Teacher Professional Development in Science:
A Case Study of the Primary Science Programme's CTI Course

Peter W. Hewson
University of Wisconsin-Madison

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Overview

Professional development for science teachers at primary and secondary levels is essential if current curricular reforms in southern Africa and elsewhere in the world are to become deeply rooted in schools, and the ambitious learning outcomes envisaged are to be achieved by all learners. As a guide to thinking about professional development, a recent review of the literature in this area identified three different conceptual frameworks specifically developed with science in mind (Hewson, 2007). These frameworks provide various ways of thinking about teacher professional development in science; they address the questions:

- What is it that good professional developers do?
- How do teachers develop professionally?
- What is the relationship between teachers and professional development programmes?

While these questions are general, the frameworks themselves were developed in different contexts. As such, it is useful to consider how the issues raised by these frameworks play out in a southern African context. This paper thus presents and analyzes a case of teacher professional development. The case is of a 3 week residential course on Natural Science for Intermediate Phase Educators.[1] The Primary Science Programme (PSP) developed and taught the course within the Cape Teaching Institute, an in-service professional development programme organized by the Western Cape Education Department. The analysis of the case is based on the three approaches.

Issues in Teacher Professional Development

Several relevant issues in teacher professional development in science preface the outline of conceptual frameworks and the case study that form the bulk of the this paper. The discussion of these issues is drawn from Hewson (2007).

Why Consider Teacher Professional Development in Science?

Professional development for science teachers is of considerable importance because of current conceptions of science teaching and learning. This is an era in which, around the world, a new vision of learner-centered instruction is being developed. This grows out of a major, extended research enterprise over the past quarter-century. The focus of attention on what learners know and can do when they enter classrooms, and how this influences the instruction that they receive, has led to significant advances in our understanding of student learning and the implications this has for teaching. In parallel with these reforms, there has been a major push to develop new curricula and to identify explicit standards that together represent significant changes in what it is that students are expected to learn and do. A third circumstance of considerable importance is the increasing recognition of the systemic nature of the educational enterprise, arising in part from the difficulties experienced by reformers who sought to introduce new curricula and new teaching approaches. Aligning different components of educational systems is not a straightforward matter, and has led to the investment of large amounts of resources for systemic reform.

There is a key argument to be made to support the idea that responses to these circumstances should necessarily, if not exclusively, focus on practicing teachers and their professional development. It addresses the question: Why focus on teachers? There is currently a broad consensus that teachers play a central role in any model of educational improvement. We are long past the era of so-called teacher-proof curricula. We have also tried, and found wanting, the assumption that teachers could be replaced by computers. Much of this recognition has come from recent research into the nature of a teacher's practice and expertise. What teachers do is not a formulaic following of rules, but nuanced, professional practice in which teachers constantly

[1] South African policy documents refer to “educators” and “learners,” in place of “teachers” and “students” (or “pupils”) respectively. Within the South African based case study, this terminology is used.

make important decisions and judgments in how they interact with their students to facilitate their learning. What this means is that if teachers are not involved, educational reform will not happen.

An extension of this argument addresses the question: Why focus on teacher professional development for *all* practicing teachers? This is necessary because in the current climate of reform, teachers' practices, even when they were highly effective at an earlier stage, may be in need of reconsideration and updating. In other words, as the educational context changes, teachers' existing practices and beliefs may not be well matched with the revised demands of new reform efforts.

What is Teacher Professional Development in Science?

First, it is about teachers and their teaching activities involving curriculum, instruction, and assessment; about their students and their learning; and about the educational system in which they practice. Second, it is about teachers being professionals who have an extensive knowledge base of conceptions, beliefs, and practices that they bring to bear on the unique complexities of their daily work lives, a knowledge base that is shared within a professional community. Third, it is about teachers as adult learners who have an interest in and control over the continuing development of their professional practice throughout their working lives, a process that is greatly facilitated by working in community with their peers. Finally, it is about science and the epistemologies, methodologies, and bodies of knowledge about the natural world that give scientific disciplines their distinctive character.

It is necessary to recognize two essential focal points when considering teacher professional development in science. One essential focus is on the *programmes* that have an explicit purpose of providing professional development to teachers. In most cases this means that one or more persons can be identified as professional developers whose purpose is to plan and implement activities for science teachers that are designed to further their professional development. Professional developers, likewise, use characteristic language: they talk about the professional development they are providing. The question that arises from this focal point is: What is it that good professional developers do? The second essential focus is on the *people* who are experiencing professional development – teachers of science – and the processes through which they are going. This is encapsulated in the language that teachers use – they talk about developing professionally. The question that arises from this second focal point is: How do teachers develop professionally? As previously argued, however, it is necessary to follow the influence of programmes into teachers' classrooms. Thus a third question to consider is: What is the relationship between teachers and professional development programmes? These questions were addressed respectively in three studies that specifically considered the teaching of science, all of which produced theoretical frameworks that conceptualize these essential focal points

What can be said about the Nature of Research on Teacher Professional Development in Science?

The short answer is that it is complicated and difficult, because the object of study – teacher professional development in science – is itself inherently complex, consisting as it does of a number of interrelated components. Therefore it is necessary for research to focus on the nature of relationships between these components, at the same time as exploring each of these components in its own right.

Conceptually, research in this area is very difficult. While the immediate focus is on the professional development activity itself and the teachers who participate in it, the ultimate purpose of professional development is the improvement of student learning. The pathways of influence of professional development from the original activity to student learning proceed through the intervening variables of teacher learning and classroom enactment. These pathways are complicated not only by the time it takes for teachers to clarify their learning from professional development activities and translate this into effective curriculum and instruction, but also by everything else that is happening concurrently in the lives of students, teachers, schools, and the community; teacher learning in professional development activities, teachers teaching in classrooms, and student learning are not isolated from the educational and social environments of schools and communities.

Conceptual Frameworks

A recent review of the literature in this area identified three different conceptual frameworks specifically developed with science in mind (Hewson, 2007). These frameworks provide various ways of thinking about teacher professional development in science; they address the questions:

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- How do teachers develop professionally?
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The discussion of these questions is drawn from Hewson (2007).

What Is It That Good Professional Developers Do?

This question was addressed by the professional development team of the National Institute for Science Education in the US that explored the nature of professional development practice through a process of collaborative reflection over the period of a year with five accomplished professional developers in science and mathematics (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Rather than thinking of their practice as the refinement and use of models of professional development that others could easily adopt, these professional developers felt that their practice was more complex. Instead, it combined components of different models in programmes that were changing over time and tailored to the particular circumstances in which they were working. In other words, they agreed that the practice of professional development is a process of design. On the one hand, professional developers have a set of purposes that they want to achieve. On the other hand, they are working in a particular context, with a particular group of teachers, in a set of circumstances that are unique to this particular project. The process of design requires that purposes be matched with context. While this inevitably will require compromises, the intent is that these decisions will be made in order to maximize desirable outcomes. These reflections were summarized, albeit greatly simplified, in the form of a framework for the design of teacher professional development in science and mathematics.

The specific components of a more recent version of the design framework for professional development in science and mathematics (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003) include several major elements. First, there is a generic *planning process*, the steps of which will be familiar to readers. These steps start with a commitment to a vision and a set of standards, and an analysis of student learning data; move on to the setting of goals, the planning and doing, or implementing, of professional development; and conclude with evaluation. Second, there are a series of *inputs* into the steps of the planning process. These inputs – *knowledge and beliefs*, *context*, *critical issues*, and *strategies* – represent the knowledge and expertise about professional development that developers bring to the process of designing programmes. Third, these inputs are most salient for different steps of the planning process. For example, knowledge and beliefs will strongly influence the step at which professional developers commit to a vision of professional development, whereas it is only at the planning step that professional developers will be making decisions about which strategies to use. This is not, of course, to say that these inputs will be exclusively considered at these different steps. Rather once inputs have entered the planning process, they will be considered in subsequent steps. Finally, there is feedback from the reflective evaluation of the project not only to the process of the project, thereby leading to improvements in the design itself, but also to the various inputs into the process that are as a result extended, deepened, and enriched. In other words, this is a dynamic framework.

The first of the inputs into planning and design is the *knowledge and beliefs* held by professional developers that addresses different aspects of the process and participants of professional development; these focus on *learners and learning*, *teachers and teaching*, the *nature of science*, the *nature of professional development*, and the *change process*. The second of the four inputs into the professional development design process are *context* factors influencing professional development. If design is the process of marrying theory with reality, and the knowledge and beliefs that professional developers bring with them is theory, then the reality of the particular project to be designed is rooted in the local context; professional developers need to know the details of this context. A third major input into the process of designing professional development is that of the *critical issues* that any professional development project will face. While these may not be front and centre for all projects, professional developers ignore them at their peril. Examples of these issues are *time, equity, professional culture, leadership, sustainability, scaling up,* and *public support*. The final major input into professional development design is that of *strategies* for professional learning. These strategies are the means to achieve ends that should already have been specified, and should be chosen in relation to the context of the project. Strategies can focus, for example, on *aligning and implementing curriculum, examining teaching and learning, immersion, collaboration,* etc.

How Do Teachers Develop Professionally?

This question was addressed in a 3-year research project, the Learning in Science Project (Teacher Development), in New Zealand (Bell & Gilbert, 1996). In the project, teachers of science learned about, and implemented teaching approaches designed with students' thinking and ideas in mind. During this time they experienced development of different kinds that were interwoven with each other. Bell and Gilbert modeled this in terms of personal, professional, and social development, and argued that, if development is to happen, teacher development programmes must address all three of these components. In the project, a total of 48 teachers of science, both elementary and secondary, participated in four teacher development programmes. Each programme consisted of 2-hour weekly after-school meetings over one or two school terms. In the meetings teachers shared their experiences of implementing new teaching activities that explicitly took account of students' thinking. The researchers collected multiple forms of data. In addition to that obtained in programme meetings, the data included interviews, surveys, and classroom observations. Bell and Gilbert's model of teacher development is detailed in the following paragraphs.

In the initial phase, *Personal Development* involves teachers coming to realize that some *aspects of their practice are problematic*. This could be a slow process, starting with an inarticulate awareness that requires time to take shape. It could also be sparked by a specific event that crystallizes dissatisfaction. This realization then becomes the spur for teachers to seek ways to address the problem. There are, of course, many cases in which teachers get involved with programmes even though they do not see their practice as problematic, e.g., a department chair has recommended attendance. Bell and Gilbert (1996) suggested that no progress happens without this phase of personal development. However, they pointed out that this is more likely to happen if teachers feel that overall their teaching is competent, with only a limited aspect being problematic. Related to this is *Social Development* in which teachers become *aware of their professional isolation* from their peers, and recognize that this, too, is problematic. This, then, helps to create a willingness to find ways of discussing their practice with others. A key element of this is the need to be able to trust that their peers will be supportive colleagues who offer critique in a non-judgmental fashion. These developments support the initial phase of their *Professional Development* in which teachers are *prepared to try out new activities* in their classrooms. In doing so, they take on the role of teacher-as-learner in which they become aware of the process of change and development; this is seen as a positive progression, the anticipated outcomes of which are better student learning and feeling better about themselves as teachers.

In the next phase, *Personal Development* involves *coping with the restraints inherent in teaching.* When new teaching activities and approaches are introduced, particularly if these give students more opportunities for input, the personal concerns include fear of losing control and not knowing when and how to intervene, uncertainty of the demands on their knowledge of the subject, worries about covering the curriculum and meeting assessment requirements, and concerns about dealing with students, parents, and others who may object to these changes. In this phase, *Social Development* involves teachers coming to *see the value of collaborating with their colleagues*. As trust in each other grows, teachers become more ready to share their experiences with each other, listen openly to their colleagues' suggestions and critiques, and offer their own ideas about ways to address questions, problems and concerns. In the process, their own self-confidence and ability to reflect critically on their own practice grows. In effect, their collaboration involves their "renegotiating and reconstructing their shared knowledge about *what it means to be a teacher of science*" (Bell & Gilbert, 1996, p. 26, emphasis added). Their *Professional Development* in this phase manifests itself in *developing a more coherent practice*. Their conceptions of teaching science become more articulated, more nuanced, and more reflective. Their classroom practice becomes more flexible, more responsive, and more able to accommodate changes in appropriate ways. More importantly, they see the need to integrate their conceptions with their practice, and thus to reconstruct what it means to be a teacher of science.

In the final phase in Bell and Gilbert's (1996) model of teacher development, *Personal Development* entails teachers *feeling more empowered* with respect to their own development. They come to trust that what they are doing will produce the outcomes they hope for, and that students will not let them down when they hand over control. Feelings of empowerment also extend to interactions with their colleagues: teachers feel good about contributing ideas and volunteering their time and energy. In this phase, *Social Development* takes place as teachers begin to initiate activities and relationships with their colleagues, thereby *fostering collaborative ways of working*. Closely related is the *Professional Development* they experience by seeking out or *initiating different development opportunities* beyond the programmes in which they are involved.

The scenario outlined in the previous paragraphs is a plausible narrative of how the various phases of the three forms of development might be interwoven with each other. There is a progression through these phases as teachers initially see themselves as competent professionals who nevertheless have room for growth in some aspects of their practice. Next, as they learn new ideas, approaches, and activities, and become more self-aware, they reconstruct aspects of the practice, and they develop a new sense of being a teacher of science within their collegial group. A natural outcome of this development is that they feel empowered to take the initiative with respect to all three types of development. Bell and Gilbert (1996), however, emphasized that their model of teacher development is not a stage model. In other words, there are no requirements that teachers complete one phase before proceeding to the next, or that they have to go through each phase in their developmental journey.

What Is The Relationship Between Teachers And Professional Development Programmes?

Fishman, Marx, Best, and Tal (2003) explored the relationship between professional development programmes and science teachers' practice and developed a model of teacher learning from professional development. In common with Loucks-Horsley et al. (2003) they viewed professional development as a process of design, in which professional developers consider a broad array of issues in order to design all the activities that constitute an effective professional development programme. In considering professional development practice, they specifically focused on the issues that professional developers have control over, or "*design* *elements*," and categorize these in four ways that have much in common with the design framework proposed by Loucks-Horsley et al. (2003). Content is the first design element; this refers to the learning outcomes for teachers who participate in professional development. This might be pedagogical knowledge (e.g., assessment knowledge), or subject matter knowledge. The second design element is strategy, used much as Loucks-Horsley et al. (2003) did. The third design element is sites: these are the settings in which teacher learning happens. This element pays attention to aspects of context, format, and place. Media is the final design element. This pays attention to the means through which professional development might be carried out, e.g., video, computers, face-to-face interactions.

Fishman et al. (2003) focused explicitly on teacher practice as an outcome of professional development programmes, going beyond Loucks-Horsley et al. (2003) in the process. For them, the primary criterion for deciding programme effectiveness was teacher learning: the *knowledge, beliefs, and attitudes* that teachers acquire as a result of participating in *professional development activities*. However, they did not stop with teacher learning. Rather, they adopted from Richardson (1996) the viewpoint that one has to consider teachers' knowledge, beliefs, and attitudes as an interactive entity with their classroom *enactment* in which each influences the other. Thus, they saw a need to consider how teachers' knowledge, beliefs, and attitudes are enacted in classroom settings, and how enactment influences student learning, as evidenced in *student performance*. They also recognized a reciprocal, interactive relation in which student learning influences teacher learning, mediated through enactment. A final node in the framework is *curriculum*, about which they made two arguments. On the one hand, they saw curriculum influencing, and being involved in, professional development activities. On the other hand they argued that curriculum materials themselves may be educative.

This framework is valuable in the emphasis that it gives to tracking the influence of teacher learning, through its enactment in the classroom, and on to student learning. This emphasis gives explicit attention to various aspects that need to be considered in evaluating teacher professional development. They illustrate this point in terms of a project they evaluated elsewhere in the article.

A Case of Teacher Professional Development

A local case of teacher professional development provides an opportunity to contextualize in southern Africa some of the issues identified by these three frameworks. The frameworks can then, in turn, be used to analyze the case, in order to understand and evaluate it and suggest recommendations for future professional development experiences.

The case is of a course on Natural Science for Intermediate Phase Educators. The course was one of several offered as part of the Cape Teaching Institute (CTI) in August 2006, an in-service professional development programme organized by the Western Cape Education Department (WCED). The WCED contracted with different service providers to plan and implement the various courses comprising the CTI. The Primary Science Programme (PSP) tendered for, and was awarded a contract to present, the Natural Science course.

The WCED specified key outcomes to be achieved by participants and the overall structure of the course; it also selected the participant educators. The outcomes specified in the tender document were drawn from the National Curriculum Statement (or NCS), an Outcomes-Based policy document. The course was structured as a full-time 3-week residential event in which the 54 participants, drawn from schools throughout the province, were released from their school responsibilities and housed for the duration of the course in Bellville, Western Cape.[2] The Intermediate Phase ranges from grade 4 to grade 6, but because some schools also included grade 7, the participant educators were divided into four groups, one at each grade level, and the course

[2] The schools had the responsibility of identifying qualified substitute teachers; their salaries were paid by the department.

curriculum focused on grades 4-7. The schools from which participant educators came were located in rural, suburban and urban areas of the province.

The goal that PSP staff set for themselves in developing the course was to "introduce and consolidate an integrated way of planning, teaching and assessing the Natural Sciences" (PSP, 2006), within the national context of the NCS. The case study first outlines the data sources used for its development. Next, it considers in some detail the NCS itself in order to understand the magnitude of the task that the PSP set itself. It then details the course emphasis on educator planning and how this was implemented. The final section of the case study illustrates participants' experiences in, and evaluation of, the course.

Data Sources

The case is based on data from different sources: materials prepared by the PSP, data gathered by the PSP, and information obtained by the author as an independent observer. Of the materials, the most important was a resource book that the PSP team developed for use in their various professional development activities: it is entitled *Tools for planning your Natural Sciences Curriculum* (PSP, 2005); because of its green cover it is colloquially referred to as the Green Book. A very extensive set of teaching materials used in course sessions was also available; a large majority of these were developed and produced by the PSP. During the course, the PSP instructors gathered various forms of data from participants: these included among others, pre- and post-tests, assignments, journals, and, at the conclusion of the course as required by the WCED, an opinion survey that included not only ratings on 5-point Likert scales but also written comments. At the conclusion of the course, the PSP summarized results, conclusions and recommendations in a report submitted to the WCED (PSP, 2006). As an observer, the author attended various course sessions, and conducted individual and group interviews with about 1/3 of the course participants. The course sessions attended included whole group plenary sessions and work sessions in which participants were divided into two or three large groups; in both of these types of sessions, participants often worked in small groups of 4-6 people.

The National Curriculum Statement

The National Curriculum Statement (NCS) for the Natural Sciences learning area is a complex, multi-strand document that demands much of educators, learners, and school systems. Although sound arguments can be made that each of the NCS's components represents current educational thinking, combining them into a coherent whole is no small undertaking for even the most competent educator.

The NCS applies to the first nine years of formal schooling. These nine years (grades 1-9) are divided into three phases – the Foundation Phase (grades 1-3), the Intermediate Phase (grades 4-6) and the Senior Phase (grades 7-9). The NCS has four major components: Critical and Developmental outcomes, Learning Outcomes, Assessment Standards and Content. The first of these components focuses on learner characteristics that generalize across content domains and are at the heart of what it means to be an autonomous, critical, informed citizen. There are seven critical and five developmental outcomes; several examples are that learners should be able to:

- Identify and solve problems and make decisions using critical and creative thinking
- Communicate effectively using visual symbolic and/or language skills in various modes
- Be culturally and aesthetically sensitive across a range of social contexts.

The second of the NCS components for the Natural Sciences includes three Learning Outcomes (or LO's). Each of these outcomes has three or four components. Their titles, outcome statements, and components are detailed in Table 1.

Table 1: Learning Outcomes in Natural Science

LO	Title	Statements	Components
1	Scientific Investigations	The learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts.	Planning investigations Conducting investigations and collecting data Evaluating data and communicating findings
2	Constructing Science Knowledge	The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.	Recalling meaningful information Categorizing information Interpreting information Applying knowledge
3	Science, Society and the Environment	The learner will be able to demonstrate an understanding of the interrelationships between science and technology (S & T), society and the environment	Understanding S & T in the context of history and indigenous knowledge Understanding the impact of S & T on the environment and people's lives Recognizing bias in S & T which impacts people's lives

The first of these outcomes – Scientific Investigations – focuses on the process of science. There have been calls to include this type of outcome in science curricula for many years, supported by two primary reasons. One is that science studies natural phenomena, and the processes of inquiry are an essential part of the nature of science; thus they should be included in science curricula. The other is that when learners interact with natural phenomena in a "hands-on" way, a widely-held belief is that it is inherently motivational, since learners are discovering the science for themselves. In practice, educators have often found it difficult to meet the spirit of this outcome: access to equipment and finding the right balance between openness and specification are common difficulties. Science educators are, however, solidly in support that this is a necessary outcome. The second outcome focuses on science as a body of knowledge that learners need to appropriate. This has always been a primary goal of science educators because of the authoritative nature of scientific knowledge, and its influence on and applicability to everyday life. The final outcome is a more recently articulated goal in science education and remains controversial and difficult to achieve. It is controversial because through its links to human society it introduces a level of subjectivity that some see as antithetical to the supposed objectivity of science. It is difficult because it requires a considerable degree of curriculum development that is linked to local circumstances.

The third of the NCS components are the Assessment Standards (or AS's); these are closely tied to the Learning Outcomes and their components. Each AS is specifically tied to a particular LO component and grade level, and their content varies from one component or grade level to another. Across grade levels for a particular component, the AS's become progressively more demanding. Finally, in the earlier grades, some of the LO components are not assessed, and thus have no AS's. Examples of the Assessment Standards and their progressions are included in Table 2 for two components of LO2.

Table 2: Assessment Standards in Natural Science

Grade	Comp. 1	Assessment Standard	Comp. 2	Assessment Standard
4	Categorizing information to reduce complexity and look for patterns	Learner sorts objects and organisms by a visible property	Interpreting information	None
5		Learner creates own categories of objects and organisms, explains own rules for categorizing		None
6		Learner categorizes objects and organisms by two variables		Learner, at the minimum, interprets information by using alternative forms of the same information

The last of the NCS components is Content. This is likely to be the one that is most familiar to educators because explicit statements of content in a syllabus have been a constant feature in South African education for decades. Four content strands are specified in the NCS: these are Life and Living, Energy and Change, Planet Earth and Beyond, and Matter and Materials. While the titles aren't identical with the common terms of Biology, Physical Science and Earth Science, the emphases of the content are familiar. Each of the strands has two or three sub-strands. The strands and sub-strands are common to all three phases. Within each phase, however, a number of topics are specified under each sub-strand. In the intermediate phase, the sub-strands, number of topics, and examples of topics for each of the strands are detailed in Table 3.

Table 3: Content in Natural Science

Strands	Sub-strands	Topics	Examples of Topics
Life and Living	Life processes and healthy living Interactions in environments Biodiversity, change and continuity	12	Photosynthesis Water in ecosystems Fossils in SA
Energy and Change	Energy transfers and systems Energy and development in SA	8	Systems for storing energy Electricity and safety
Planet Earth and Beyond	Our place in space Atmosphere and weather The changing earth	13	Earth's rotation The water cycle Erosion and deposition
Matter and Materials	Properties and uses of materials Structure, reactions and changes of materials	6	Boiling and melting points Changes brought about by heating

As this partial summary indicates, the NCS is detailed, complex, and multi-stranded. In total, it is an impressive curriculum document, particularly because sound arguments can be made that each of the NCS's components represents current educational thinking. Putting it into practice is, however, a difficult task, not only because of the complexity and detail embodied in each of the components, but also because the NCS says little about how the various components could fit together to become a coherent curriculum. For many this is an overwhelming task: as one of the course participants said: *we'd sit with all the documents around us and go from one to the other, and we were so confused*. It is thus clear that achieving the PSP's goal statement of helping educators develop a coherent understanding of the NCS within the context of their practice is a significant undertaking.

The PSP's Focus on Educator Planning and Course Implementation

The PSP team adopted a two-part strategy for achieving their goal. First, educators would have to engage in sophisticated planning exercises that reflected the complexity of the NCS in terms of its different components as they played out at phase, grade, and lesson levels of detail. Second, educators would have to experience the implementation of these different components as learners themselves, this being an essential part of developing a conception of the NCS robust enough to influence their own planning and teaching.

With respect to the first strategy of supporting educator planning, the PSP team developed a resource book entitled *Tools for planning your Natural Sciences Curriculum* (PSP, 2005); because of its green cover it is colloquially referred to as the Green Book. In summary, the Green Book presents a *Big Picture* (p.2) of the different components of the planning process, outlines the different components of the NCS with helpful illustrations and summaries[3], includes a section on *Developing learning experiences and assessment tasks* (p.37), and concludes with a set of *Planning Formats* (p.42). The planning formats provide a set of structures within which educators can work to pull together the various components of their curriculum.

The planning formats include a phase plan (divided into 3 grades per phase, 4 terms per year, and 10 weeks per term), a grade work schedule for each term, a lesson plan outline, and a daily work schedule. These are supplemented with assessment task and assessment feedback formats. Within the lesson plan and assessment format structures are a series of handy check-lists reminders for educators to refer to as they are planning. To illustrate, the lesson plan includes lists of *Concepts to be built* and *Process Skills*, and the assessment feedback sheet includes *Forms of Assessment* and *Modes of Communication for assessment tasks*.

It is worthwhile noting that if support materials such as these planning resources are to be helpful to, and used by, educators, their design is critical. An important principle is that educators need to see them as a tool for gaining access to the NCS rather than a compounding of its complexity. Issues such as the magnitude of the planning task (educators have limits on the time they can spend planning) and the connection of the planning outcomes to the tasks of teaching (of relevance here are educators' knowledge, experience, access to other teaching resources, and school context) are sensitive factors in educators' decisions of whether to use the resources to engage in the type of planning envisaged. That these resource materials have achieved a delicate balance between complexity and triviality is a testament to the excellence of the PSP team's design and development skills, and is rooted no doubt in their extensive experience as educators and as professional developers.

With respect to the second strategy of course implementation, the PSP team planned a full, intricate, layered schedule for the three week course. This was necessary if all the various NCS components were to be given due attention and if educators were to have multiple opportunities to develop competence in planning to teach in the ways envisaged in the NCS. There were four major aspects to the course: 1) a focus on the role of language in teaching and learning, 2) developmental loops structured around the four content strands, 3) specific emphasis on the learning outcomes (LO's) and assessment standards (AS's), and 4) evaluation of both participants and course.

The language focus both for educators as participants in the course and (subsequently) for learners when educators returned to their classrooms was a constant theme with multiple purposes running through all aspects of the course. To illustrate: language showed up with respect to the range of mother tongue languages brought by participants; it was the means of communication in

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[3] The summary of the NCS previously presented in this paper is based on this section of the Green Book.

the social construction of meaning and understanding in group work; it took the form of journal writing as a regular opportunity for reflection on the course by participants; and it appeared when participants were strongly encouraged to use diverse modes of communication for assessment purposes. In short, it formed an essential component of the tripartite *hands on – minds on – words on* philosophy of learning upon which the course was designed.

The developmental loops occupied the bulk of the time during the course. Within each loop the same sequence was followed. This started with a focus on *concept development* for the particular strand; through mind-mapping exercises, a landscape picture of the strand with its big science ideas was drawn for all grades in the phase. This was followed by *practical and collaborative learning experiences* derived from the LO's and AS's for the phase; in these participants acted as learners, before using these learning experiences in planning lessons and developing assessments. This provided them with practical experience of how the three elements of planning, learning and assessment are integrated. *Content enrichment* from a specialist introducing new knowledge and *contextualizing* in which participants developed 30% of their lessons from their own local content were then followed by an *assignment* to develop lesson plans and assessment tasks in order to draw together "teaching experience, course experience, new knowledge and skills, language development work and resources" (PSP 2006, p.5). During the first developmental loop, course instructors worked closely with participants on the assignment to provide step-by-step guidance. Thereafter groups of educators worked independently on subsequent assignments. Each loop closed with *feedback on assignments*, *reflection in journals*, and an *evaluation of the module*.

The LO's and AS's were used within the course design not only as the explicit focus of attention in key activities, but also as a common thread running through all of the activities. In the latter role they provided a vital element of structure for the course. To illustrate the former, a majority of the activities that comprised the *practical and collaborative learning experiences* phase of each developmental loop were designed to address LO1 (Scientific Investigations), all activities addressed LO2 (Constructing Science Knowledge), and one whole day was devoted to three parallel investigations of LO3 (Science, Society and the Environment). To illustrate the latter, all planning and assessment formats explicitly required the specification of the relevant LO's and AS's alongside the specific topics.

Implementing such a complex design effectively is no small undertaking, and yet it is one that the PSP team carried off very effectively. Some essential elements that contributed to this were the detailed planning resources previously outlined, and a team of instructors who worked very well together: they trusted and supported one another. An instance of this is that the course was structured with frequent opportunities for participant feedback, both formally and informally; this presented the team with many opportunities to reflect on the progress of the course and make adjustments, as necessary; this they did on a regular basis.

Educators' Reactions to the CTI

In the interviews conducted by the author during the last few days of the course, most educators were willing to speak at some length about various aspects of their experiences. To illustrate their views responses were selected that express views clearly and succinctly, without their being unique. In other words, while there were differences of opinion, the quoted responses express viewpoints that were common within the group of interviewees. The responses are included in Table 4.

Table 4: Educator Responses to PSP's CTI Course

Topic	Educator Response
Planning	- *Previously we'd sit with all the documents around us and go from one to the other, and we were so confused. We've got the structure now and it'll be much easier and more pleasurable to do it.*
Planning and Content	- *It became clear to me to connect strands to LO's and AS's. I've always taught science, but I never knew how we got to the strands. If we could use this with other learning areas that would make it much easier for us.* - *[Now] I know how to evaluate a textbook, how to find my content in the curriculum. I'm more certain to sit and plan: planning was a nightmare, but we went four times through the process of planning – how to go about it and what to do, and with every science lesson you have to teach the science behind it.*
Planning and Assessment	- *I didn't see the need for planning as an old teacher – I had the textbook and I'd go and see what was needed and go and explain it. But now with the assessment thing, it forces you to go and plan and how to get to that assessment, so you must know beforehand what you want the child to be able to do, and then work towards it.* - *We were only assessed through test and test and test. Now we assess in much more detail: maybe a child can do planning and conducting, but he can't do the communicating and the evaluation part. And now I've learned to see what is the level of that child, and what part of the investigation process the child can and cannot do – but it doesn't mean that child can't be that scientist also.*
Translating into practice	Is it going to be possible to take all this back into the classroom? - *Maybe not everything at once, but slowly and surely. I won't be perfect in the next school quarter or term or year, but maybe in 2 to 3 years in my grade, together with my colleagues.*
Overall perceptions	- *A very good learning experience* - *I told my colleague: Wow! I've learned a lot.* - *I'm much more confident in going back to the classroom knowing what to do.* - *I'm going to build my own laboratory.*

Conclusion

The PSP staff set a goal for themselves of developing a course that would "introduce and consolidate an integrated way of planning, teaching and assessing the Natural Sciences" (PSP, 2006). In order to achieve this goal, the PSP team adopted a two-part strategy of focusing on sophisticated, complex educator planning on the one hand, and expert implementation of the course on the other. With respect to educator planning, the course provided multiple opportunities for educators to engage with the different elements of the NCS both separately and in combination; it also supported these activities with a broad set of resources that were accessible and appropriate. The comments of the educators indicate that the majority emerged with a detailed and powerful conception of planning that they would immediately be able to use in their teaching. With respect to course implementation, a key feature was the way in which the team modeled the philosophy of learning that underpinned the course design. Thus participants were able to learn in ways that they would then implement with their own learners. In short, the PSP team's implementation of both aspect of its two-part strategy was excellent.

Analysis

The three conceptual frameworks previously outlined provide the means to analyze a few key aspects of the design and implementation of this course. While these serve to illuminate the quality of the PSP course, they are a selection from the many issues that these frameworks identify as being relevant; others would need to be addressed in a complete analysis of the course.

Loucks-Horsley, et al. (2003) highlighted the need for professional developers to pay explicit attention to various inputs in the design of professional development. One of these inputs is *Context*, a complex notion with many different factors. A key factor in this case is the National Curriculum Statement (NCS). This is a document that recognizes the complexity of curriculum by outlining a series of parallel components. Within the Natural Sciences Learning Area, these components include Critical and Developmental Outcomes, Learning Outcomes, Assessment Standards, and Content. As previously outlined, each of these components contains a significant amount of detail. Each can be justified with sound educational arguments. The NCS document implies that all of these components need to be related to one another in the implementation of the curriculum, but provides no guidance on how this might be achieved. The PSP staff recognized that this integration task is considerably more than most teachers are able to undertake on their own; thus they set themselves the goal of making the NCS accessible to teachers. They did this through an explicit focus on teacher planning and, in preparation for the course, developed a set of materials to facilitate the process of integrating the various components of the NCS. They then designed an implementation programme that introduced participants to the materials and provided them with many opportunities to use them in planning their teaching. In other words, the PSP staff paid detailed attention to a critical feature of the context in which the course participants worked in their design of the course.

Another input into the design of professional development, according to Loucks-Horsley, et al. (2003), is *Strategy*. While there are a large number of potential strategies, they should be chosen by recognizing that strategies are the means to achieve ends that should already have been specified, rather than ends in themselves. In this case, the primary purpose of the course was to facilitate effective implementation of the NCS into local schools. This dictated the use of the strategy of *aligning and implementing curriculum*, through careful attention to planning to integrate the various components of the NCS. A more specific strategy arose out consideration of the learning outcomes (or LO's). Participants were *immersed* as learners in both science investigations (the essence of LO1) and explorations of cultural and societal practices (the essence of LO3). These two examples illustrate the careful attention the PSP staff paid to the implementation of the course.

Bell and Gilbert's (1996) model of teacher development focused on the teacher participants in professional programmes, and detailed the interrelated strands of their personal, social, and professional development. In the PSP case study, there were several sources of information from teachers that provided evidence of their development. They submitted several unit plans during the course, they took tests on each of the content strands, they filled out an evaluation questionnaire, and more than a third of them were interviewed. An illustration of teachers' personal development was a realistic assessment that they would have to cope with *restraints inherent in teaching*. While many were convinced of the need to change their teaching, they recognized that their colleagues might not be willing to do likewise. One teacher commented: *I can't go back doing it the old way. It won't be easy, but I'll do my best*. An illustration of social development was that a number could *see the value of collaboration*: for example, one said that he would try to form a science cluster of teachers, because he had learned so much from his colleagues on the course. An illustration of professional development was that teachers could see that the planning they had learned to do would help them *develop a more coherent practice*. A common viewpoint was that they could now see that the same activity could achieve more than one outcome. In the words of one teacher: *I have a definite sequence. I can cluster LO's, see connections between strands*.

Fishman, et al. (2003) stressed the importance of being explicit about the connections between programme, teacher practice, and student learning. Because of the structure of the course established by the WCED, the PSP had no formal possibility of following up course participants on their return to their schools. This clearly was a weakness in the design of the course of which both the WCED and the PSP staff were aware. On the one hand, the WCED have redesigned the CTI course structure to include a two-week course, a term in which course instructors visit some of the course participants, and a concluding one-week course that will provide an opportunity for reflection on teachers' experience in putting their plans into effect. On the other hand, the PSP has another initiative – the Cluster Schools project – in which they work with clusters of schools over an extended period of time, thereby allowing them the opportunity to trace the effect of PD inputs on teachers, their teaching practices, and their learners.

Summary

The three frameworks provide perspectives on teacher professional development in science that complement one another. Together, they illuminate the many different components of the complex enterprise of professional development that has the goal of facilitating changes towards more effective teacher practices that ultimately are intended to improve students' science learning. The three frameworks were used to illuminate different aspects of a teacher professional development course in science – the PSP's CTI course – and pointed to the importance of paying careful attention to context and strategy in the course design, to the different types of teacher development, and the essential (though, in this case, not possible) task of following teachers (and their learners) into their classrooms.

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