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Classroom-Based Professional Development: Teachers' Reflections on Learning Alongside Students

Introduction

This article contributes to the knowledge base on professional development (PD) by reporting on teachers' perspectives of their PD experiences when learning alongside children. Teachers participated in a six-step program of research entitled *In-service in context: Learning science and technology in elementary classrooms* (ISIC). ISIC represents an alternative form of professional development in which teachers work alongside students in a classroom as they experience a new pedagogy for teaching and learning in elementary science and elementary technology. The study set out to address the following research questions: (a) To what extent does in-service given in a classroom context help teachers construct a pedagogy for elementary technology or elementary science? and (b) To what extent does in-service given in a classroom context help teachers acquire subject knowledge in elementary technology or elementary science? Ultimately, this article reveals teachers' perceptions of their learning as professionals at an event commonly labeled *professional development*.

Professional development for classroom teachers, that is, experiences that help teachers not only learn new skills but also develop new insights into pedagogy and their own practice, remains a critical dimension of a profession coping with ever-changing curricula and pedagogical knowledge. In a study of 1,059 teachers in Newfoundland schools, Sheppard (1996) found that professional development was the single most significant leadership activity related to (a) increased levels of teacher commitment (the degree to which teachers are supportive of and committed to the school and their colleagues); (b) professional involvement (the degree to which teachers are concerned about their work, are keen to learn from one another, and committed to professional development); and (c) innovativeness (the degree to which variety, change, and new approaches are emphasized in the school). Guskey (1994) states,

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never before in the history of education has there been a greater recognition of the importance of professional development. Every proposal to reform, restructure, or transform schools emphasizes professional development as the primary vehicle in efforts to bring needed change. (p. 42)

Notable also is how theorists such as Fullan (1993) and Guskey (2000) link teacher development with improvements in student learning.

The educational literature is replete with suggestions for effective professional development (Ball, 1996; Cameron, 1996; Carney, 1998; Vukelich & Wrenn, 1999). Yet no form emerges as the most effective for changing classroom practice. It is not clear how teachers learn *in* and *through* professional development experiences and if and how they apply their learning. Missing from the literature are teachers' perspectives on their professional development learning experiences. For example, Loucks-Horsley, Hewson, Love, and Stiles (1998) identified 15 strategies used for professional development for teachers of science and mathematics. Not one strategy involved teachers and students learning together or with the professional development occurring in the context of an active classroom. These gaps in the literature (teachers' perspectives and teachers and students learning together) provided the foci of the study reported here. Empirical research that investigates how teachers describe and reflect on their professional development learning could provide an informative link in shaping and guiding teachers' ongoing professional development needs. At the same time, such research will give voice to teachers by respecting their professional judgments and perceived needs for ongoing professional growth.

Structured opportunities to collaborate with peers and engage in authentic pedagogical conversations are not often part of professional development experiences. The most common form of professional development appears to be "twilight sessions," what Shanker (1996) refers to as "one-shot" after-school workshops. Sparks (1994) describes how the usual practice is for "educators [to sit] relatively passively while an 'expert' 'exposed' them to new ideas or 'trained' them in new practices" (p. 26). In addition, Sparks suggests that "rather than receiving 'knowledge' from 'experts' in training sessions, teachers ... [should] collaborate with peers, researchers, and their own students to make sense of the training/learning process in their own contexts" (p. 27). Insights from teachers about the quality of their professional development experiences, and if and how these influence their teaching, would be most informative for professional development providers in school districts and at universities. What do teachers think is important for their professional development? What opportunities can and should be provided for teachers to reflect on their professional development? Ultimately, if teachers are to be responsible for their own professional growth, then they must be permitted to make decisions about how to improve as professionals.

In the following section, we provide an overview of the literature describing crucial elements in effective professional development for teachers. This is followed by a brief description of the Elementary Science and Technology (EST) project and its approach to teaching elementary science and technology. Finally, we report some results of the ISIC research, a study designed to investigate the effectiveness of a professional development experience in

which teachers worked alongside (and observed) grade 6 students as they completed a technology or science unit.

Review of the Literature

Research identifies four crucial elements in effective professional development, that is, development that leads to positive change in the classroom. First, professional development must provide a challenge to teachers' frames of reference (Carney, 1998). Although new professional demands (e.g., created by the introduction of a new curriculum) can make teachers receptive to new understandings and practices, they may lack frames for these situations and seek help in structuring new routines. Professional development must challenge teachers to investigate, experiment, consult, and consider outcomes: to take a stance of critique and inquiry toward practice (Ball, 1996). Overall, teachers must use an inquiry and problem-solving paradigm that results in their constructing new knowledge, rather than a training paradigm that results in their consuming knowledge. The question of how to create such professional development learning contexts is central.

Second, situating professional development in relevant contexts is recognized as a critical component if teachers are to learn and to apply new knowledge (Carney, 1998). Numerous scholars refer to the importance of learning contexts when describing situated learning and sociocultural contexts (Lave & Wenger, 1991; Rogoff, 1994; Wertsch, Del Rio, & Alvarez, 1995). Cameron (1996), for example, suggests that professional development must be relevant to actual classroom work and to what students need to know and be able to do. Grossman (1992) argues that teachers must be able to situate new knowledge and understanding in the specific context of classrooms. Vukelich and Wrenn (1999) add that professional development should be based on participants' interests and needs. Altogether, it seems essential to solicit critique from teachers who receive professional development in order to determine if the professional development learning contexts are indeed relevant for them. It may also be crucial to examine how and when such critiques are requested from teachers so that comments are informative. Without appropriate classroom follow-up and discussion with other professionals, the effect of professional development remains unknown and, therefore, cannot influence the nature of future professional development.

A third crucial element in effective professional development is collaborative support from colleagues, which greatly increases the likelihood that changes in practice will be sustained (Fullan & Stiegelbauer, 1990; Lee & Shulha, 1999). Smylie (1996) points out that because learning is incremental and teachers do not change their practices overnight, professional development should be long-range and ongoing. Teachers need the opportunity to talk together and to reflect on their teaching practices. According to Ball (1996), teachers need time to unlearn as much as they need time to learn. They need colleagues with whom to focus on problems of teaching and learning, to work out how to deal with new subject matter, and to engage in innovative work aimed at curriculum reform (Olson, 1997; Shanker, 1996). In short, professional development needs to be regarded as a continuous cycle of learning, practice, and reflection with colleagues.

Fourth, the importance of professionals engaging in reflective practice is widely recognized (Ball, 2000; Cochran-Smith & Lytle, 1999; Loughran & Russell, 1997; Schön 1983). However, no common definition or description of such practice is known. It is one thing to agree that *reflection-in-action* and *reflection-on-action* (Schön, 1987) are central to the development of professional practice, but quite another matter to demonstrate what this means in a professional development context. Other researchers emphasize that professional development must provide opportunities for teachers to form “communities of practice” (Lave & Wenger, 1991) that encourage them to reflect on the content and contexts of their pedagogy. Time and guidance are required to begin, to establish, and to sustain such communities where teachers engage in inquiry about practice (Lieberman & Miller, 1990; Smylie, 1996). However, if teachers’ perceptions about their own professional growth are not integrated into a plan for professional development, such communities of practice are not likely to be initiated or sustained.

The Elementary Science and Technology Project

The ISIC research project reported here has its roots in the Elementary Science and Technology (EST) project, a four-year collaboration between the Faculty of Education at Queen’s University and two local school boards. One of the primary goals of EST was the provision of professional development for a group of teachers implementing a new grade 1-8 science and technology curriculum (Ontario Ministry of Education and Training, 1998). This curriculum poses significant challenges for elementary school teachers about how to teach the subjects, how to assess students’ learning in the subjects, and how to use the document to plan units of work (Barlex et al., 2000; Welch et al., 2000). Early in the project it was decided that limitations in resources, both human and capital, militated against providing professional development for all teachers in the partner school boards. Hence it was decided to provide intensive and extensive professional development for a small number of teachers who would in turn become PD leaders in their respective boards. To this end, 20 teachers were invited to join the EST project, 18 of whom remained until its conclusion.

A new pedagogical approach to teaching elementary science and elementary technology developed by the EST project has at its center the concept of a Big Task. Details of this pedagogical approach are reported in an earlier article (Welch & Mueller, 2003). A Big Task (BT) is an activity in which students apply in an integrated and holistic way the knowledge, understanding, and skill they have learned. It forms a focal point in a teaching sequence and enables students to reveal what they have learned through what they can do. For students to be successful in a BT they will need particular and appropriate knowledge, skill, and understanding. These are taught through a series of Support Tasks: short, highly structured, and focused activities. The effectiveness of this teaching and learning is evidenced through the quality of the responses to the BT. This is a development of the Capability Task/Resource Task approach developed by the Nuffield Design and Technology Project in the United Kingdom (Barlex, 1995).

During its first two years the EST project provided a range of ongoing professional development experiences, including practical workshops (in both science and technology), seminars, writing days, tutorials, and conversations

by telephone and e-mail. However, during reflections on the effectiveness of these PD experiences, teachers in the project pointed out that although their professional development in the Faculty of Education was informative and valuable, they still did not know how it would apply in classrooms. For example, teachers wished to know how students would react to the pedagogical model, what problems students might encounter, and how classrooms could be organized to implement the model. The elementary teachers emphasized that they had little or no prior experience and knowledge of technology education, having neither studied the subject themselves in school nor seen it taught in elementary classrooms. In response to these concerns expressed by teachers, two teacher educators (ourselves) designed the research project entitled *In-service in context: Learning science and technology in elementary classroom*. In the following section, we describe the method used to introduce teachers to a pedagogy and subject matter in elementary science and elementary technology, as well as methods of data collection and analysis.

Method

The Educational Context

The ISIC program of research on professional development emerged as a result of conversations between teacher educators (ourselves) and teachers during EST professional development days. An extensive search of the literature found no guidelines on, or examples of, how to conduct professional development in a classroom with both teachers and elementary students working and learning together. Moreover, it was uncommon for two teacher educators to team-teach elementary students throughout a regular school day.

The Participants

ISIC was designed to respond to one of the EST mandates, namely, that responsibility for ongoing professional development of all elementary teachers in the partner school boards would become the responsibility of a subset of the EST teacher partners. Hence it was decided that ISIC would be the six-step program of research described below. In Steps 1 and 2, six teachers (3 men and 3 women) were drawn from the EST project with the intention that some would ultimately become the professional development leaders for Steps 5 and 6. In Steps 3 to 6, the 12 participating non-EST teachers (two men and 10 women) were drawn from local elementary schools. Local principals were asked to assist in the selection of teachers available to participate. A letter of information and a letter of consent were sent to all teachers, with a modified version provided for students and parents being distributed by the regular classroom teacher. The response to these letters was 100% agreement to participate in the study. To ensure anonymity, each teacher was assigned a code number for use in transcripts and reporting the data. In each of the six steps, teachers worked at the same table as students to complete the same curriculum unit. On average, each table accommodated five students and one teacher.

In Step 1 of the ISIC research program, two faculty instructors (ourselves) taught a technology unit entitled *Pop-up Pals* to a class of 27 grade 6 students over a full school day. Both instructors were experienced classroom teachers and had responsibilities for teacher education in elementary science and technology (Mueller) and in elementary and secondary technology (Welch) respec-

tively for several years. Six EST teachers worked alongside the students. Collectively, these teachers shared a wide range of teaching experience (from 5-22 years) and taught a range of elementary classes (grades 2-7). Through the school principal, arrangements were made for the school gym of one of the EST project teachers to be equipped as a classroom. Students were well behaved and responded enthusiastically to the tasks. The design brief for the unit read as follows: "Design and make a pop-up book that will amuse and intrigue a particular reader. The book may be for you or for someone else." Before tackling this design-and-make activity, students completed the following eight Support Tasks.

- Investigating pop-up books;
- Exploring a box fold;
- Exploring a mouth fold;
- Exploring a slider;
- Exploring a lift-up flap;
- Exploring a rotator;
- Exploring illustration styles;
- Writing the design specification.

In Step 2 of the ISIC research, we taught a science unit in a second school in the school library of one of the EST teachers. Unfortunately, we could not return to the school in Step 1 due to a change of local circumstances. All but one teacher (on maternity leave) remained the same as in Step 1. Her replacement was also an experienced EST teacher. In contrast to the students participating in Step 1, who were well behaved and motivated, students participating in Step 2 provided exceptional challenges, there being eight students identified as having either severe behavior problems or a learning disability. At the beginning of the unit, grade 6 students were presented with the following Big Question: *Why is it important to classify living things?* Before answering this big question, students completed the following six Support Tasks.

- Classifying objects;
- Classifying living things;
- Using and creating a word key;
- Exploring the animal kingdom: Vertebrates;
- Exploring the animal kingdom: Invertebrates;
- Investigating leaf litter.

In Steps 3 and 4 of the ISIC research program, faculty instructors taught the technology and science units used in Steps 1 and 2 to a group of grade 6 students in a regular classroom setting in a third school. Six non-EST teachers (1 man and 5 women) from various elementary schools worked alongside students, once again with each teacher working at a table with five students. These six teachers were responsible for teaching various grades between 4 and 7 and had between two and eight years of prior teaching experience.

In Steps 5 and 6 of the ISIC research program, two EST teachers who had participated in ISIC 1 and 2 team-taught the same technology and science units to a group of students in a fourth school where a portable classroom was provided as the research site. A second group of six non-EST teachers (1 man and 5 women), all from the same school, worked alongside students to complete the units. These six teachers were responsible for teaching various

grades between 3 to 8 and had between one and 11 years of prior teaching experience.

This professional development afforded teachers an opportunity (a) to participate in a new pedagogical approach to teaching science or technology; (b) to acquire subject knowledge, skills, and understanding; and (c) to reflect on issues related to teaching and learning elementary science and elementary technology.

Data Collection and Analysis

Data were collected in a variety of forms and in three phases of the study. Phase 1 occurred before the unit was taught. A written questionnaire was used to identify (a) teachers' current knowledge and skills, and (b) teachers' current knowledge about teaching science or technology. For example, Section 1 of the questionnaire collected demographic data about the respondent. Section 2 asked teachers to describe their prior domain knowledge in science and technology. Section 3 asked teachers to describe their prior experience teaching science and technology. Section 4 investigated the nature of the teachers' other professional development experiences.

Phase 2 of data collection occurred while students and teachers completed Support Tasks and a Big Task. Teachers recorded their ongoing thoughts about teaching and learning science or technology or about the professional development experience in a prepared field notes booklet. In Step 1, each page of the field notes booklet contained a specific question. However, at the end of the day teachers made it clear that this was too complex a task to complete while engaging in the tasks. Hence in Steps 2-6 teachers were provided with a booklet that contained blank pages and were instructed to record their ideas about events as they were encountered.

Phase 3 of data collection had two components and occurred after the unit had been taught and once students had been dismissed. The first component, which required approximately 30 minutes, was a written questionnaire to identify (a) teachers' post-inservice domain knowledge and skills, and (b) teachers' post-inservice knowledge about teaching science or technology. Teachers were also asked (a) to list the questions they had about teaching and learning in elementary science or elementary technology as a result of the ISIC professional development experience, and (b) to contrast the ISIC experience with other PD experiences. In the second data collection component, we conducted an audiotaped focus group interview with teachers. This interview was conducted immediately after the written questionnaire was completed and lasted approximately one hour. Faculty instructors initiated discussion with guiding questions. The development of the questions for the focus group interview and the analysis of data were informed by the work of Morgan (1998).

Analysis of responses to the two questionnaires, comments in the field notes booklets, and focus group interviews involved thematic analysis and concept analysis. Etic categories were derived from an analysis of the relevant literature and emic categories from our analysis of the data (McMillan & Schumacher, 2001; Miles & Huberman, 1994; Silverman, 1993; Strauss & Corbin, 1990). A member of the research team (Welch) had experience conducting focus group interviews (Welch, 1998, 1999; Welch & Lim, 2000).

Results

Four categories of teachers' experiences emerged from the data: (a) experience with a new pedagogy in action, (b) experience learning with students, (c) experience actively participating in the professional development, and (d) experience reflecting on the professional development. The first two categories point to common experiences identified by both EST and non-EST teachers. The last two categories represent the expressed experiences of only the two cohorts of non-EST teachers.

Experience With a New Pedagogy-in-Action

EST teachers participating in the two professional development days reported that seeing and experiencing the EST model in action was particularly informative, even though they were familiar with the pedagogical model from previous professional development as part of the project. As one teacher explained, "You could see things that may need to be changed or adapted because actual students are doing the stuff, not teachers. You didn't have to try and speculate everything" (T4). Another teacher commented that it was "very interesting to see how a 'challenging' class responds to this model. Really rewarding to see certain children respond to this method" (T10). All the EST teachers reported that the two professional development days provided valuable learning opportunities that would influence their teaching practices.

Similarly, non-EST teachers indicated that experiencing a new pedagogical model-in-action for teaching science and technology made the professional development experience effective. One teacher from the first non-EST teacher cohort reported, "I learned a new approach—to start with the Big Question and to record the emerging questions as they arise in the unit" (T16). Another teacher suggested, "Asking one main question at the beginning of a science class such as 'Why is it important to classify living things?' is effective. The teaching strategies used today are effective" (T11). In general, non-EST teachers asserted that the pedagogical approach demonstrated in the ISIC professional development experience was informative and useful for them.

The second cohort of non-EST teachers also indicated that the experience of seeing the model taught was critical. One teacher remarked, "I was interested to see how [the instructors] took a big topic like classification and ... make it into something ... broke it down into lessons and just how they did that in a big topic like that" (T18). A second teacher affirmed, "I would say that just seeing somebody else teach it ... I already [knew] the information, but just to see a different way to teach it was ... really important" (T20). Non-EST teachers underscored how valuable it was to experience this pedagogy-in-action in contrast to sitting passively and being told by an "expert" what it might look like in a classroom.

Experience Learning With Students

The unusual opportunity to work alongside students prompted experienced teachers to reflect on their own learning, children's learning, and to examine their teaching practices from new perspectives. Both EST and non-EST teachers commented that observing students and participating as learners with students provided a unique insight into students' engagement with and acceptance of a new pedagogy. As Teacher 1 commented, "If a teacher is not

completely immersed in the experience as we were today, they don't pick up the info and pointers that the children are offering in their groups, the frustration in some activities." Teacher 5 added, "What I really like about getting in a small group with them, you're privy to that conversation, which as a teacher at the front you don't usually get." And Teacher 4 observed, "You could learn along with the kids, through trial and error experiences." Teachers 10, 20, and 22 reflected in the following ways.

WOW! You really have to deal with the model in-context to realize the reality of what happens in science and technology classrooms. By putting myself in the shoes of a student, I realize that we assume too much prior knowledge and sometimes go too fast when we think they should I get it. I saw the model really work! (T10)

It was important to see how the students reacted to the different types of techniques. It allowed the teachers to see which techniques the students excelled at and which were more difficult. It was also important to hear their unit review ... what they liked about their work and where they would like to improve. It gives me an idea as to what points to stress when teaching this unit. (T20)

It was great to be able to do the activity alongside of the students. I got to see "words" put into action. Learning with kids is effective because when it is just teachers there are many off-topic discussions. Learning with the students encourages all involved to remain focused. (T22)

Teachers emphasized that they learned not only more about how students learn, but also about the importance of learning alongside students. This was relevant and meaningful professional development for teachers.

Experience Actively Participating in Professional Development

Non-EST teachers highlighted how critical it was for their learning to participate actively in the professional development experience. In particular, teachers pointed to the sharp contrast between their typical professional development experiences (which concentrate on a passive intake of ideas, generally without any discussion) and actively participating in a professional development model that required them to think and act like a student and also reflect on elements of teaching and learning. Specifically, teachers' directed attention to the following.

I really noticed that when you go to the [school] board ... they give you all the information, but you don't try it, you don't get to see the finished product.... You take the papers home, you file it somewhere, you lose it and you never use it again, at least in my experience.... [Today] I've actually done it. I've tried it. I've seen the kids do it. I know it works. And yeah I'll do it. (T20)

I abhor PD experiences that are not centered on teachers being active in the process. It's why I am reticent to devote a significant chunk of time and money to a PD form that I usually find unproductive. Having the children present reminds me that tasks like this one are pedagogically superior, and interesting for the kids. (T21)

I prefer this method ... if you were to take me to the Board office and show me these units I probably wouldn't read them or you know what, I would flip through them and say okay is this doable, and then I would see all these

materials required and I'd probably shut it and put it away somewhere, but actually seeing this now in action I would use it. (T22)

The big difference for me was we actually did it. When we go to most workshops, they're like maybe an hour and a half, a day at the most, and someone stands there and says ... just tells you what to do and shows you what they've done and that's the end of it, and a lot of the time you don't actually get to use it and do it yourself. (T15)

Previous professional development experiences for these teachers had not usually been productive, specifically because these experiences did not provide them with understandings about implementation in a classroom context. Instead, in typical professional development sessions, as described by teachers in this study, teachers are expected to sit and listen while someone tells them how to teach by providing piles of paper to read at home. Interestingly, this model of *teaching as telling* is precisely the model future teachers at our Faculty of Education are generally taught to avoid.

Experience Reflecting on Professional Development

It is important to note that non-EST teachers identify the experience of reflecting on their professional development as significant. The opportunity to discuss pedagogy with other educators was key and, as they reported, an unusual opportunity for them as a planned part of professional development. In a focus group interview, one teacher put it this way:

Well, the one thing is that you're asking us what we think of what has been presented to us, and that's never happened at an in-service. Usually it's like here's the package, this is how you're going to do it, and bye-bye. So the great thing is I think that you are taking the time to actually talk to us a little bit about it and my assumption would be that maybe you would go back and maybe change a few things or look ... revisit some things um and I think that that's good. (T12)

This particular teacher described previous professional development sessions as "telling" sessions, at which no discussion about the content took place. It would be informative to know to what extent this is standard practice and how both teachers and providers judge the effectiveness of such professional development experiences.

A second teacher reflected on the ISIC professional development experience as follows.

I really liked seeing the whole thing. All the ... like all at once, the introduction, the plan, the discussion, the trial, so [the instructors] introduced each of the concepts, and so you got to see kind of like a unit that you might do in a month or you could do it in a day like this depending on what the focus is, depending on what the curriculum is. And then the review, the self-reflection and self-evaluation [with students]. All these things that I would like me as a teacher to do all the time ... every time I do something, but because of time I find sometimes I skip it. I skip the self-reflection, I skip the, you know, practice, practice, practice of a concept. Sometimes you just go boom, boom, boom, and today I really saw the effectiveness, because the things that the kids were saying ... at the end really showed their learning. (T17)

It is most informative to recognize that this teacher appreciated the importance of self-reflection and opportunities to practice concepts when reflecting on her ISIC professional development experience. Teacher 12 commented, "This was the best in-service that I have attended in the past three years. I will definitely use these techniques in the classroom." And Teacher 22 reflected, "Today's in-service experience was very valuable and rewarding. I learned new skills and a new teaching approach. I also learned a new form of assessment that seems quite valuable. This was a very positive professional development opportunity." Teacher 22 was quite clear that,

In teacher resource manuals and all that stuff, they say this is how you should do it and I've tried it, but it's never been successful, so it was helpful to see it actually modeled to me that way, and with the charts up there and all the steps for the kids to see themselves was very helpful to me.

Once again, the opportunity to discuss the effect of a professional development experience with other teachers is identified as a unique experience. Not only do non-EST teachers appreciate being asked if the professional development experience was effective for them, they believe it needs to be an integral part of typical professional development experiences. It would be informative for professional development providers to think about what formats might be appropriate for teachers' reflection on their professional development (e.g., small-group discussion, large-group discussion, or panel presentations with mind maps). In contrast, EST teachers had multiple opportunities to discuss issues of pedagogy as part of their participation in the EST project, and this is perhaps why their comments do not focus primarily on the value of teacher discussion. Instead, as a result of their participation in the project, EST teachers recognized that discussion and reflection were essential components of their learning, and at this point they simply assumed that it would be part of their professional development.

Discussion

Analysis of the data draws attention to five critical dimensions of an active experience for teachers who engage in professional development. First, and without exception, both EST and non-EST teachers identify experience as central to their learning. According to teacher participants, this professional development experience provided unusual opportunities to discuss not only what worked and what did not work, but also to experience first hand with students the pedagogy and the new subject knowledge. This in itself was a dramatic departure from their common professional development experiences. As Loucks-Horsley and Matsumoto (1999) point out, "too often professional development is not connected to [teachers'] own teaching; nor do they have opportunities to build relationships with their colleagues by studying together" (p. 263).

Second, ISIC provided a new pedagogical approach, a framework, for teaching elementary science and elementary technology. It is important to note that all too often curriculum documents provide only lists of content knowledge to be taught and suggestions for types of activities. Teachers are expected to develop their own frameworks for teaching science and technology as well as for other subject areas. This is no small challenge. Teachers who participated

in this research project were challenged to reflect on and debate the effectiveness of the ISIC approach. As suggested by Ball (1996) and Carney (1998), teachers were invited to take a stance of critique and consider how they might change their practices

Third, the ISIC professional development experience was situated in a learning context, that is, a classroom with students. Teachers who participated in the project had the unique experience of observing two faculty instructors or two EST project teachers teach children for two full days and at the same time participate in the learning experience. This professional development experience was not only relevant to actual classroom work (Cameron, 1996), but it was based on participants' needs as recommended by Vukelich and Wrenn (1999). Instead of receiving stacks of paper about how to teach science or technology, the ISIC professional development experience required teachers to be active participants in a pedagogical approach and to reflect simultaneously as learners and as teachers. It was a live experience; teachers were not passive spectators.

Fourth, collaborative support from teacher colleagues was an integral part of the ISIC project. At the end of each professional development day, teachers knew that they would meet to discuss the effectiveness of the professional development experience (Olson, 1997; Shanker, 1996). The non-EST teachers involved in ISIC 5 and 6, all of whom taught in the same school, had the additional opportunity during lunch breaks and at other times to continue informal conversations based on this professional development experience. The importance of this opportunity for informal conversations during breaks and at lunch is not to be underestimated. These teachers viewed professional development not just as a series of workshops, but as an instance where teachers could work together to examine practice and exchange ideas about teaching. Increased collegiality became a valued part of the professional development experience (Mundry & Loucks-Horsley, 1999).

Fifth, opportunities to reflect-in-action and reflect-on-action (Schön, 1987) were built into the program of ISIC research. For example, during each professional development day, teachers were invited to record their thoughts and questions in a field notes booklet in a format of their choosing (visuals, point form, questions). At the end of each professional development day, teachers were invited to record written reflections individually and subsequently to participate in a focus group interview that centered on their immediate professional development experience. Teachers' comments during the focus group interviews indicate how important they thought it was to have opportunities to discuss the professional development experience with their peers and with the instructors.

In the final analysis, ISIC was an intensive professional development experience for a small number of teachers. However, we are convinced that devoting large amounts of time and energy to a few teachers is more likely to lead to real change in teachers' understanding of subject matter and pedagogy and to lasting change in classroom practice. Even so, this approach to professional development limits the opportunities, at least in the early stages, for large numbers of teachers to acquire the knowledge and skills required to teach a new curriculum. Recognizing this limitation, and at the same time wishing to

maximize dissemination of the EST curriculum units, we decided to make the professional development available through a pilot program involving teacher candidates. This pilot, currently in progress, will be reported at a later date.

Conclusion

In this article, we describe the results of a program of research entitled *In-service in context: Learning science and technology in elementary classrooms*. This research grew out of feedback from teachers participating in the Elementary Science and Technology project, who reported that although a variety of professional development experiences provided by the project had been extremely valuable, the introduction of a radically new pedagogy for teaching and learning in science and technology posed new and unresolved dilemmas for them. Therefore, they wished to see the pedagogy in action, that is, being taught to students. In addition, the mandate of EST required gradually transferring to teachers the responsibility for professional development to support a new Ontario science and technology curriculum. ISIC was designed to respond to both of these demands.

Identifying and then engaging EST teachers as professional development leaders in Steps 5 and 6 of ISIC proved extremely successful. Unfortunately, the school boards have not yet taken advantage of this expertise. As a result of a major government initiative for increased amounts of literacy and numeracy, schools chose to reduce their commitment to the development of teaching and learning in science and technology. The number of professional development days provided for teachers in Ontario has been sharply reduced in many school districts and rarely exceed more than two full days each year. In addition, continuing cuts in government funding translate into a disastrous shortage of tools and equipment necessary for teaching the two subjects.

Teachers participating in ISIC made it clear that many of their previous professional development experiences had not been helpful. They identified the experience of professional development in context with children as a unique and effective professional learning opportunity. In working alongside students, each teacher (a) learned the subject content, (b) learned to recognize if and when students were engaged with learning, and (c) learned how to teach the particular subject content. In addition, participating in ISIC assisted teachers with the creation of a *community of practice*, a significant contribution to the overall professionalization of these teachers.

The time to reflect on the professional development experience, as well as the opportunity to talk to colleagues about the learning that was taking place and its implications for implementation in the classroom, was seen as critical. The ISIC research indicates that if experienced teachers do not engage in shared reflections on their professional development experiences, then professional development providers only make assumptions about what teachers need to learn and need to do in order to learn. The research reveals insights from teachers that can contribute to a model of professional development that invites shared reflection as a regular part of professional development. Providing the opportunity to discuss issues of teaching and learning with peers as part of a professional development session goes beyond simply asking for written comments. If professional development, that is, development that leads to positive change in the classroom, is to be successful, then teachers must be

afforded opportunities to direct, actively engage in, and reflect on their professional growth. As long as others (PD providers) make primary decisions about what type of professional development experiences teachers need, teacher professionalism will not be rightfully acknowledged.

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