Teacher development using group discussion and reflection within a collaborative action research project

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Abstract

This paper presents outcomes from a study of middle and secondary school science teachers participating in a collaborative action research project. A case study methodology was used to describe and analyze the views and actions of teachers participating in the project. Through group discussion and reflection with other participants, the teachers discussed and critiqued current practices, clarified action research questions, and explained and evaluated their students' activities. This collaborative and communal discussion and reflection process helped promote problem-solving and dialogical thinking, and resulted in teachers' views changing from the contextual particulars of their local school to a more systematic awareness of their curricular actions. At the same time, these reflective experiences exposed teachers' personal tensions related to implementing their action research plans. The idea of using group discussion and reflection as one method to complement and support perceptual restructuring of teachers' experiences in order to promote teacher development are presented.

Introduction

In education, there exists the perpetual quandary of teachers linking professional practice with educational theory. According to Richardson (1996) the integration of educational theory and practice occurs most productively when questions arise in the context of real students and instructional practice, and where disciplined practical inquiry is also occurring. As Elliott (1991, p. 50) explains, the concept of reflection and practical inquiry is fundamental to any form of action research:

> Both product and process need to be jointly considered when attempting to improve practice…This kind of joint reflection about the relationship in particular circumstances between processes and

> products is a central characteristic of what Schön has called *reflective practice* and others, including myself, have termed *action research*.

This productive relationship between reflection and practical inquiry (i.e. *praxis*) has perhaps been one of the primary reasons for utilizing action research to promote teacher development.

The notion of teacher reflection as a method for improving teacher practices can be traced back to John Dewey, who established the importance of 'reflective thought' in educational contexts. While Dewey had been the traditional source for a philosophical rationale of the 'what' and 'why' of reflection in education, Rodgers (2002) argues that there is no exact, systematic, or operational definition of reflection for educational contexts. Nevertheless, the importance of reflection in education has been undeniable, with Dewey (1933) defining it as a special form of thinking:

> Active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends, constitutes reflective thought (p.9).

Reflection is generally recognized as an important part of effective teaching because it assists teachers in becoming more aware of their views, subjects these views to critical analyses and, if possible, restructures them (Korthagen, 2001). In particular, reflective processes have had significant influences on science teacher education (Nichols, Tippins, and Wieseman, 1997).

The primary purpose of this collaborative action research project was to improve the teaching and learning of two critical goals of scientific literacy: scientific inquiry and nature of science. Seminal to curriculum action research is the notion of 'deliberated' teacher reflection (see Sweeney, 2003) in relation to actions and ideas of science teaching, student learning of scientific inquiry and nature of science, and the educational context. While autobiographical reflection is the most commonly used form, because of the nature of this collaborative project, group reflection was also used to complement strictly 'autobiographical-type' reflection. Through group discussion and reflection with other participants, teachers discussed and critiqued current science curricula, clarified

teaching practices, and explained and evaluated their students' actions. Using data drawn from this collaborative action research project, this paper analyzes teachers' espoused views expressed during group discussion and reflection, illustrating what Hatton and Smith (1995) describe as *dialogic* and *critical* reflection.

Theoretical Perspectives

Science Curriculum Reform, Teacher Views and Development

The ubiquitous status of scientific inquiry (SI) and nature of science (NOS) within science curricular reform documents (American Association for the Advancement of Science, 1993; Council of Ministers of Education Canada, 1997; Ministry of Education and Training, 1999; National Research Council (NRC), 1996, 2000) asserts the importance of SI and NOS in science education contexts. These goals can be concisely described as students' being able to engage and have some procedural and conceptual expertise in SI, as well as developing an appreciation and critical understanding of the important conceptions of the philosophical and social underpinnings of science (a.k.a) NOS. Regardless of the perennial call for addressing these scientific literacy goals, evidence suggests that they are not reflective of normal classroom practices of science teachers or outcomes of student learning (Bybee, 2000; Hodson, 1986; Lederman, 1992; Nadeau & Desautels, 1984). Teachers should possess knowledge and beliefs that are congruent with these reform goals if they are to translate their understanding into appropriate curricular experiences for students.

Practicing teachers develop their views from many years spent in the classroom as both students and teachers (Nespor, 1987; Pajares, 1992). Many teachers have not had an opportunity during their secondary and post-secondary science experiences to learn the academic content knowledge necessary to equip them to teach SI and NOS effectively. Furthermore, faculties of education have been inconsistent in preparing teaching candidates with the appropriate pedagogical

content knowledge to teach these concepts (Lederman, Schwartz, Abd-El-Khalick, and Bell, 2001). Disconcertingly, the beliefs and knowledge (i.e. views) of teachers are not necessarily consistent with curricular reform efforts (Lumpe, Haney, & Czerniak, 2000). Since teachers' beliefs and knowledge can guide instructional practice and curricular decisions within the classrooms (Fang, 1996; Nespor, 1987; Pajares, 1992), fruitful endeavours are ones which explore and promote enhancement of teachers' views in order to realize recently proposed reforms. As Thompson and Zeuli (1999, p.1) state regarding the role of professional development: "…teachers will have to unlearn much of what they believe, know, and know how to do while also forming new beliefs, developing new knowledge, and mastering new skills".

Teacher development can be succinctly described as teachers acquiring or adapting new knowledge, beliefs, and skills in order to change their educational practice. The most common teacher development methods used in schools and school districts are transmission-type models: teachers attend one-day workshops or presentations, which are de-contextualized from their everyday practice. The assumption is that teachers will adopt and implement all ideas presented in these one-off sessions. This linear and mechanistic teacher development model is generally ineffective (see Loucks-Horsley, Love, Stiles, Mundry, and Hewson, 2003) in promoting transformative teacher development necessary for changing beliefs and the adoption of complex knowledge schemata and skill sets. Hoban (2002) suggests promoting teacher development through a systems theoretical framework. This, he suggests, gives consideration to sustaining long-term and non-linear teacher learning in order to change professional practice.

Professional learning involves not only the development and use of teaching activities in the classroom, but also the development of personal views and conceptions underlying their practice. When these developmental elements are fully actualized, collectively they create an emergent

complex system of interdependent processes (Fazio, 2006). A collaborative action research project is well-suited to support a complex teacher development system.

Action Research, Teacher Reflection

Action research, having its roots in the social research of Kurt Lewin in the 1940s (see McKernan, 1996) has evolved in the education community as a process of a systematic research in which teachers examine their own practice and take action to improve teaching and learning within their own classroom situation (Elliott, 1993; McNiff, 1992). More specifically, it involves *cycles* of problem formulation, planning, action, reflection, evaluation, and communication (McKernan, 1996). Action research has been utilized in three basic domains of science education: teacher education; classroom teaching and learning; curriculum development and implementation (Feldman & Capobianco, 2000). There are important benefits to action research: (i) the research activity adds to local educational knowledge and, thus, has potential to motivate teachers to be aware of their findings because of the local context within which the data is collected; (ii) collaborative action research projects can foster collegiality between teachers and promote the development of communities of learners within schools.

Carr and Kemmis (1986) describe three variants of action research: *technical* (focuses on solving externally generated problems), *practical* (stresses local understanding and solving practical problems), and *emancipatory* (promotes critical inquiry and organized action to overcome social obstacles). Although these typologies are convenient for theoretical discourse, action research does not fit neatly into any single model.

Rearick and Feldman (1999) present a useful framework of action research that transcends some of the differences amongst the theoretical variants described above. They utilize a three dimensional analytic to plot and evaluate various action research projects. These dimensions are: (a)

theoretical orientation, (b) *outcomes* (purposes and products of the action research), and (c) *types of reflection*. The theoretical orientations align with the Carr and Kemmis' variants identified earlier. The outcomes (or purposes) are intelligible, plausible, and fruitful future-oriented goals that can provide motivational contexts for action researchers. Some of these outcomes include *professional* understanding (e.g. teacher development), *personal* growth (e.g. personal skill development), and *political* empowerment (e.g. critique of work conditions). Furthermore, in any action research process, reflection is of the utmost importance; nonetheless, Rearick and Feldman explain that not all 'reflections' are alike. Before elaborating on these reflective typologies, however, it is important to frame the discussion on what constitutes 'reflection'.

While researchers agree on the fact that reflection is a special form of thought (Hatton & Smith, 1995), the term continues to be represented by a wide variety of conceptualizations in the educational research literature (Rodgers, 2002). A useful definition of reflection comes from LaBoskey (1993, p. 9), who believes that:

> …the fundamental goal of teacher education is to teach novices to temper their judgments, to replace unsubstantiated opinion with … grounded belief that is constantly in flux and open to revision … good teaching requires thoughtful, caring decision making wherein educators are able to move beyond the tendencies of their own biographies and the apparent mandates of their current circumstances to envision and consider alternative interpretations and possibilities.

From this foundation, LaBoskey (1994, 1997) expounds on three domains that constitute the construct of reflection. The first of these is the content that is to be reflected upon, along with the theoretical orientation of the reflective content, vis-à-vis, technical, practical, and critical orientation. The second domain of reflection is the process by which rational and intuitive thought processes are brought to bear on the content under reconsideration. The third domain involves teachers' attitudes of open-mindedness, responsibility, and wholeheartedness (LaBoskey, 1993). In addition to these

domains, Rodgers (2002) reminds us of an additional domain: reflection must eventually happen within an interactive community of teachers.

Returning back to Rearick and Feldman's (1999) framework, they identify three forms of reflection: *autobiographical*, *collaborative*, and *communal*. Autobiographical reflection involves researcher introspection or self-reflection as a way of detailing, decoding, and interpreting objects and events in the 'research space'. Collaborative reflection (with other colleagues) can engage participants by providing greater clarity to issues than can be individually perceived. This clarity provides a platform from which to elevate considerations above subjective particulars of individual school contexts, and abstract and communicate at a level that can promote problem-solving and further actions. Furthermore, Rearick and Feldman identify communal reflection as going beyond collaborative dialogue and engaging the participants in reflecting on contexts beyond their individual research and collaborative space. Considerations of cultural, historical, and institutional objects and events are surfaced. These considerations are not embedded within individual representations; but rather, they are social representations (e.g. democracy, social justice; 'science for all') that are located beyond the immediate situation of the collaborative group.

These reflective practices are cogent with the research experiences of others in teacher education and development (Loughran, 1995; Nichols et al., 1997; Sireen-Desouza and Czerniak, 2003; Sweeney, 2003; Zeichner and Liston, 1996; Melville, Fazio, Bartley, and Jones, in press). Overall, the researchers' experiences have highlighted the importance of dialogic and critical reflection impacting teachers' thinking and practices. Aligned with other researchers' approaches, this paper reports on how the discussions and reflections of a group of science teachers participating in a collaborative action research project can complement and encourage teacher development.

Methodology

The study used a collective case study methodology (Stake 2000) to interpret the ideas and actions of four science teachers and a facilitator participating in a collaborative action research project (herein referred to as "the project") during the 2003-2004 academic school year. The focus of this study was on providing detailed description and analysis of each teacher's expressed views, their teaching practices, and to identify any changes in their development over the duration of the project. The techniques used to capture teachers' oral and written discourse, are representative of various observational and narrative methods (Erickson, 1998; McKernan, 1996; Miles & Huberman, 1994). While various methods were used to collect data from each participant (interviews, questionnaires, classroom observations, journal entries, response to cases), the focus of this paper is to highlight the rich discussion and reflection which occurred during twelve collaborative meetings throughout the project. The general intentions for the meetings were to share ideas, critically examine and reflect upon their views and current practices, and collaboratively reflect on the processes and products stemming from their individual action research projects. All dialogue from the meetings was audio recorded and later transcribed for analyses.

The collected data were analyzed using an extensive coding process. Codes can be generated using two main approaches: *a priori* and grounded. A priori codes were generated from the conceptual framework, research questions, and key variables (Freeman, 1998). In contrast, grounded codes were generated from the data themselves (from the collaborative meetings) and described using *in vivo* descriptors, then selected and applied in a constant and comparative method (Glaser, 1992). Data displays were used, when appropriate, to enhance the analytical process (Miles & Huberman, 1994). Coded data were clustered and then categorized to identify themes and patterns.

To enhance the validity of the data analysis, triangulation was accomplished vis-à-vis multiple sources of data (e.g. interviews, questionnaire, and journals). Furthermore, the prolonged participation of the teachers in this study and the involvement member checks of transcripts ensured achievement of a reputable level of data trustworthiness (Lincoln and Guba, 1985).

Research participants and collaborative group

The teachers for this project were recruited as volunteers from a science graduate education course at a local university in Ontario, Canada. The recruitment technique, referred to as purposive sampling, was preferable to probabilistic or random sampling because it supported the scope and range of data collected during this naturalistic, qualitative study (see Lincoln and Guba, 1985). The following accounts briefly describe the participants' professional and academic background. Pseudonyms are used for all teacher participants.

Luke was in his fourth year of teaching during this project. He had experience teaching Grade 9 and 10 general sciences along with Grades 11 and 12 chemistry and International Baccalaureate (IB) chemistry at a suburban secondary high school. He has also taught an alternative outdoor/experiential education program for students-at-risk, as well as intermediate mathematics. He has a Bachelor of Science degree, with a major in human sciences.

Alicia had just entered her fourteenth year as a teacher when she participated in the collaborative project. She teaches at an urban secondary school and has taught Grade 11 and 12 biology, 9 and 10 general sciences, and Grade 11 chemistry. Alicia's many years of teaching experience has given her an opportunity to teach not only science courses, but also subjects such as mathematics and drama. She has an undergraduate science degree with majors in microbiology and chemistry and began working as a laboratory technologist with a chemical research company prior to entering the teaching profession.

James was entering his twelfth year of teaching when the project began. He had taught a unique senior science course called “Science in Society” for a number of years and over his teaching career has taught a variety of science classes, including Grades 9 and 10 general sciences and senior level biology, chemistry, and physics. He currently teaches at a secondary school in a suburban community.

George is a relatively new teacher, entering his second year of teaching in an urban elementary/middle school (kindergarten to Grade 8). His subject teaching experiences are broad considering his ‘novice’ status. He has taught Grades 6, 7, and 8 science and technology courses, and has also taught Grade 7 history, geography, and the arts, although he indicated that he would prefer to teach in a secondary school.

While there are many types of action research (Rearick & Feldman, 1999), for this study there was no attempt to categorize either the group collaborative action research or the individual action research projects. Twelve collaborative action research meetings took place throughout the project. These meetings were approximately 2.0h in length and occurred once every two weeks. Discussion prompts and agendas were initiated for the early meetings; later meetings were open-ended yet focused on science education and the action research projects. The project was facilitated by the author, who was also a participant researcher. Journal reflections from the author are also included as a data source for this paper.

According to Elliott (1991), the initial phase of action research involves identifying and clarifying the research idea, a reconnaissance of the literature, and construction of a general plan of action. All the teachers participated in these stages, albeit, in idiosyncratic ways. By the end of the first meeting it had became clear that the participants were embarking on individual action research projects, as opposed to a unified group action research project. This was a consequence of their

different perspectives and prior experiences. Nonetheless, all the projects were unified under the placard of two scientific literacy topics — SI and NOS — and subsequently the discussion and reflection during the collaborative meetings were purposeful and persistent. While they all agreed to implement an individual action research project focused on SI or NOS, they seemed disinterested with a 'common' curriculum development focus. Rather, their individual projects were on some form of practical curriculum development product which was appropriate for their local school and classroom context.

Findings

Rearick and Feldman (1999) identify *collaborative* and *communal* reflection as reactions to the inadequacies of strictly autobiographical reflection. Collaborative reflection is a dialectical process whereby participants can discuss and critique current practices, clarify research questions, and explain and evaluate evidence from their classroom with other participants. Communal reflection, in contrast, involves reflecting on the self and practices in a broader community context. For instance, a science teacher could reflect on their particular science educational context with reflection upon the Ministry of Education's role in the development of the mandated science curriculum. The following section will present some exemplars from the data corpus collected during the collaborative meetings, which illustrates the type and content of group discussions and reflection. The teachers' conversations are categorized using Rearick and Feldman's reflection typology.

Collaborative Group Reflection

In the following sample dialogue, based on James' reflection on some inconsistent evidence and challenges in implementing his action research project within his classroom, collaborative reflection is illustrated as both teachers problem-solve collaboratively.

> I am looking for techniques to use for group work. I want to use jigsaw [cooperative learning strategy] and it was used before but not properly. But I think this time the jigsaw has a very specific purpose to it. Borrowing from Copernican vs. Galilean vs. church astronomical models, I want the students to discuss various opinions to come up with workable arguments with conclusion premised items. So I want them to look at the same thing through four different eyes so that they understand that there are multiple ways of looking at science and even to accept ambiguity when nothing better is available. (James, collaborative meeting #6)

> The *Tribes* feature is great for coming up with various strategies for group work. It has things like: in class having all students that agree with a theory form a line while others go on the opposite side and those who are undecided or see benefits in both theory and its rejection can stand in the middle. Another way is to throw crumpled pieces of paper with incorrect and correct information on them until someone receives one with correct info. (George, collaborative meeting #6)

> Good, because right now I'm looking at different ways of constructing this. I want to counter the fact that right now validation for performance or ideas only comes from me. I want them to get a more communal validation. I've been using 'place-mats'[1] to show them that they have their own ideas of what's going on It's good for me to see what information is filtered out. I also get some ideas of their social construction and who's the leader and so on through this technique. (James)

Moreover, both James and George began to highlight a larger teaching issue (the role of teacher affirmation during student independent work). This issue was also identified by Luke in a different classroom context. His comments were spurred on by the above dialogue during the same meeting:

> In my project some kids are asked to formulate their own questions, hypotheses and their own procedures: the actual 'scientific method' if you will, on their own without a question given. A couple of things I've noticed over the last few weeks: they're always looking for validation for their own ideas… I catch myself giving too much assistance as opposed to being more of an advisor, rather than helping them come up with a question. (Luke, collaborative meeting #6)

The clarifying of ideas, problematizing of action research experiences, and the relationship of teaching and student learning to the mandated science curriculum, was enriched by the introduction

[1] "Place-mats" is a cooperative group strategy whereby participants within a group are given one large piece of paper, and each is given the opportunity to write their ideas on a specific topic. Once finished, they pass the 'place-mat' to another to write upon. The next individual can amend or add to the existing written work, or write a new idea.

of educational theories by participants during the meeting. This assisted the reflection upon the data being collected by the participants in their individual classroom. An example of this was introduced by Alicia:

> I liked what he [reference to a professor she heard] said: "you haven't really taught anything in a classroom unless a student has learned". I liked this simple concept, as well as the other one he said that teachers tend to focus on the curriculum instead of the students. Development of teacher needs based on teacher and students…. Teacher focuses on themselves, e.g. 'how am I going to teach this and control the classroom?' After a few years it changes from the 'I' mode, e.g. 'what kind of teaching things can I do?' Final stage focuses on learner and how do I know that the student has actually learned what I've taught. Very few teachers reach this *stage*. (Alicia, collaborative meeting #6)

All participants used a theoretical framework to rationalize their own contextual experiences, as can be seen from the rich commentary below between all participants, when prompted by the discussion of a 'stage theory' and its relationship to student learning during collaborative meeting #6:

> I have another stage, 'did I teach what I intended them to learn?' (James)
>
> He [professor noted above] is asking us to take a different approach. But we're not comfortable with it. (Luke)
>
> The problem is how do you do that? (James)
>
> He added that if we don't go into that [student] realm all we're doing is transmitting knowledge. (Alicia)
>
> But the 'how' is a frustrating process. It's much easier to do it step-by-step. (Luke)
>
> One of the problems with the content [of science] is how to apply the 'habits of mind' and scientific inquiry. (Alicia)
>
> I'd go one step further: I don't think we're transferring knowledge. We're transferring information. It becomes knowledge when the student acquires meaning…We deliver the content in a packaged form and don't worry if it makes any difference at all. (James)
>
> I have a student who is 'mildly intellectually delayed'. But every once in a while he comes in with information that I am pretty sure he has no knowledge of. But in certain contexts, he can plug in this information because that's what he's supposed to do…. This student is full of bits of information, but doesn't have the context. But he's coded them so that he knows when to use them. (George)

Participants used a 'theoretical' framework to place their varied contextual and subjective experiences and views into inter-contextual space. This allowed a hermeneutical analysis of the role of teacher and student. In order to change teachers' views, clarification, evaluation, and dissatisfaction of their existing views is required along with re-construction, modification, and acceptance of alternate views (Posner, Strike, Hewson, and Gertzog, 1982). As shown in the above excerpts, the reframing of views cannot occur without schematization of practice in dialectical relationship with theory.

Communal Group Reflection

At the beginning of the collaborative meetings, as a facilitator, I felt anxious when discussion about SI or NOS led to topics embedded in larger contexts, such as school district governance, corporate involvement in education, and socio-cultural impacts on the process of schooling. I felt that this may have reflected my facilitation abilities. I recorded the following observation in my journal:

> It is interesting to note that the discussion about SI and NOS always seems to 'boil down' to a discussion of the purpose of science education, and schooling for students. Why is this so? Does theorizing about education make you a better teacher? (Xavier, personal journal)

Nevertheless, group reflection about the perceptions, values, and views about science education (and education in general) was a normal focus of discussions, especially during the latter stages of the collaborative project. Below is a lengthy discussion from collaborative meeting #4, illustrating the theorizing regarding the lack of explicit NOS expectations in the Ontario science curriculum:

> It's just a part of so many other factors that it gets put to the wayside. So you can't explore this [NOS] because the [Ontario] curriculum document requires straight content. (Alicia)
>
> How many people studied NOS during their undergraduate education? (Xavier)

Perhaps the scientists [professors] generally feel that it is unimportant to teach NOS. It is clear by the way some scientists conduct their courses, NOS is not mentioned at all. Thus by omission it means it is not important. (Alicia)

You're not taught NOS. You're taught 'x, y, z' and at the end of the day you have an idea of what science is to you, so why should they teach you that? You've already formed your understanding of what science is. You've never been asked to question it. (George)

Scientists don't talk about the nature of science because they live within it. They are surrounded by it always and may not even be conscious of it. As a graduate student in Botany, you learn about what counts or doesn't count from your supervisor, not from a text…It is assumed that you picked up NOS somewhere along the line by diffusion. But kids don't know this and they get the idea that science is very positivist… I think this is a mistake and it is dangerous to society. (James)

Do you think students are just 'picking-up' NOS when they do experiments in science class or doing a scientific inquiry and so on? (Xavier)

Over the years you pick up something about your understanding of NOS. Now, because you've been doing something called science, you've never been asked to articulate it, but you do have an understanding of it by what you do in class, by the media, culture. I think it should be discussed throughout the entire science curriculum. But it doesn't surprise me that these curriculum documents don't have any of it [NOS] because we've never discussed it. The people who wrote this were never exposed to it themselves. (George)

I think that students don't pick it up if you hit them over the head with it, and students might actually gravitate toward more teaching of it, but we tend to be more content based and I think that's one of the reasons students tend to have little understanding about NOS. I really resent that it is not taught in undergrad at all. And then you wake up years later to find this thing called NOS. (Alicia)

I think the NOS should be left for the next step. In grad school you're trained to think a little bit more, to question, to analyze, and I think that NOS is so philosophical that it should be left for graduate school. (Luke)

With that in mind, does it [NOS] need to be in the secondary curriculum then? (Xavier)

I think it's a double-edged sword. What is it and so on, requires deep thinking. (Luke)

I think it should be there precisely because without it we give a false view of what science involves and that tends to exclude things that would otherwise be very well suited. And people start thinking that scientists get excited by the details, whereas it's the science not the data. (James)

I look at the students that I teach and they're very similar in thinking to the way I thought in school. And I fall into the same traps now that my teachers

> fell in when I was a student. I know that it isn't the best way of teaching and I catch myself doing it. We need to challenge ourselves to go in a new direction and get away from the old methods. We have to take them a step forward to abandon the status quo. (George)

This interesting dialogue around NOS as 'subject matter' echoes a long debate still found in science education arenas. The character of the dialogue was intriguing because of the systematic links between curriculum 'commonplaces' (learner, teacher, subject, and milieu) and the autobiographical experiences of the participants, especially with reference to their science education experiences in secondary and post-secondary school. This public dialogue and reflection was also important because it exposed some of the participants' views about NOS (e.g. how scientific is a human endeavour; nature of scientific knowledge) in relation to science education. Furthermore, the sharing of unique experiences (e.g. James as a Botany graduate student) provided inter-subjective knowledge for the other, less experienced, participants and enhanced the other participants' views.

Discussion

The teachers' participation within this project promoted what Rearick and Feldman (1999) identify as collaborative and communal reflection. In particular, as illustrated from the verbal excerpts from group meetings, group discussion and reflection helped promote collaborative analysis of their classroom practices. Additionally, views changed from the contextual particulars of their local classroom to a broader communal awareness of their curricular plans and actions. This discourse movement from the contextual particulars of their local school to a more systematic awareness is evident in the following dialogue, regarding action research results collected in James' classroom:

> …some people get stuck at that point where they always need some authority figure to take over and will never interact and become part of the discourse….I'm asking the students to break this pattern, the school pattern, because you can't use it in life. Inasmuch as I try to do this I realize that I'm fixed in my role as teacher as they are in the role of students and we can't break either one just like that. (James, collaborative meeting #9)

> But look at society; it hasn't really broken out of the school mould. Few people are comfortable enough to form their own judgments. There are the yes people, 'when do you want it', 'when it is due', and so on. People are always following the wishes of those in positions of authority. (George, collaborative meeting #9)
>
> Well I don't necessarily wish to have everyone coming up with their own things, but I would like to see more reflection and thinking about things. That's foreign to them [students]. Comments are made directly to me, as if I'm the 'speaker of the house', rather than to each other. I also found out that what the students dislike in classrooms is precisely what NOS is about. They feel that if they are uncomfortable in class and don't understand what's going on, that must be what science is really about. If they enjoy the class, they assume that it isn't science. (James)
>
> Well I note that in class some of the students say exactly what they think and will ridicule other students' comments. So I intervene, but I also realize that this is what we would like them to do, only under certain circumstances, however. (George)

The reflexive quality of the group discussion and reflection is of note here. Both James and George identified school issues, related these issues to society, and transferred these issues back to their local context; in this case, they highlighted issues of authority and power between the teacher and learner. This reiterative discourse is exemplary of communal reflection because it identifies contradictions in practice and highlights relationships to broader societal representations.

At the same time, group discussion and reflection caused personal tensions in the participating teachers because of the dissonance between their ideal teaching ambitions (identified in their action research plans) and their realistic teaching practices. Korthagen's research (2001) on reflection in teacher education concluded that viewing reflection as a purely rationale process is limited – indeed, emotions play a significant part. They suggest that emotional support is required during this 'confrontation stage' where confusion and insecurity may prevail. One participant expressed this tension:

> You're trying to do both: student-directed or open-ended things but then you have to have some kind of lessons to give them some background. So, I'm constantly struggling with that and this is one of the things that I've come to the conclusion that you're not going to

> have these open-ended, problem-based learning activities. It would take three or four days of curriculum. I don't have that kind of time and it's a constant struggle (Alicia, collaborative meeting #5).

Korthagen recommends that facilitators be empathetic, accepting, and genuine. This support need not come from one individual; rather, a community of practitioners can provide an effective environment during these personal and professionally challenging episodes (Wenger, 1998; Fazio, 2005). Indeed in this project, participants received this support.

Implications

The concept of using group discussion and reflection to support perceptual restructuring of teachers' experiences is an important implication of this study. Using Korthagen's (2001, p. 58) cognitive notion that: "reflection is the mental process of trying to structure or restructure an experience, a problem, or existing knowledge or insights". This notion allows one to view group reflection as not only a social-pedagogical process, but as an individual perceptual restructuring process. This insight forms the basis for Korthagen and Kessels' (1999) model of "realistic teacher education" (see also Korthagen, 2001, chapter 4). They argue that the process of reflection allows a teacher to move from a Gestalt (holistic) *concrete* experience during teaching (e.g. a student unsuccessful in designing a science experiment), to a *schema* level of understanding, and finally to a *theory* level. Korthagen reminds us that the 'moving up of levels' is not so much new learning, as it is a reframing or restructuring of perceptions. New knowledge can be created by the teachers from this reframing of perceptions, and thus the opportunity exists for effectively linking theory and practice (Schon, 1987). This collaborative group discussion and reflection parallels Kortahgen and Kessels' reflective approaches for encouraging the restructuring of perceptions.

The idea of systematic reflection is central to action research. In this study, during collaborative group reflection, the action researchers moved from the contextual particulars to the

systematic nature of their curricular actions and consequences. This resulted in a heightened level of awareness and a new clarity of thought, thus prompting future problem-solving and actions. Furthermore, communal group reflection lead to investigation into the social fabric of science education and, ultimately, into the power structures and processes inherent in educational institutions (i.e. schools). The overall outcome from communal group reflection was not necessarily "emancipatory" for the teachers in this study, but may be described as more instrumental in nature because consideration is given to the external socio-political factors directly influencing the practical reality of their curriculum experiences in schools. Teacher development is challenging given the external factors influencing this reality of contemporary classrooms. One way to address this challenge is to promote collaborative action research.

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