ You know, there are a lot of things that you went through in the early days when you started teaching that made no sense at all to you but you had to do it and now it makes more sense (Yvonne, 18Dec01).

Unfortunately, Yvonne was not able to illustrate what she meant with an example. I thought that perhaps she was talking about a feeling of liberation, so I asked all the teachers that question. Jodi, another North Team member, agreed that she felt more liberated. Katy stated that she felt she gained more control of her classroom. Yvonne replied by stating that she already had control within the classroom; however, she felt the action research process allowed her to organize her thoughts more actively. However, Jodi felt that she was jumping

all over the place.

> I couldn't seem to concentrate just on the inquiry. There was too much out there to learn, too much to think about. So I found I was thinking about it all and nothing was really making any sense but I was happy and that was the enlightening part. I was happy that I was finally thinking about this stuff (Jodi, 18Dec01).

Katy agreed that while there were many ideas that she had not been able to fully explore yet, action research did

> change my idea of what action research was and my initial ideas about what I was going to do to motivate students have changed considerably as a function of, well, finding things that will work and won't work and interacting with particular students that I have. And I think that's been the lesson, that change is inevitable and if you are going to do action research it teaches you that you have to change your strategy depending on your situation. To me that was the most powerful thing (Katy, 18Dec01).

If the definition of educational change is accepted as learning how to do something new (Fullan & Steigelbauer, 1991), the participants in this action research project were changed because of learning how to do new things and then doing them. Katy created many PBL activities to motivate her students in their learning of science and technology. Jennie applied several activities gleaned from a variety of sources into her science and technology program and then integrated

them with computer applications. Lana generated ‘science-problems-of-week’ as a means of stimulating interest and motivating her students. Sharon took some of her classes to the stream behind the school and allowed the students opportunities to apply their science skills in ‘real world’ situations. These changes were important modifications to the curriculum that the teachers developed for their students. Curriculum development occurs only in the presence of teacher development (Elliott, 1990).

When the teachers were asked to reflect on the changes that occurred because of their work in the project, they had a number of reactions. Facilitator 2 stated that she had seen the teams come together in the sharing of ideas which resulted in implementation in a variety of ways, in different classrooms. Jerome, an elementary teacher in the North Team, said that “they kept me on track” (Jerome, 18Dec01). When asked what, he meant, Jerome stated that the group had established a sense of expectancy that he felt committed to. He felt he would be letting the group and himself down if he did not carry out science and technology activities for his students. Jodi stated “Every week, we expected something from him” (Jodi, 18Dec01). Jerome added “(the other teachers) made me realise how important it is to implement a good science program in your classroom” (Jerome, 18Dec01). The teachers all agreed that they had modified their programs based on the interactions that occurred in the project. Jerome stated that “there (had) been a huge change in my classroom” (Jerome, 18Dec01).

Progressive Knowledge Building

When the teachers engaged in action research they shared their classroom experiences among the group

members. These experiences became a source of information that the other teachers heard and absorbed. The other teachers responded in appropriate ways based on their own background experiences. Gradually, the entire team worked at shaping the information into a new form, an abstraction that was demonstrated by the teachers as they began to talk about classroom events. Gradually a new common understanding about the experiences arose because of the discussion. The process of increasing understanding is known as knowledge building (Wells, 1999).

In this project, the teachers engaged in dialogue with each other and the facilitator. The topics of the discussions were not only based on the teachers' own experiences but also augmented by the facilitator exposing them to different ways of thinking about a variety of issues, thus leading the group to new understandings that grow while learners interact (Bereiter, 2002). Some of these new understandings focused on encouraging student reflection, others led to new ways of using the observation of everyday objects to encourage student thinking about 'science- problems-of-the-week,' for instance. The development of new understandings was particularly apparent in the WebKF exchange between Sharon and Katy regarding visual learning. The two teachers had obviously previously entertained the ideas shared but had not applied them to the contexts of their classrooms.

Scientists, in community, test their colleagues' work by engaging in peer reviews of written work and by designing inquiries that attempt to verify the results of earlier work. In doing so, the scientists confirm that the new 'knowledge' is more than mere opinion (Longino,

1994). Throughout the project, each of the teacher colleagues participated in a similar process resulting in new understandings.

Skilled and Knowledgeable Facilitator

This project was built on an established relationship between a large university and a large district school board. The relationship consisted of, in this instance, one person: the author. For the duration of this project, I was employed as a project manager by the school board and simultaneously I was seconded, part time, to the position of Teacher-in-Residence to the university. I also held a dual role within the project. I was both the administrative manager of the project and a facilitator for one of the two teams. I became the primary access vehicle to resources found at the university. The other facilitator was a centrally-assigned instructional leader for the school board, and she had direct access to resources from the board but not to those from the university. While working in the project we made use of journal articles and additional curriculum resources that had been developed by the school board. The use of WebKF was also provided by the university. The teachers felt that the support and presence during the face-to-face meeting and in the online forum on WebKF was vital to the success of project. Per the teachers, the facilitation of the project was essential. “It wouldn’t have happened if we didn’t have facilitators” (Jodi, 18Dec01). Yvonne and Jodi added that the facilitators, among other things, provided access to resources and individuals that were not usually readily available to classroom teachers. The resources (articles and other materials) provided at the meetings and through the WebKF forum were also noted as being of assistance. Additional comments by the

teachers about the importance of the facilitators were categorized in the following ways:

1. resource person, “they have access to materials that (the team members) don’t have access to” (Yvonne, 18Dec01);
2. networking manager, “(The facilitators knew the) names of people (providing services in the school board)” (Jodi, 18Dec01);
3. support person, “(Facilitator 2) was always checking up (monitoring)” (Jerome, 18Dec01);
4. idea generator, “(Facilitator 1) gave us all of those sheets about questioning techniques and we looked at some of the curriculum” (Jodi, 18Dec01);
5. critic, “It’s difficult as a facilitator. You don’t feel like you want to push. You sort of present and offer things and then you sort of want to go with where people are and what they are interested in” (Facilitator 2, 18Dec01).

Facilitator 2 reported that those who take on the facilitator role need to have specific skills.

> “It’s difficult as a facilitator, you don’t feel like you want to push. You sort of present and offer things and then you sort of want to go with where people are and what they are interested in. So it is a delicate sort of balance, but I think that is something that would have been nice to keep going” (Facilitator 2, 18Dec01).

It is apparent that the facilitators played a significant role in determining the extent to which a teacher progressed in each of the dimensions used as measures in this study. The goal of exposing the teachers to an alternative

culture of learning (Fullan & Stiegalbauer, 1991) was reached while the teachers participated in the action research project.

Conclusions and Implications

Teacher professional development is a tricky business. “Nothing has promised so much and has been so frustratingly wasteful as the thousands of workshops and conferences that led to no significant change in practice when the teachers returned to their classrooms. Neither teacher participants nor workshop leaders are satisfied with the results of their efforts” (Fullan & Stiegelbauer, 1991, p. 315). My past experiences suggested that collaborative action research might hold some answers for providing science and technology teachers with professional development that meets their needs. It was anticipated that this methodology would have resulted in significant changes in the locations of each of the teacher within the defined action research space. However, during the course of the project, it became apparent that there was a lack of progress when teachers only addressed concerns as defined by their own practice. As a result, purposeful action research was implemented.

The phrase purposeful action research was created to describe types of interactions that grew from the series of intentional interventions provided by the facilitator as a stimulus to the participating teachers. Purposeful action research is a variation of collaborative action research. Purposeful action research shares many of the characteristics of collaborative action research: teachers’ share their experience, listen to others’ remarks, make suggestions in response to others, try to apply other teachers’ ideas to their own situation and take action within their classrooms (Baird & Mitchell, 1987; Baird &

Northfield, 1992; Mitchell et al., 1995; Pedretti & Hodson, 1995; Pedretti,1996: Tabachnik & Zeichner, 1999). Purposeful action research differs from the collaborative variety in that it also includes deliberate facilitator interventions. The nature of the interventions depends on the interests of the teachers and the nature of the subject matter studied, in this case, science and technology teaching.

The purposeful action research project described in this article was successful on several levels. However, there are a few specific recommendations that can be made to improve the effectiveness of the method for school boards considering similar efforts.

1. Implement action research groups within the structure of specific schools or families of schools. Teachers need to be able to concentrate on issues that they hold in common. If these issues arise in conjunction with school improvement or reform, they will provide a focus for the work in which the teachers will engage.
2. Provide support for the groups and teachers over an extended period. Four months was inadequate for these teachers. Many of the teachers suggested that a year-long study with bi-weekly meetings would have been much preferable.
3. Decrease the workload that inquiry requires of teachers by incorporating action research into the professional lives of the teachers by providing meeting time within the school day.
4. Teachers must continue to be allowed to participate in voluntary fashion. Forcing teachers to participate in action research will not result in effective professional development. The recruitment

methods used must respect the needs of the teachers.

5. Allow the groups to have freedom in determining the focus of their research but also ensure that they have opportunities to speak freely about issues of justice and equity. Forcing teachers to address only issues deemed by the board to have practical value within the classroom will not allow the teachers to grow in directions of value to them. In addition, school reform and reform focussed on the system will not result if the teachers are not given opportunities to discuss these issues (Fullan & Stiegelbauer, 1991).
6. Ensure that participating teachers are aware of issues of importance beyond what they experience within their classrooms. This can be done by presenting many appropriate interventions to the participating teachers.
7. Present issues related to teaching and learning in the subject being researched. In science (and technology) action research, the list of issues should include topics related to: learning science (and technology), learning about science (and technology) and learning to do science (and technology).
8. Establish and support the development of a pool of trained facilitators who can work with teacher researcher groups. Ensure that facilitators have a wide-ranging background in science (and technology) education and curriculum development, so that they will be able to provide the interventions described earlier in this thesis.

While purposeful action research was successful for the professional development of the participating teachers,

several questions remain unanswered. These include:

1. Since the nature of teacher research is very much of a ‘grass-roots’ nature, what is the feasibility of using purposeful action research as a mechanism for the professional development of teachers on a larger, district-wide scale?
2. What factors affect the sustainability of purposeful action research, for the participating teachers but also as a mechanism for schools and families of schools?
3. Purposeful action research was used for the professional development of science and technology teachers. Is the process equally valid for teachers in other subject areas?
4. What is the effect of authentic professional development on the students of participating teachers?

Besides addressing problems of professional development for teachers using a hybrid face-to-face, online methodology, as was primarily used in this project, applications using an ‘online’, computer-mediated variation of this process can be envisioned. Teachers comfortable with synchronous and asynchronous communications could participate in programs in which purposeful action research is employed. Instead of meeting together in a common physical space to share their experiences and classroom interventions, using the flexibility of the internet, teachers can meet with others in a virtual environment to explore and improve their teaching and learning. The facilitator role, in this type of environment, would be vital in order to promote healthy pursuit of the goals of the program.

References

Baird, J.R. & Mitchell, I.J. (Eds.) (1987). Improving the quality of teaching and learning: *an Australian case study - The Peel Project*. Melbourne: Monash.

Baird, J.R. & Northfield, J.R. (Eds.) (1992). *Learning from the Peel experience*. Melbourne: Monash.

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

Bencze, J.L. (2000). *Repertory grid technique for eliciting individuals' conceptions.* Unpublished.

Bereiter, C. (2002). Education and mind in the knowledge age. New Jersy: Elbaum.

Bereiter, C., Scardamalia, M., Cassells, C., & Hewitt, J. (1997). Postmoderism, knowledge building, and elementary science. *The Elementary School Journal, 97*(4), 329-340.

Bogdan, R. & Biklen, S.K. (1992). *Qualitative research for education: an introduction to theory and methods.* (2nd edition). Boston, MA: Allyn & Bacon.

Burnaford, G. (1999). *Teacher action research as professional development in schools: four paths toward change. School wide inquiry: a self-study of an "outside" teacher researcher*. Opinion Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, PQ., April.

Carr, W. & Kemmis, S. (1986) Becoming critical: *Education, knowledge and action research*. Lewes:

Falmer Press.

Cognition and Technology Group at Vanderbilt (1992). The Jasper experiment: An exploration of issues in learning and instructional design, *Educational Technology Research and Development*, 40, p. 65-80.

Elliott, J. (1990). Teachers as researchers: Implications for supervision and for teacher education. T*eaching and Teacher Education*, *6*(1), 1-26.

Feixas, G. and Alvarez, J.M.C. (2000). A manual for the repertory grid. Retrieved June 1, 2003, from http://www.terapiacognitiva.net/record/pag/contents.htm

Flores, M.A. (2003). Teacher learning in the workplace: Processes and influencing factors. Paper presented at the Hawaii International Conference on Education, Honolulu, Hawaii, January 6-10, 2003.

Fullan, M. (Ed.) (1992). Successful school improvement: *The implementation perspective and beyond.* Buckingham: Open University.

Fullan, M. (1993). Change forces: *Probing the depth of educational reform*. Lewes: Falmer.

Fullan, M. & Stiegelbauer, S. (1991). *The New Meaning of Educational Change.* (2nd Ed.). New York: Teachers College.

Gaines, B.R. & Shaw, M.L.G. (2003, March 30). *Repertory Grids: WebGrid III.* Retrieved April 5, 2003 from http://gigi.cpsc.ucalgary.ca/WebGrid/

Glaser, B.G. & Strauss, A.L. (1970). Discovery of

substantive theory: A basic strategy underlying qualitative research. In Filstead, W. (Ed.) (1970). *Qualitative methodology: Firsthand involvment with the social world.* Chicago, IL: Markham.

Glesne, C. & Peshkin, A. (1992). Becoming qualitative researchers: *An introduction.* New York: Longman.

Guba, E.G. & Lincoln, Y.S. (1988) Naturalistic and Rationalistic Enquiry. In: J.P. Keeves (Ed.), *Educational Research, Methodology, and Measurement: An International Handbook* (p. 81-85). Pergamon press, Oxford.

Hodson, D. (1998). Teaching and learning science: Towards a personalized approach. Philadelphia: Open University.

Hoepfl, M.C. (1997). Choosing qualitative research: A primer for technology education researchers. *Journal of Technology Education. 9*(1), 47-63.

James, E.A. (2006). A study of participatory action research as professional development for educators in areas of educational disadvantage. Educational Action Research, 14(4), 525-533.

Johnston, S. (1994) Resolving questions of 'why' and 'how' about the study of curriculum in teacher education programmes. *Journal of Curriculum Studies*, 26, 525-540.

Kemmis, S. (1988). Action research. In J.P. Keeves (Ed), *Educational research, methodology and measurement: An international handbook.* (p. 42-49), London: Pergamon Press.

Kemmis, S. (2006). Participatory action research and the public sphere. *Educational Action Research, 14*(4), 459-476.

Longino, H. (1994). The fate of knowledge in the social theories of science. In Schmitt, F.T. (Ed.), *Socializing Epistemology: The Social Dimensions of Knowledge.* Lanham, MD: Rowman & Littlefield.

Maykut, P. & Morehouse, R. (1994). *Beginning qualitative research: A philosophic and practical guide.* London: Falmer.

McNiff,, J. (1988). *Action research: Principles and practice.* London: Macmillan.

McPherson, M. & Nunes, M.B. (2004). Developing innovation in online learning: An action researchframework. New York: RoutledgeFalmer.

Ministry of Education and Training, Ontario. (1998). *The Ontario curriculum: Science and Technology, Grades 1-8*. Toronto: Queen's Printer for Ontario.

Ministry of Education and Training, Ontario. (1999). *The Ontario curriculum: Science, Grades 9 and 10*. Toronto: Queen's Printer for Ontario.

Ministry of Education and Training, Ontario. (2000). *The Ontario curriculum: Science, Grades 11 and 12.* Toronto: Queen's Printer for Ontario.

Mitchell, J., Rijneveld, L, & Mitchell, I. (1995). *About PEEL: The project for enhancing effective learning.* Melbourne: Monash Education Faculty.

Nott, M. & J. Wellington (1993). Your nature of science

profile: an activity for science teachers. School Science Review, 75(270), 109-112.

Olson, J.K. (1990) Teachers' conceptions of their subject and laboratory work in science. In E. Hegarty-Hazel (Ed.) *The student laboratory and the science curriculum*. London: Routledge.

Pedretti, E., Bencze, L., Hodson, D., DeCoito, I., & De Giuseppe, M. (2002). Building and sustaining communities of practice beyond the fold: Nurturing agency and action. In J. Wallace and J. Loughran (Eds.). *Leadership and professional development in science education: New possibilities for enhancing teacher learning*. (p. 219-237), New York: Routledge Falmer.

Pedretti, E. & Hodson, D. (1995). From rhetoric to action: Implementing STS education through action research. *Journal of Research in Science Teaching, 32*(5), 463-485.

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.

Rearick, M.L. & Feldman, A. (1999). Orientations, purposes and reflection: A framework for understanding action research. *Teaching and Teacher Education* 15, 333-349.

Sagor, R. (1992). *How to conduct collaborative action research.* Alexandria, Virginia: Association for Supervision and Curriculum Development.

Stake, E.R. (1995). *The art of case study research.*

California: Sage.

Strauss, A. & Corbin, J. (1990). *Basics of qualitative research: Grounded theory, procedures and techniques.* London: Sage.

Tabachnick, R.R. & Zeichner, K.M. (1999). Idea and action: Action research and the development of conceptual teaching of science. *Science Education*, 83: 309-322.

vanOostveen, R. (2005). Using action research for teacher professional development: Research in science and technology education. Unpublished PhD Thesis. Toronto: The Ontario Institute for Studies in Education, The University of Toronto.

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education.* Cambridge: Cambridge University Press.