

REFLECTIONS OF SCIENCE TEACHERS IN AN IN-SERVICE TEACHER EDUCATION PROGRAMME

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This instrumental case study was conducted to determine the nature and levels of science teachers' reflections during a year-long in-service postgraduate Diploma in Education programme. Four science teachers comprised the case. The data were analyzed inductively through a process of open coding and categorizing to determine patterns and themes. Van Manen's (1977) framework was used to determine the levels of reflections. The following themes emerged: "Confronting fears/limitations/insecurities;" "Students take centre stage;" "Trying something new;" and "Breaking down barriers." The four teachers reflected at all levels – technical, practical, and emancipatory. However, only two teachers reflected at the emancipatory level. These findings have implications for the manner in which we, as science teacher educators, facilitate the development of the reflective habit.

Introduction

Reflection is considered to be central to the professional development of teachers, and since the 1980s, there has been a proliferation of teacher education programmes that incorporate reflective practice. In keeping with this movement, reflective practice is now a component of the teacher education programme at the School of Education (SOE) at the St. Augustine Campus of The University of the West Indies (UWI) in the Republic of Trinidad and Tobago.

The Diploma in Education (Dip. Ed.) is a one-year postgraduate in-service programme, designed to provide graduate teachers who are employed full-time in secondary schools with the relevant knowledge, values, attitudes, and skills for their personal and professional development. It begins in July and runs to the end of May of the following year. Teachers attend classes at the university on a full-time basis during the July/August vacation, and part of the Christmas and Easter vacation periods. They are released from school for one day during the normal school terms.

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For the majority of teachers who enter the programme, this is initial teacher education since professional certification is not a requirement for entry into the Teaching Service. The entry requirement for a graduate teacher is a first degree in the area of subject specialization. Consequently, the model of teaching that guides the practice of the new entrants into the programme is often based on (a) their own experiences as students, (b) their observations of peers, (c) advice from a senior teacher/mentor, or (d) combinations of these.

At the beginning of the programme, all teachers are exposed to courses/modules in the Foundations of Education, Curriculum Process, Media in Education, Assessment in Education, Research Methodologies, and Elective Areas (e.g., photography, videography, dance, music, yoga, and creative writing). The teaching of science is one of the options of the course "Curriculum Process." The aim of this option is to encourage science teachers to bring theoretical perspectives to their classroom practice, as well as to confront their beliefs about the nature of science and the teaching/learning process. Teachers are therefore given opportunities to engage in reflection as "systematic enquiry into [their] own practice to improve that practice and deepen [their] understanding of it" (McIntyre, 1993, p. 42).

The other course related to the teaching of science is "The Practice of Education." The focus here is on school practice, under the guidance and supervision of curriculum tutors who conduct the field experiences (practicum). During field visits teachers are provided with opportunities for guided experimentation with new methods. Teachers are assessed in two areas: classroom practice, and a curriculum portfolio that documents and provides evidence of growth and development in specified areas. The portfolio includes a reflective journal in which teachers are expected to critically appraise educational issues and events as well as classroom practice, and to plot significant growth points.

This paper reports on the nature and levels of the reflections of four "experienced" science teachers who were enrolled in the Dip. Ed. programme. Most of the literature on reflective practice reports on novice teachers enrolled in pre-service programmes. The research we are reporting here is significant because it focuses on "experienced" teachers, that is, teachers who have been teaching for some years without any formal teacher training, as opposed to what the literature refers to as

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“expert” teachers. It attempts to give some insights into how these “experienced” science teachers reflect when they come to a programme for initial training, having gained considerable practical knowledge in the classroom. Specifically, our research study sought to answer the following questions:

- What is the nature of science teachers’ reflections?
- At what levels do science teachers reflect as they attempt to articulate their knowledge of practice?

Review of Related Literature

The works of Dewey (1933) and Schon (1983) have shaped the ways that researchers and teacher educators have thought about reflective teaching. Dewey separates reflective teaching from routine action. The Deweyan notion is that education is reconstruction, so that reflective teaching involves the reformulation and recreation of teachers’ knowledge.

In the literature on reflective practice, there is a link between reflection and the empowerment of teachers. Calderhead and Gates (1993), for example, suggest two main functions of reflection in initial teacher education, which speak to the empowerment of teachers through greater knowledge and understanding of the teaching/learning process. The first is to give student teachers an understanding of their own problems and needs, in order to give direction and purpose to their search for ideas from other sources and to their theorizing about these ideas. The second is to provide guided practice in the skills and habits of reflection. The critical theory of Habermas (cited in Calderhead & Gates, 1993) has also stimulated thought about the importance of increasing teachers’ awareness of the causes and consequences of their actions. The theory holds that teaching is a process of constructive self-criticism whereby teachers examine and reflect upon underlying assumptions, norms, and rules that constrain and shape their practice (cf. e.g., Calderhead & Gates, 1993; Zeichner & Liston, 1996), and which leads to emancipatory knowledge.

Drawing on the critical theory of Habermas, Van Manen (1977) proposes a hierarchical model of *levels of reflectivity*. He identifies three levels, each of which focuses on a particular aspect of knowledge. The first level (technical) is concerned with the effective application of skills and

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technical knowledge in the classroom. The second (practical) involves reflection about the assumptions underpinning classroom practice, as well as the purposes and consequences of actions in the classroom. The third (critical/theoretical/emancipatory) focuses on the development of emancipatory strategies, and involves the questioning of moral, ethical, and other issues, such as fairness and justice, that relate directly or indirectly to institutional and wider social and political contexts. Van Manen sees these three levels as spanning the growth of the teacher from novice to expert, so that as teachers engage in the highest forms of reflection they should be empowered to make decisions that would not only be beneficial to classroom practice but would also inform educational policy.

Fuller's (1969) model of concerns has also been used to explain teachers' stages of development during initial pre-service teacher training. This model describes three stages of development, which are characterized by concern for self, concern for the task, and concern for impact. While Fuller's model has been used as the framework for analyzing teachers' concerns during their development, its use has traditionally been in the context of pre-service teacher education. It is important, therefore, for us as teacher educators to gain some insights into how experienced teachers engage in the reflective process, so that we, in turn, may be empowered to make decisions about our classroom practice.

The literature also refers to five traditional approaches to reflective teaching (Zeichner & Liston, 1996) that have guided reform efforts in teaching and teacher education. They are labelled *academic*, *social efficiency*, *developmentalist*, *social reconstructionist*, and *generic*. With the exception of the generic approach, each of these approaches identifies a particular emphasis in the content of teachers' thinking. The academic tradition stresses subject matter and how it translates into student understanding. The social efficiency tradition focuses on application of teaching strategies. The developmentalist tradition looks at teaching that builds on students' experiences and patterns of developmental growth, while the social reconstructionist tradition explores the social and political contexts of schooling. The generic tradition emphasizes thinking about teaching actions without deliberate attention to the quality or substance of that thinking. A modified generic approach might best describe the strategy that was adopted with the teachers in the science option of the Dip. Ed. programme. While we did not attempt to prescribe the substance of the teachers' thinking, our responses, either through

probing questions or pertinent comments/suggestions, were influenced by Van Manen's levels of reflectivity and Fuller's model of concerns.

Methodology

The study is qualitative in nature and is situated within the interpretive inquiry paradigm. The goal was to achieve, through inductive and qualitative modes of analysis, understandings, interpretations, and meanings of particular contexts (cf. Hoy & Miskel, 1987). The design used was an instrumental case study (cf. Cresswell, 1998), in which the focus was the issue of reflective practice with the case used instrumentally to illustrate the issue.

At the beginning of the programme, teachers were engaged in formal sessions on developing the reflective habit. They were exposed to the "four commonplaces" of schooling, that is, the features common to any teaching situation—the teacher, the subject matter, the learner, and the milieu or context (Schwab, 1971). They were also introduced to different formats for writing reflective pieces, including the structured format of Posner (1985). Posner's approach was suggested for those who preferred some structure in the beginning. It involves identifying and describing some educational situation or problem, analyzing the problem to generate possible solutions, and identifying learning experiences and emerging issues. The teachers were also given opportunities to analyze, individually and collectively, selected reflective pieces from the literature. They were, however, given a free hand in terms of choice of format and the issues upon which they chose to reflect.

During the July/August session, the teachers reflected upon the issues raised during lecture sessions as well as past practice. The process of developing the reflective habit continued after the teachers returned to school and during formal sessions on campus. For example, during the field experiences, there were one-on-one conferences between tutor and teacher, and group conferences among groups of teachers and tutor. During these sessions there were opportunities for oral reflection on practice. The issues discussed ranged from their attempts to meet student needs, their approaches to teaching, the rationale for these approaches, classroom management, the theory/practice interface, and peer and administrative support. These discussions informed subsequent journal entries.

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Teachers were encouraged to write as often as possible, but a minimum of two entries per week was suggested. They were asked to submit their journals once a month. The reflective pieces were read and, in direct response to the issues raised, comments and questions were recorded. Some of the questions that were posed to teachers in response to their written pieces were:

- What does this episode tell you about how students learn?
- What does this episode tell you about your teaching?
- What does the literature say?"

Sometimes teachers responded to the questions in subsequent journal entries, but this was not generally the case. Our intention in the beginning was to have teachers move from merely describing practice to making their underlying beliefs and assumptions explicit. Later, they were encouraged to use public knowledge such as educational theories, teaching principles, and other research evidence to appraise their practice.

Four teachers, three of whom were female, were the participants in the study. They were selected by purposive sampling from the cohort of graduates at the end of the programme. The main criterion for selection was a Grade A in the course *Practice of Education*. These teachers excelled in classroom practice and attained the required quality levels for curriculum portfolio entries. Their reflective journals were further examined and final selection was based on overall number of entries, spread over the course of the programme, and regularity of submissions. The participants selected were Joan, Brad, Kay, and Lynn (not actual names). They taught at different types of schools and came with varying experiences of classroom teaching including length of service, which ranged from 5-11 years. While gender was not a key factor in the selection process, the composition of the selected group did reflect the ratio of females to males in the cohort.

Data collection, as mentioned earlier, was confined to the reflective pieces in the journals of the four teachers. The data were analyzed using open coding to arrive at themes. Further in-depth analysis was done to identify assertions and interpret meanings in an attempt to arrive at levels of theorizing and reflecting. This interpretive phase drew on Van Manen's (1977) analytical framework of levels of reflectivity.

A limitation of this study is that data collection was confined to a single source—the reflective journals of the four participants. The data, therefore, were subjected to continuous examination/analysis by the researchers, both individually and collaboratively, in order to clarify meanings and ensure that the grounds for the interpretations were sufficient. In addition, the findings and interpretations were subjected to external audit by another colleague.

Findings

The findings follow in the form of responses to the two questions posed earlier. For the first question, a description of each emerging theme is presented supported by verbatim examples from teachers' journals. This is followed by a brief summary. For the second question, a short analysis of the levels of reflection is provided along with a summary table.

What is the nature of science teachers' reflections?

The common themes that emerged from the analysis of the data from the four teachers were "confronting fears/limitations/insecurities," "students move to centre stage," and "trying something new." Another theme that emerged from two of the teachers was entitled "breaking down barriers." These are discussed below.

Confronting fears/limitations/insecurities

All four teachers were engaged in a critical self-analysis, and they identified their fears and uncertainties. Kay, for example, mentioned her concerns about exposure to scrutiny as she revealed private thoughts and feelings, which could make her vulnerable to criticism. She wrote of her desire to "flee" from the process:

Knowing that over the year as a Dip. Ed student, I will have to face some negative truths about myself and my work, and worse yet, admit them in the presence of someone else (via reflections) is somewhat disconcerting.... Therefore, I must resist the 'flight' response, and confront my fear head-on. I am willing to change for the better, so I must submit to the process.

She also reflected on her limitations with respect to incorporating practical work in science teaching. She expressed feelings of insecurity

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because she did not have first-hand experience of the kind of laboratory activities that she was expected to have students involved in:

I was not fully satisfied with this lesson. I must admit that I am somewhat uncomfortable about practicals - it stems from my not having done A-level physics and hence, I have had little exposure to the kind of labs that are required. Thus, I tend to feel unsure of myself in practicals.

Lynn also wrote about her perceived limitations and the accompanying emotions. She said that her inability to conceptualize the planning and design component of the examination syllabus led to feelings of inadequacy:

I think that I have not as yet gotten the idea of planning and design clear in my head, and I sometimes feel inadequate teaching it.

In addition, she described her teacher-centred approach with the classes, which are being prepared for external examinations [Caribbean Secondary Examination Certificate of the Caribbean Examinations Council], as a shortcoming. She concluded that institutional forces had shaped her beliefs about her worth as a teacher and that these beliefs had impacted on her actions:

I tend to be teacher-centred with the 3s and 4s [Grades 10 & 11]. Experiments with 1s and 2s [Grades 8 & 9] only. In a school where your worth equals your results, I have not been very successful in separating myself from the mainstream of thought.

Joan identified what she also perceived as her shortcomings as a teacher, and she attributed these to the lack of congruence between her beliefs and her actions:

I began to realise that my tendency to sometimes snap and hurl insulting comments at students who I considered to be asking stupid questions was rooted in selfishness and impatience. Mentally, I knew that students learn in different ways but it was never reflected in my attitude and style.

In other reflections she continued to focus on her perceived limitations. For example, she recognized a deficiency in her teaching when she failed

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to make important conceptual linkages during the execution of a lesson so students did not always see the bigger picture:

After all the inquiry into the nature of the respiratory surfaces, I failed to make the link with gaseous exchange.

She was also uncertain about how to achieve the balance between institutional demands and what she considered to be good teaching:

I tend to be over ambitious, i.e. attempting to achieve too many objectives in one period I always have at the back of my mind the syllabus to be finished. After eleven years of being syllabus-driven, it is difficult to remove the concept from my mind. I recognise mentally that if my lesson plans are well conceptualised and executed then I need have no fear of completing the syllabus in ample time.

Brad recognized his inability to delegate responsibilities to students as a limitation that he needed to address:

The excitement and high level of motivation I experienced today have only reinforced what I have long known about myself as a student and teacher. I get bored and demotivated in highly structured environments.... Rigid schedules and demands stifle me. I am largely self-directed and work best when minimum restrictions are placed upon me.... This forces me to consider whether I am a “controlling teacher” who imposes rigid demands on my students. In some ways I am. Delegating has never been one of my strengths. I must remember the emphasis is on “student-oriented” ... learning strategies.

Summary

The issues raised in this theme were vulnerabilities to criticism, perceived shortcomings—both personal and professional—insecurity in effectively carrying out teaching functions in the classroom, and a tendency to be controlling. For the first time, teachers had begun to articulate their feelings and to look at themselves as teachers in a critical way, and to revisit their assumptions about teacher efficacy. These reflections show their attempts to move away from routine and unrealistic behaviours.

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Students move to centre stage

As the teachers reflected, their students became a central focus of their thinking. Brad, who had encountered some difficulty in understanding some readings in philosophy in the programme, and had expressed his frustration at trying to make sense of unfamiliar words and a complex language style, quickly came to empathize with his own students who were experiencing similar conceptual and linguistic problems at their level. He began to explore ways of helping them:

The language barrier, which may exist in the classroom, has never been more real to me. I have experienced some of their [his students] frustrations today. When I return to the classroom, I'll have to ensure that students have an easier task understanding what they read.... A long-term solution would be to systematically build up the vocabulary of my students.

As Joan's understandings about student learning developed, she began to involve the students more actively in learning activities:

I myself had always believed that more student learning took place during lecturing. I now see that students can effectively learn from each other. I should reduce my talking and allow students to participate in group work, discussions, role-play and so on.

Lynn removed herself from being the focus of the teacher/learner interaction and began to view the interaction from the students' perspective. She became aware that her values and beliefs could impact on the students:

From the lecture, I understood how my world of class, culture, religion, intellect, etc. can impact on a child. I previously always looked at the impact of the child's world on mine.

Kay placed more emphasis on her relationships with her students. In this piece, she demonstrates her concern for issues of fairness and justice in the classroom:

Writing now has led me to consider something I never have before - what has come to the fore is the vast difference between my schooling background and that of my students. Therefore, I now ask myself, "Is it fair to expect of him the same, as I would expect of a "convent girl"? It is clear to me that if I would like to see long-term changes in the students' behaviour, then I must first make the effort to understand their current and historical situations. (Wow! What an eye-opener?! I am actually

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stunned to find myself thinking along these lines after just beginning to write this reflection.) This is a tall order- Am I up to it? I wonder.

She also began to use students' interests as an important criterion for her choice of teaching/learning strategies:

My unenthusiastic feeling was beginning to disappear as I realised that I had already captured the students' interest. Further use of this technology appeared to interest the students. I guess the change in modes of delivery accounts for the additional interest. My challenge is to be creative and find other modes to attempt with my class, in an effort to provide variety and, hence, maintain interest.

All teachers experimented with small-group, student-centred approaches. The following vignettes (from Joan and Kay) demonstrate how the students became the central focus:

This lesson taught me a lot about student learning ... the wider the range of methods you use in the classroom, the greater the number of students reached.

This episode showed me that I should distribute questions more evenly, taking into consideration sex, ability, and location in the classroom. Too often I tend to take the path of least resistance and ask those who I know would answer or participate readily.

V [male student] was probably more motivated [today] because he was asked to participate.... Based on my reflection on the previous lesson, I was very particular to have more male participation. It tells me ... that it is counter-productive to (wittingly or unwittingly) exclude some students.

Summary

The teachers focused on making the students central to the entire learning process through their selection of teaching and management strategies. They encouraged full participation, and identified strategies to promote equity in the classroom. Their own difficulties with particular aspects of the programme made them empathize with their students and recognize the importance of improved student-teacher relationships.

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Trying something new

The teachers all accepted the challenge to attempt new strategies in their classroom. Brad acknowledged the value of formal lesson planning after his first attempt and described the experience as most satisfying:

I used my first lesson plan today.... The lesson was quite a success. The set induction fulfilled its purpose ... the lesson just flowed naturally into the development phase.... This was a most satisfying experience for me. The extra effort involved in formally planning the lesson paid off.

He also wrote of his attempts to use various types of graphic organizers and the perceived benefits in terms of developing independent learners:

We have also been using concept trees showing the hierarchical relationships among concepts. The response has been very favourable. The graphics have led to the classes becoming more vocal as we discuss the relationships between concepts.... I am learning that I don't have to "teach" everything. I am gradually letting the students take more responsibility for their learning while guiding them along.

Joan looked at whole-group teaching through different conceptual lenses. Her previous approach was to get as much information as possible across to her students. After attempting an interactive whole-group approach, she wrote:

This class went much better than my whole group teaching in the past.... Whole group teaching does not mean no student-student interaction and boredom. I used to have to work extremely hard asking question after question to get student participation.... It is good that I have a clearer understanding of this "teaching stuff" now.

Kay was enthused by her attempts to introduce a new strategy on model building that allowed her to concretize abstract science concepts:

I was thrilled with this response to my first attempt to incorporate model construction into the science classroom. I found that this exercise seemed to reinforce the students' knowledge and to bring alive and make concrete the information/theory to which they had been exposed. Consequently, model construction will definitely form part of my teaching repertoire in future.

Exposure to the multiple roles of practical work in science on the Dip. Ed. was an "eye-opening experience" for Kay. She recognized that her old

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approach to laboratory work was limited to verification of theoretical concepts, and she attempted a new approach in which students were given the opportunity to construct knowledge from their practical work. This episode demonstrates her evolving understandings of this aspect of the nature of science:

The session on the role of practicals was another one of those eye-opening experiences that have occurred during the Dip. Ed. - the kind that are signalled by an internal churning that suggests a subtle paradigm shift.... Like most science teachers, I usually use the practical as a means of verifying some taught theory. We learnt that practicals could actually be used for investigations from which the theory could be drawn out. Last week, I attempted the latter approach.

Lynn implemented a new strategy in which the students were expected to create notes on various topics. She termed this activity the "great note-taking experiment." She became aware that students' motivation might be directly linked to the teaching/learning strategy:

I had initially thought that note taking was about creating independent learners. Never in my wildest dreams did I connect this to improved learning and further away still, to an increased desire to learn.

All the teachers came to a new understanding of the importance of affective outcomes of science lessons and the challenges that they face in marrying the affective with the cognitive. Examples are drawn from the writings of Kay and Lynn:

Once again our consciousness is being prodded. ...We have been encouraged to raise the impact of our lessons by teaching for affective outcomes. This is a new and appealing idea.

In the past, I have approached this lesson [the effects of smoking] from a strictly cognitive viewpoint, hoping that at the end ... students would be able to describe the effects of smoking. Any affective outcome would have been achieved unintentionally. This time around, I approached the topic ... from a health education perspective. Through this experience, I have learned that affective objectives can be interwoven with cognitive objectives in the teaching of science. Maybe the more frequent inclusion of affective objectives will result in better-adapted, more rounded students.

Summary

Teachers increased their repertoire of strategies, and they recognized that by employing a wide range of strategies more students became engaged in the learning process. They also came to appreciate that teaching strategies can focus on the product as well as the process of learning, on affective as well as cognitive outcomes, and that practical work in science can facilitate concept development and theory formation. Finally, new assumptions about effective science lessons led teachers to identify new criteria for evaluating and developing their practice.

Breaking down barriers

A theme that emerged from the analysis of the reflections of two student teachers was termed "breaking down barriers." It was obvious that these teachers were moving into uncharted waters. Although this theme is not representative of all four teachers, it is included because it demonstrates tentative questioning of past and present actions, and considerations of how to go about making the best choices in the future. In these reflective pieces, the teachers addressed the wider political and social contexts of schooling. Kay, for example, began to think of new roles that she could play within the educational system as she reflected on issues raised during a lecture session on an educational issue:

As he [lecturer] spoke, I felt a churning within- something of an awakening of consciousness. He spoke of teachers and their perspectives. I became aware of some internal changing, a move from a helpless, "one drop in the bucket" kind of feeling in the macro perspectives, to a sort of individual empowerment, "I can make a difference" kind of feeling....His overall message? We cannot sit and simply allow things to go by. Be aware of the ripple effects each of us has, and execute desired behaviours accordingly.

She also attempted to influence students' out-of-school behaviour through infusion of health-related issues and associated high-risk behaviours into a science lesson. The lesson, entitled "AIDS and me," was taught during the pre-Carnival period [a period of time devoted to calypso music, steelpan orchestras, and masquerade]. She encouraged students to explore issues related to sexually transmitted diseases:

This represents an area that I usually address with my students- young adults aged 18-22 years. The strong points of this lesson are its relevance to the students' experiences, the mode of delivery that draws on their prior knowledge and the creativity-based method of

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evaluation. It was not a difficult lesson to attempt because I am accustomed to practising some kind of pastoral role with my students and I believe that this has always been a part of my teaching.

Lynn reflected on reform in education and began to question the lack of support systems to assist teachers in the delivery of new curricula:

I understand that youth is in crisis. As the children at the forum [panel discussion during which school students shared experiences of learning] pointed out, it is really the parents in crisis and of course the teachers are required to pick up the slack. It is my society too and I hope to make a difference. The problem is that we were not even asked. HFLE [Health and Family Life Education] will be taught in schools. Apparently CARICOM States have signed documents. No problem. But where's the support system for teachers who implement such a mentally burdensome system? The children are saved, but what about the teachers?

She also expressed concerns about the moral and ethical bases of her actions in the classroom. Negotiating issues of values clarification and establishing supportive learning environments could sometimes be problematic. In the latter case, she looked to the educational literature for support:

How do we marry morals with critical thinking? Can we trust students who lack experience to choose? Is it only if we are assured that they will [choose wisely] that we are comfortable opening up critical discussions on morals?

Every class... same story. Then I'd fire the speech, 'if you don't feel to do chem. go and do whatever subject you like, I won't keep you.' Kutnick and Jules (1993) have students defining 'good' teachers as disciplining students' misbehaviour, asserting class rules, and maintaining order. The good teacher was also respectful and friendly. Humble too. S and K struck my raw nerve. Disrespect always sends my head swirling. Finally, I am calm enough to read Beihler. I know that in their search for identity they must challenge me and that out of my love for them I must correct them. But I needed [sic] to change my methods of disciplining.

Summary

This theme highlights the teachers' examination of the contexts of schooling. These excursions into reflections about wider societal issues revealed the teachers' attempts to revisit their roles as teachers, and to

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bridge the theory/practice divide as they grappled with moral, ethical, and policy issues and sought to validate their practice.

At what levels do science teachers reflect as they attempt to articulate their knowledge of practice?

When the themes were analyzed within the Van Manen framework, we found that all four teachers theorized primarily at the practical level. The ratio of reflections at the practical, emancipatory, and technical levels was 4:2:1 respectively. Only two teachers, however, reflected at the emancipatory level. The focus of teachers' thinking at the emancipatory level was on issues related to the wider social and political contexts of schooling.

When the reflective pieces were analyzed within the themes identified, we found that teachers reflected at all levels in themes 1 and 3; in theme 2 there was no evidence of reflection at the technical level; and in theme 4, teachers reflected at the emancipatory level only.

Table 1 shows the main themes that were identified, with illustrated examples from the teachers' reflections, and how these were classified within Van Manen's (1977) analytical framework.

Discussion

The aim of this paper was to report on the nature and levels of reflections of experienced science teachers. We found that while the substance of individual teachers' reflections varied, there were concerns about knowledge of the following: self, their students, the subject matter of their lessons, and the context of teaching (cf. Schwab, 1971). They spoke about their fears, limitations, and vulnerabilities. They were concerned about providing environments that were conducive to student learning. They were sometimes unsure about how to teach with the bigger picture in mind, or how to organize their subject matter in ways that fostered creativity while still meeting syllabus requirements. They were also very sensitive to institutional and other constraints that impacted on their work. The study therefore provided us with some understandings of how these teachers interpret and give meaning to their practice, how they attempt to come to terms with their own realities, how they theorize about their practice, and how this knowledge could inform our own practice.

Table 1. Themes, Selected Examples, and Levels of Reflection

THEMES	ILLUSTRATIONS	LEVELS OF REFLECTION
Confronting fears/limitations /insecurities	I was not fully satisfied with this lesson. I must admit that I am somewhat uncomfortable about practicals - it stems from my not having done A-level physics and hence, I have had little exposure to the kinds of labs that are required.	Practical
	After all the inquiry into the nature of respiratory surfaces, I failed to make the link with gaseous exchange.	Technical
	I tend to be over ambitious i.e. attempting to achieve too many objectives in one period.... I recognise mentally that if my lesson plans are well conceptualised and executed then I need have no fear of completing the syllabus in ample time.	Practical
	I tend to be teacher-centred with the 3s and 4s. Experiments with 1s and 2s only. In a school where your worth equals your results, I have not been very successful in separating myself from the mainstream of thought.	Emancipatory
Students move to centre stage	I myself had always believed that more student learning took place during lecturing. I now see that students can effectively learn from each other. I should reduce my talking and allow students to participate.	Practical
	From the lecture, I understood how my world of class, culture, religion, intellect etc. can impact on a child. I previously always looked at the impact of the child's world on mine.	Emancipatory
	The language barrier, which may exist in the classroom, has never been more real to me.... When I return to the classroom, I'll have to ensure that students have an easier task understanding what they read.	Practical

Table 1. (continued)

THEMES	ILLUSTRATIONS	LEVELS OF REFLECTION
<p>Trying something new</p>	<p>I used my first lesson plan today.... The lesson was quite a success. The set induction fulfilled its purpose ... the lesson just flowed naturally into the development phase.... This was a most satisfying experience for me.</p>	<p>Technical</p>
	<p>I was thrilled with this response to my first attempt to incorporate model construction into the science classroom. I found this exercise seemed to reinforce the students' knowledge and to bring alive and make concrete the information/theory to which they had been exposed. Consequently, model construction will definitely form part of my teaching repertoire in future.</p>	<p>Practical</p>
	<p>This class went much better than my whole group teaching in the past.... Whole group teaching does not mean no student-student interaction and boredom. I used to have to work extremely hard asking question after question to get student participation.... It is good that I have a clearer understanding of this "teaching stuff" now.</p>	<p>Practical</p>
<p>Breaking down barriers</p>	<p>I understand that youth is in crisis.... It is really the parents in crisis and of course the teachers are required to pick up the slack. It is my society too and I hope to make a difference. The problem is that we were not even asked. HFLE will be taught in schools.... But where's the support systems for teachers?</p>	<p>Emancipatory</p>
	<p>I became aware of some internal churning, a move from helpless, "one drop in the bucket" kind of feeling in the macro perspectives, to a sort of individual empowerment, "I can make a difference" kind of feeling.... Be aware of the ripple effects each of us has, and execute desired behaviours accordingly.</p>	<p>Emancipatory</p>

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There was no established pattern of levels of reflection among the four teachers. The teachers operated at the three levels at various times throughout the course of the programme. This supports the position of Martinez (1990), cited in Dobbins (1996), that elements of all levels may (and indeed should) be present as characteristics of reflection rather than a strict developmental stage hierarchy as suggested by Van Manen (1977). It should be noted that we made no direct attempts to make teachers aware of the various levels at which they were thinking, or of how this awareness could contribute to praxis.

It is instructive that all four teachers theorized at the practical level, and there were very few attempts at theorizing at the technical level. There may be two explanations for this trend. The first explanation is that the teachers were not novice teachers, and so were not overly concerned about developing technical proficiency. It is plausible that teachers who have had some years of teaching experience may have mastered some technical aspects of teaching, and may be more concerned with interrogation of their practice to make explicit their assumptions, and the purposes and consequences of actions in the classroom.

The second explanation is that while we wanted them to reflect on their attempts to apply their skills and technical knowledge, and to become aware of instances where skills need to be developed, we may have inadvertently presented a model of reflection during the classroom sessions that did not highlight technical proficiency. For example, in our selection of illustrative pieces, a lot of the discussion focused more on assumptions and underlying beliefs that guided practice, and on educational theories that informed desirable practices, rather than on technical issues. In retrospect, this focus was also apparent in the kinds of responses that we made to their written pieces. There was also a heavy focus on the teaching/learning process during field visits, and in our dialogue with the teachers we focused primarily on pedagogical issues that bounded the discussions within the classroom walls. The teachers, in turn, used these issues as stimulus for their reflective pieces. In the absence of any direction from us on the degree to which their reflections should focus on examining the social and institutional contexts in which they work, we surmise that the four teachers focused primarily on the knowledge gained from their actions in the classroom. There are implications here for the kinds of models that we present to teachers in the future.

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It was noted that the teachers attained the higher emancipatory level of theorizing only when they reflected explicitly on the context or milieu of teaching and learning. For example, both Kay and Lynn revisited the role of the teacher in policy formulation and curriculum reform. They moved outside the mandated syllabus requirements and made deliberate decisions about what should be included in science lessons in order to respond to students' needs. They also addressed ethical and moral issues that impinge on the profession. Lyn, for example, confronted such questions as, "What is right?" (How to meet institutional goals that focus on examination results without compromising good classroom practice). "What is fair?" (How to discipline effectively while recognizing students' need to search for identity). "Whose values?" (How to negotiate issues for values-clarification).

In addition, both teachers made conscious efforts to increase professional knowledge and to enhance their professional development as they attempted to integrate educational theory and classroom practice. While this finding is commendable, in retrospect, we would have liked all four teachers to reach this emancipatory level of theorizing. It is also significant that Lynn and Kay were unable to demonstrate this same level of theorizing about the subject matter. Science by its very nature encompasses ethical, political, and societal issues. It is evident, then, that we will have to revisit what we do in the curriculum sessions if we want to provide opportunities for, and support attempts by, all teachers to theorize at the emancipatory level about the four commonplaces.

It is clear that the existing structure of the in-service Dip. Ed. programme has provided some practice for the teachers to develop the skills and habits of reflection. This is one of the functions of reflection in initial teacher education, which speaks to the empowerment of teachers (see Calderhead & Gates, 1993). It is apparent, however, that our teachers need to be encouraged to further develop the skills of critical inquiry, if they are to be empowered to systematically make decisions about teaching and learning, based upon analysis and consideration of alternatives within an ethical and political framework. The absence of pedagogy to promote this higher level of reflective inquiry is obviously a shortcoming of the science option of the Dip. Ed. programme. Beattie (1997), citing the work of Barone et al. (1996), speaks to the need for teachers to be educated in three dimensions of professional knowledge. One of these is the political dimension, in which teachers describe and analyze the social and cultural contexts and curriculum content, in order

to be capable of inspiring and influencing others to respect their ethically grounded set of beliefs and practices. Perhaps there should be greater focus on this dimension in the science option of the programme.

Reflections and Recommendations

Our reflections on the findings of this study have led to the conclusion that our actions as teacher educators have been congruent with the stated aims of the Dip. Ed. programme. We now recognize, however, that our interpretation of these aims may have been limited, or that the stated aims do not fully reflect our expectations for teacher empowerment and transformation of classroom practice.

We have also become aware that there are gaps between our actions and the outcomes that we expect from the teachers in the programme. Raines and Shadiow (1995) suggest that reflection has the potential to benefit both teacher and student, and that “thinking-beyond-doing” challenges teachers at all levels to be more conscious about how and why they teach as they do, as well as about how the new awareness benefits their students.

We may need to re-examine our orientation to reflective teaching. Since we concur that higher levels of reflection are directly related to deeper understandings of the contexts of schooling, we may need to adopt aspects of the social reconstructionist tradition (Zeichner & Liston, 1996) that encourage reflection at the emancipatory level. We also suggest that the aims of the Dip. Ed. programme should be revisited to include the third dimension of strong professionalism (Beattie, 1997) in which emancipatory thinking is facilitated.

The challenge for us as teacher educators is to inspire our teachers to set off on a journey of exploration during which they will become transformed and empowered. To do this, we must enter into the kinds of relationships with our teachers that will help them to develop their voices and understandings. As we engage in this dialectic we can, in turn, reform and transform our own understandings.

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In the short term, the following are some strategies that we plan to implement:

- ❑ Facilitating the process of reflection by providing opportunities during the curriculum sessions for science teachers to engage in dialogue about their teaching and learning. Such a forum that allows for the critical examination of experiences, beliefs, values, and attitudes should enhance the quality and direction of their written reflections.
- ❑ Including in curriculum sessions a critical examination of the impact of the current educational landscape on teachers' practice and professional development. This should also include the social, institutional, and political contexts of schooling.
- ❑ Writing and critiquing of reflective pieces during curriculum sessions so as to emphasize the substance and levels of teachers' reflections.
- ❑ Structuring reflection time into the teaching practice experience, for example, during the conferencing sessions, to provide a context for written reflection (see Zeichner, 1992) and to underscore the importance of reflection in practice.

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