Evaluation of the Western Cape Primary Science Programme (PSP): Stage 3, 2003

by

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The Evaluation Plan

Recognizing change

This is the third and final year of our longitudinal study of the PSP, building on the two earlier ones (Malcolm and Kowlas, 2002; Malcolm, Kowlas and Stears, 2003). In it, we have opted in general not to reproduce findings from the earlier reports: for a comprehensive picture, the earlier reports should be read in conjunction with this one.

The study, especially through its longitudinal character, has provided us as a research team with rich opportunities to work closely, over time, with PSP staff, teachers and children. It has enabled us to come to know, first hand, the professionalism (including the struggles) of the PSP staff and teachers, and the seriousness with which children, in general, go about making sense of their lives and their learning in science. The close working relationships enabled the PSP staff and many of the teachers (especially the three involved in the 'detailed study') to continually shape the evaluation, and us to feed results and questions to PSP as they arose.

The three-year period of the evaluation has continued as in turbulence as South Africa continues to 'transform' itself in the wake of Apartheid. This has had ramifications for the original Evaluation Plan and its implementation. At a policy level, there has been the Review of Curriculum 2005 (Chisholm, 2001), the development of the National Curriculum Statement (Department of Education, 2001) and then the Revised National Curriculum Statement (Department of Education, 2002). The changes should not be underestimated. The radical shift in definitions of 'science' (in a real sense a shift in epistemology from science as discipline centred truth to science as socially-contexted theory), pedagogy (from a content focus to outcomes, behaviourism to social constructivism, teacher-centred to learner-centred) and assessment (from reductionist testing of 'content' to context-based assessment of competence) that were central to Curriculum 2005 were retained in the National Curriculum Statements, but 'streamlined'. The streamlining gave new emphasis to content and vertical development, through more structured learning as expressed in a series of grade-based achievement standards. Within this framework, opportunities for locally-designed curriculum (relevant to the lives and purposes of the learners, and including 'indigenous knowledge') were strengthened by promoting not only of local choice of detailed content (consistent with the outcomes and standards), but by encouraging schools to choose 30% of the content themselves, consistent with the outcomes but not necessarily the content suggested in the Statement. Further, the integration of Science with Technology (especially) was affirmed for Grades 1-6, assisted by overlap and complementarity in the Science and Technology Statements.

Alongside these changes were refinements of policies of Whole School Development, Whole School Evaluation, Teacher Appraisal and the Norms and Standards of Teacher Education, all linked to the National Curriculum Statements and assessment of learners' performances. These shifts have to be seen as 'two-edged swords': on the one hand, they further devolve responsibility for curriculum and school management to schools and teachers (in that sense respecting teachers' professionalism), but on the other hand they tighten the control of teachers through elaborate and detailed ‘performance indicators’ and accountability frameworks. Principals, teachers and School Governing Bodies, education departments, the PSP and other school-support organisations continue in turmoil as they come to understand these policies and their ramifications, and as education departments introduce, again and again, new systems and new ways of working.

Amongst this, the PSP relocated its offices in January 2003 from Guguletu to Philippa – a shift that created new opportunities for PSP and schools, but was also disruptive for PSP staff and schools involved in the programme.

To these changes must be added increases in unemployment and poverty, especially for poor communities such as PSP serves, and the deepening effects of HIV/AIDS. Increasingly, children, families and schools face issues of survival, emotional upheaval, and new priorities, changing in profound ways the roles and functioning of schools and teachers in their communities. Life in the Cape Flats and in the rural areas of the Boland and Paarl was not easy in 2001. It is harder now.

Neither have things been stable in the arena of Higher Education and research. Teacher education, which subsided in the late 1990s as a result of oversupply of teachers and the closure of colleges of education, is now expanding dramatically. The expansion is occurring in pre-service programmes and, even more, through in-service programmes to upgrade the qualifications of teachers, and bring to fruition the opportunities for credentials that underlie the National Qualifications Framework. (This shift in in-service education is highly significant for the PSP). The research team has also been involved in the merger of the University of Durban Westville with the University of Natal, which came into effect on January 1, 2004. It offers exciting new opportunities, but has been at the same time disruptive and demanding.

The PSP Manager described the period as follows:

> *The PSP’s move from the Uluntu Centre in Guguletu to the Edith Stephens Wetland Park in Philippi was a Godsend. It happened conveniently at the end of term one last year, and no staff members experienced disruptions. Most schools involved expressed their satisfaction about coming to this venue for meetings.*
>
> *However the educational climate in SA has been very turbulent in the past few years – and the PSP has seen the confusion that teachers have faced, the sometimes unrealistic requirements for implementing the earlier policies and the sense of helplessness as many teachers felt they were working in the dark.*
>
> *It was in response to this situation that the PSP decided that the best way to support teachers on a bigger scale was to develop Learning Experiences or “chunks of work” in all four new content areas in the Natural Sciences …*
>
> *The response from teachers was so encouraging that I felt that the PSP was a sea of calm at that time for many teachers in their confusion.*

In short, for the research team, PSP, the Western Cape Education Department, schools, teachers, children and communities, the last three years have been times of enormous change.

For none of us has our operation been ‘business as usual’. The Evaluation has to be viewed in this context.

Background

The PSP was originally created in Cape Town in 1984 and scaled up into a national PSP Trust in 1993. The present Western Cape Programme grew out of the national PSP, as an independent organization when the national Programme closed in June 1999. The PSP supports science teaching and learning (with extensions into language, mathematics and human and social sciences) through teacher development (including workshops, school visits and support for networks), curriculum development and materials development. It serves directly the needs of teachers and indirectly the needs of children, in historically disadvantaged schools. It works cooperatively with the Western Cape Education Department (WCED) and other educational groups within the frameworks of national and provincial education policies. It functions as an NGO, responsible to its Board of Management. It provides materials and services free, and is dependent entirely on sponsorships for income.

In 2001, the PSP commissioned the Centre for Educational Research, Evaluation and Policy (CEREP), then part of the University of Durban Westville and now the University of Kwa-Zulu Natal (Westville Campus), to conduct an external evaluation aimed at:
- informing and guiding PSP practices and
- describing PSP’s impact and effectiveness in the context of curriculum change in South Africa.

The primary audiences for the evaluation were:
- the PSP Board and staff, as part of ongoing programme development and implementation
- funders and Education authorities to whom the PSP is accountable
- the broader Educational community, who can benefit from knowing about the PSP, its practices and achievements.

The evaluation was conducted from 2001 to the end of 2003. Its longitudinal nature enabled assessment of impact over time, and exploration of processes, problems and achievements within the PSP, its participating schools and communities. The original plan is described in detail in the *Proposal for an Independent Evaluation of the Primary Science Programme (Western Cape)*, (Malcolm, 2001) which was the basis of the research contract. It centred on the following questions:
- What approaches to curriculum and teaching are advocated by the PSP, though its workshops, materials and support services? How do these approaches relate to government policies and the lives and needs of teachers and students in the participating schools?
- What changes in classroom activity, theoretical understanding and curriculum approach have resulted from the PSP workshops, materials and support services?
- Have these changes resulted in enhanced learning outcomes for students?
- How effective and efficient are the planning and management of the PSP operation, in serving teachers and students and other audiences such as Education Departments, the education community and sponsors?

The evaluation was framed in two strands. The first gathered ‘large scale’ data on the PSP, through questionnaires and learner assessment from a representative sample of schools, and descriptive data from the PSP office. This general study provided summary ‘snapshots’ of the PSP at various points in time. It had a strong summative dimension, but also contributed to formative purposes. The second strand explored in depth the contexts, inputs, processes, interactions and outcomes within the PSP itself and a small selection of schools and classes. It was strongly formative, feeding back into the schools and the PSP, and responsive to them. Within this emphasis, the detailed studies also provided summative descriptions – similar to the ways in which continuous formative assessment in classrooms provides summative data on children’s achievements.

The general study was given major emphasis during the first two years. It showed the PSP staff to be highly professional and highly active, deeply committed to science and maths education, government policies, and the schools with whom PSP worked. From random samples of schools and teachers over the two years, it was clear that teachers valued highly PSP workshops, materials and general accessibility. Interviews, classroom observations and reviews of children’s written work showed that participating teachers, almost without exception, ‘taught well’: lessons were well organised, goals and classroom ‘rules’ were clear, children were deeply engaged, enjoyed their science classes and found them useful (though they kept little in the way of written work).

At the same time, our attempts to measure children’s achievements through ‘standardised tests’ that we developed in 2001 and 2002 were unsuccessful, in spite of improvements we made in the second year: in both years the children did poorly on the tests. This made little sense in the light of our observations of classrooms and our interviews with children and teachers: surely children who were deeply engaged in reasonably well designed and executed lessons were learning ‘something’ (and in interview they and their teachers believed they were). Accordingly, in the 2003 study, we abandoned plans to repeat the classroom observations, teacher interviews and tests (on the basis that they were unlikely to yield much information that was ‘new’), and sought instead a broader approach to assessment of children’s achievements, using open assessment tasks coupled with follow-up interviews of children about what they had written.

PSP’s curriculum materials are a vital part of its work. Created over time through workshops with teachers and trials in schools, the modules are the basis of workshops and are readily available to teachers, who generally use them. (In all of the classrooms we observed in 2001 and 2002, the lessons presented were direct from the PSP materials, used with only minor variations. This observation was consistent with teachers’ reports on questionnaires and interviews.) In 2002, we assembled a team of ‘curriculum experts’ to evaluate the materials as curriculum documents. The report was critical of many aspects of the materials (see Malcolm, Kowlas and Stears, 2003). Consequently, we took two steps: the researchers led a workshop on curriculum design with the PSP staff (which included making available references and ‘models’ from other published curricula), and, as part of our work with three schools in the ‘detailed studies’, we developed an exemplar of curriculum design based in the children’s lives and interests and closely linked to the Revised National Curriculum Statement. That development began in 2002 by exploring notions of relevance for children and their parents in the Cape Flats area, and intensified through 2003, with the completion of the module and its trial with three grade 6 classes. PSP staff, but especially the participating teachers and children, contributed to the module and were part of the trials.

The ‘detailed studies’ began in 2002, and saw the research team working closely with three teachers and their Grade 5 classes in the Guguletu and Khayelitsha areas. In 2003, we followed the three classes into Grade 6. In two of the schools, the teachers moved with the children; in the third, there was a change in teacher part way into 2003. Our objectives in the detailed studies were to work closely with the teachers, children and communities to develop ideas of relevant curriculum in the context of the Cape Flats; to experiment with approaches to assessment, as part of the module development; and to follow a particular cohort of students from 2002 to 2003, to see how they ‘progressed’.

Alongside PSP’s involvement in teacher workshops and provision of materials for teachers, PSP works with the WCED and other support groups with ‘school clusters’. The objectives of the Clusters Programme are to strengthen whole school development (by working with whole schools, and not just science teachers), and at the same time build networks of teachers (in various subject areas) and school managers across schools. We evaluated the Clusters Programme in 2002, and again in 2003.

In summary, while the initial purposes and the broad plan of the Evaluation were retained, the details of the plan shifted. In the area of assessment the shift was from testing (in the first two years) to alternative assessments (in the third year), in a large-scale study, and with three schools selected for detailed study. In curriculum and teaching, the emphasis shifted from classroom observations to curriculum design and materials development. And, as the cluster schools project took shape in 2002 and continued into 2003, we included evaluation of that project.

Chapter 2
Assessing children's learning

The need to evaluate children's achievements as part of a comprehensive evaluation of the PSP is incontestable. The work that PSP does with teachers – interpreting curriculum policies, expanding teaching and assessment methods, improving science knowledge and strengthening school management and teacher-networks – are all intended to increase children's learning. The modules that PSP produces, which teachers use quite faithfully, provide the basis for structured programmes of learning in science, augmented by various planning documents and proformas to help teachers do their work. The effectiveness of teachers' work is determined ultimately on the quality of children's learning, so assessment of children's achievement is critical to the evaluation.

Our first approach (in 2001) was to develop pen-and-paper tests, based on the PSP modules, which could be administered across the schools in our sample. We expected that the results on the tests might correlate with classroom effectiveness as indicated by our observations of lessons and our interviews with teachers, and provide guidance on the ways that PSP support to teachers could be improved. We also had in mind that, over the three years of the study, we might see improvements in test scores, as a result of teachers' and PSP's longer involvement with each other and the policies. In making these plans, we were well aware of the difficulties we faced. For example, pen-and-paper standardised tests face validity problems in that:

- they cannot canvass the kinds of outcomes defined in Curriculum 2005 (especially the critical and developmental outcomes);
- they cannot respond to the localised aspects of curriculum that are the cornerstone of Curriculum 2005;
- they cannot know the experienced curriculum in classrooms;
- they are bound to privilege some children, depending on language and details of experience, and the timing of presentation of different modules over the school year.

At the same time, counter claims can be made. For example, all of the teachers who participate in PSP tend to use the PSP modules, and teach them in much the same order. Thus there *is* a commonality of classroom experience across schools. Further, while pen-and-paper tests cannot adequately assess the complex competences that underpin Curriculum 2005, they can assess some aspects of that competence – especially knowledge of terms and consequences, and analyses of situations somewhat similar to those considered in class. Third, while language is clearly a major issue, it can be ameliorated to some extent through use of diagrams and stories in the tests, by allowing children to talk to their teachers and/ or the researchers during the assessment, to assist with understanding, and by encouraging children to respond to the questions in whatever language they chose. This was the strategy we adopted in 2001 and persisted with in 2002. In both years, the test items were trialled with children and PSP staff, and, in 2002, with PSP teachers as well.

The results of tests in 18 classrooms in 2001 yielded such poor scores that item-analysis and any attempt to correlate achievement with classroom observations was pointless. This result was of major concern to us, while our classroom observations and interviews with teachers and children showed that lessons were generally well designed and presented, learners were deeply engaged, and children and teachers alike felt that considerable learning was occurring.

These impressions were supported by children's reports about what they had learned and ideas from science that they talked about with each other and members of their families. So, in 2002, we revised the tests – replacing some questions, improving the wording of others, and generally working with layout and structure to provide children with more 'cues' about what was required in their answers. This resulted in improvement of scores by about 15% (on average) – though this improvement is worrying in itself: probably a matter of cues, layout and test design more than children's better knowledge. The results were still poor, but with sufficient spread to enable item analysis. The analysis suggested that the major problem was that children did not understand the questions. However, we were had no way of determining the extent to which this was a problem of language, knowledge, or guessing. Certainly the children worked hard on the tests, often for more than an hour, suggesting that they were taking them very seriously. In 2002, as in 2001, the teachers helped us mark the tests, and were as perplexed as we were: they felt that the tests were generally 'fair' and expected their learners to do better. Even so, we were mindful that our classroom observations showed that classrooms generally scored lower on 'intellectual quality' and 'connectedness' than they did on management and learner engagement, and that this pattern is reflected in the PSP materials. However, our tests were not only about higher-order thinking.

The question of language – reading, articulating and writing in English when it is the children's second or third language – is surely important. We know that many of the children have difficulty in interviews where they use English, and reading and writing are more difficult than oral language – especially in the formal language of tests. Further, in the majority of schools with which we worked, teaching is in isiXhosa in Grades 1-3, Grade 4 is a transition year, and English (or Afrikaans) is the language of instruction from there on. Many of the children have little contact with English outside the classroom – especially as a language for communicating the kinds of ideas that are important in school. In many cases, the children don't have 'serious' conversations with adults or older siblings in any language. Research into children's mathematics and science knowledge such as the TIMSS projects show that language and location were by far the most significant determinants of achievements in Mathematics for Grade 8 children (Howie and Plomp, 2001; Howie, 2001). The situation is complicated because, in South Africa, language and location are proxies for socio-economic level, education of parents, health of parents and children, school resources, teacher-supply and qualifications.

Hence, as an alternative to testing in the general study, in 2003 we offered children from ten schools an open task, where they were to:

- Record for us in a way they found interesting something important they had learned as part of studying the module in progress, or recently completed. They could tell us by writing, drawing, talking, enacting, using any language they wished.
- Explain for us why this was interesting, what it meant to them, and why they told us about it in the ways they chose.

On the following day, after working through what the children had given us, we interviewed selected children about their presentations and understandings, including questions on why the learning was important, and why they had chosen their particular forms of presentation.

Our objectives in this were three. First, by allowing the children to choose what they thought was important, we obtained data on their interests. Second, by centring on things they found important, we were centring on things they should be able to talk about. Third, their free choice to 'speak in their own words', whether orally, in writing, drawing, acting, sought to circumvent language difficulties. Thus the strategy was to find out what they *did know*, rather than what they should or might know: if the children couldn't talk sensibly about one thing that they wanted to talk about, we could conclude along with the test results that very little learning had occurred!

Our sample consisted of ten Grade 5 classes whose teachers had considerable experience in the PSP, had participated in earlier phases of our study and scored well in our observations of their classes. With class sizes typically around 40, this provided data from about 450 children. Four of the selected schools were in rural districts (in the Worcester area of the Western Cape) and six in Guguletu and Khayelitsha (in Cape Town). A month before the task, we held group meetings with teachers, to outline the plans. This included discussion of our findings from the tests, speculation on reasons for the poor results, and anticipation of the modules that would be running in a month's time. We encouraged the teachers, over the next month, to teach in ways that would enable a rich variety of responses to our task – perhaps with children going beyond the 'science' to personal development, self-confidence, enjoyment of science. We knew from our previous work with PSP that our request was consistent with the teachers' usual approaches. Further, we asked the teachers, during the month before data collection, to provide opportunities for the children to practice reflecting on their learning, so that they might develop confidence and skills in introspecting and saying whatever they wished. This request too was consistent with the teachers' usual approaches, and we needed their help in assuring the children that they could speak openly to us.

Given this collection of strategies, we expected (and hoped) to get rich information from the children. This was our purpose. As it turned out, we did get rich responses: only in one of the ten schools was there considerable similarity of answers, suggesting some kind of class rehearsal. The discussions with the children that followed their presentations, in all schools, provided opportunities for us to explore in depth the children's understandings.

The theoretical frameworks for the task study were drawn from ideas of metacognition and deep learning (eg. Baird and Mitchell, 1986) and situated cognition (eg. Lave and Wenger, 1991): children reflected on what they had learned and talked about learning as a situated experience. Consistent with these frameworks, and anticipating that children might raise a wide range of outcomes and detailed information, we used an assessment rubric that is generic across subjects and learning areas, oral, written and visual presentations. We chose the SOLO taxonomy, which examines the "Structure of Observed Learning Outcomes" (Biggs and Collis, 1982; Biggs, 1999; Atherton, 2003). It calls for analysis of the *structure* of students' texts and presentations, looking for the number of ideas offered and logical relationships between them. There are five levels:

1. Pre-structural: children present bits of unconnected information, with no organisation.
2. Unistructural: children offer few ideas, and while simple and obvious connections are made, the significance of the connections is not grasped.
3. Multistructural: a number of ideas and connections are made, but the meta-connections between them are missed, as is their significance for the whole.
4. Relational level: the significance of the parts in relation to the whole is appreciated.
5. Extended abstract level: connections are made within the given subject area and beyond it, generalising and transferring the principles and ideas underlying the specific instance.

The SOLO taxonomy has advantages, for our purposes, in that it fits with situated cognition, metacognition and deep learning, and is independent of detailed content. At the same time, we were aware of weaknesses – for example, the rubric does not necessarily discriminate the quality (eg, accuracy, significance and insight) of the propositions, relationships and abstractions the children offer. It is possible for an extended abstract text to be wildly fanciful, and in that sense 'less advanced' than an insightful and accurate multistructural text. Further, at the Grade 5 level, we could expect only short texts: in long texts, connections and structure would be more obvious, and classifications easier. As always with constructivist conceptions of learning, judgements about levels of understanding are inferences, not measurements. The interviews we conducted with the children, in combination with their presentations, provided us with opportunities to improve our inferences. Aware of these difficulties, we sought in our analyses to use the whole scale, and as necessary to make compensatory adjustments. For example, we ignored errors of fact such as "Pluto is the closest planet to the sun" where the discussion of planets and their motions was otherwise profound, or down-graded texts that were 'relational' but 'wrong'. As part of our analyses, we used two judges, especially in cases where classification was difficult.

Findings: the quality of answers

The children enjoyed the task immensely, and went about it with earnestness and pride. Mostly they wrote their ideas, and drew pictures, then talked about what they had written. They usually focussed on learning in 'science' rather than, for example, personal development or language. Typically the science they reported was factual (such as the life cycles of various animals or the names and characteristics of planets), but often it was about a model (such as the motions of planets, or phases of the moon) or a concept (such as energy). While their knowledge was sometimes inaccurate in detail, it provided insights into their deeper understandings and interests.

Examples of children's answers (from presentations and/or interviews) according to Biggs and Collis' five stages are presented below. The examples are representative.

Pre-Structural Responses:
We classified as pre-structural responses those that offered not structural information at all. Most often, they were simple statements of topic – for example, "What matter means", "Day and Night", "Science of [Electric] Plugs", "Good of Electricity", "Where clouds come from", "Spinning of the Earth". Such responses arose especially in presentations on the first day – in follow up interviews children moved to higher levels, as a natural result of conversation about their presentations. One explanation for these simple statements of topic on the first day might be that the children were simply indicating something they would like to talk about during interviews on the second day.

Unistructural Responses:
The answers we classified as unistructural were typically single propositions: "Water pollution is when people make water dirty"; "I want to show you that the earth is round"; "Evaporation is when water changes to gas". As with the pre-structural responses, these arose especially during presentations on the first day.

Multistructural Responses:
Multistructural answers usually consisted of a number of propositions, but connections between them seemed not to be clearly grasped. They arose in the presentations on the first day, and during interviews.

- *Because I live in the earth. Because I learn everything I was don't know about the earth. Because my teacher always told me about the earth. If I was home I sit down and read my books about science because I want to know everything about science. Water is more than the land because I live in the land.*
- *The light from the sun makes the plants to make its own food. Plants use the light from the sun, water and air to make its own food. Plants use their own food to grow. You get light energy from electricity and you get light energy from the candle, we can get light energy from the coal and heat energy from the sun. You get heat energy from the wood.*

The second example points to difficulties of classification with the SOLO taxonomy. It is not clear in this example whether the child is using organising principles about light/heat energy, or energy in general (in which case the category would be relational), or whether, as we decided, he/she is simply assembling a number of propositions.

Relational Responses:
In this category are responses where the child clearly recognizes the relationships between the propositions offered, indicating an understanding of a larger model or concept. We categorised the following examples as 'relational' even though both have 'appended ideas' – in the first case that plants provide fresh air, and in the second that we cannot live without water. The quotes are from interviews.

- *Energy is important because it gives you the power to walk. We can't do anything without energy. Plants make you breathe fresh air. It grows food and then you eat the food. You've got stored energy and then you burn the stored energy by doing action.*
- *The picture is about water cycle. Because we wanted to show you where does the rain come from. The sun heats the river then the vapour goes up to form clouds again; the clouds get heavy and the vapour goes down to the earth as rain. Vapour is water. The brown [in the picture] is land. We cannot live without water. Water is important because if we cannot drink water we can die.*

Extended Abstract Responses
In this category, answers go beyond appreciation of relationships between ideas, stretching into abstract conceptions and generalisations.

- *[Working from his/her drawings of the life cycle of frogs] The frog is an amphibian. It lives on land and water. It lays its eggs in water. The frog does not have a tail. The adult is the frog, the tadpole is the baby. The eggs grow into tadpoles. The tadpoles grow legs and the tail disappears and it becomes a big frog. Because it lives in the water like the fish it has the scales. Frogs have slimy skin. Slimy is like something when you take it and it falls [slips] down. Other times it is dry and other times it is wet. The frog is different from the tadpole: the frog's tail disappears when it is growing and the frog has, well, fingers and legs. The tadpole is smaller than the frog. Tadpole doesn't jump; it swims like a fish. The frog jumps and it likes dirty water. It likes to jump on the leaf. The frog likes green water because the skin is green. The frog swims with a web-feet: if he doesn't have the web he can't swim. We have male* *and female frogs. The female lays the eggs and the male fertilises the eggs. Fertilises means the male puts his sperm in the eggs.*

- *[Working from his/her drawings of the solar system] Pluto is far from the sun. Mercury is near to the sun. There are nine planets from Mercury to Pluto. We have different planets. The fourth planet is Mars. Pluto is very far from the sun and very small too. Earth has oxygen. We need oxygen to breathe and survive. There is also a moon. The moon has eight faces [pointing to drawings showing how phases arise]. We can see the moon at night if there are no clouds. People can go with a space shuttle to the moon but not to the sun. The sun is very hot.*

Findings: a quantitative analysis

What the children talked about:

All of the children's presentations from Day 1 were analysed. The topics that the presentations drew from were determined by the topics that the class had been working with over the last month. The classification of answers by topic is shown in Fig 4.1. In their presentations, learners usually focussed on learning in 'science' rather than, for example, self-confidence, personal development, social skills or language – a result that surprised us: the children appeared to have a prejudice about what outcomes should be talked about in the science class. Typically the science they reported was factual (such as the life cycles of various animals or the names and characteristics of planets), but often it was about a model (such as the motions of planets, or phases of the moon) or a concept (such as energy). It was also interesting that very few of them presented stories of investigations and the processes of science, or reports on science and environment. Some picked up on ideas of safety and the usefulness of science in their lives. For example, children in the Cape Flats spoke about the dangers of naked wires, stoves being left on, and electric heaters starting fires. While a major concern for them was the safe use of the electricity, they also spoke about how electricity makes life easier. For example, "We do not have to make fires to keep warm in winter. We have heaters. Heaters can be very dangerous too."

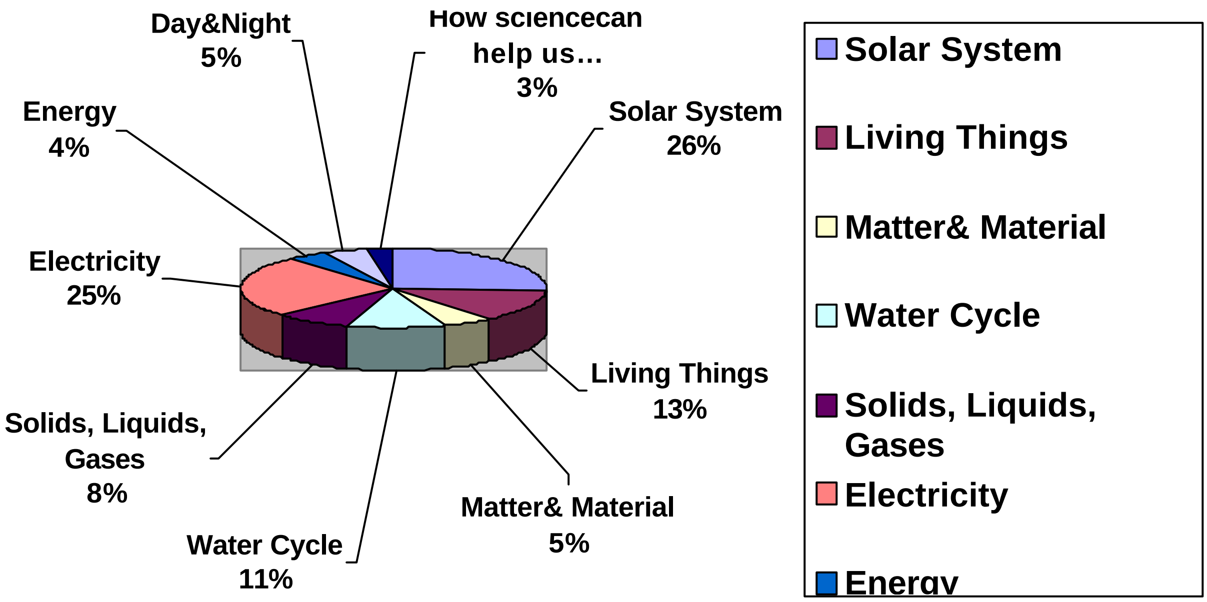

Fig 4.1: Topics raised

Most of the schools in the rural areas of DeDoorns had just completed Earth and Beyond, and the children spoke of planets, phases of the moon and the Earth's structure. Presentations were often about the distance between planets, the position of planets in the solar system, the phases of the moon and the possibility of life on other planets. Children explained why humans could not live on Mercury or Pluto and expressed their belief that there could be no life on other planets because there was no oxygen and/and temperatures would be too high or too low. "Pluto is very far from the sun and it is very small. People cannot live on Pluto because it is very cold." Some talked excitedly of Mark Shuttleworth, their desires to become astronauts, and the role of science in space travel. Learners were excited about their knowledge and wished to express as much as possible in their presentations and when talking with the researchers.

How the children chose to present their learning

More than 60% of the children chose to present their learning in writing and drawing, usually as drawings accompanied by explanatory texts. Very few children wrote or drew things without explanations, and almost all wrote in the formal language of instruction. The other 40 % chose to present enactments (for example of planets, or day and night) and oral responses. Given freedom to choose their topic of interest and communication mode, and given time to produce their presentation, the children did not shy away from using the language of instruction.

Day 1 Presentations and the SOLO taxonomy:

All of the children's Day 1 presentations were classified using the SOLO taxonomy (Fig 4.2). Most children responded at multistructural and relational levels. Multistructural and relational responses arose especially from written or drawn representations and enactments (usually role-plays, sometimes songs), as shown in Figs 4.3 and 4.4. Teachers often helped children in their plays during the presentations. While children's knowledge was sometimes inaccurate in detail, the children demonstrated broadly accurate insights into the models, processes and theories they were presenting. Unistructural and prestructural responses came especially from oral-only responses. However, the ways these children delivered their oral presentations suggested that many of them had misunderstood the task, and were merely indicating a topic they would like to talk about on the second day. On the second day, almost all children at the prestructural and unistructural levels demonstrated higher levels of thinking (see below).

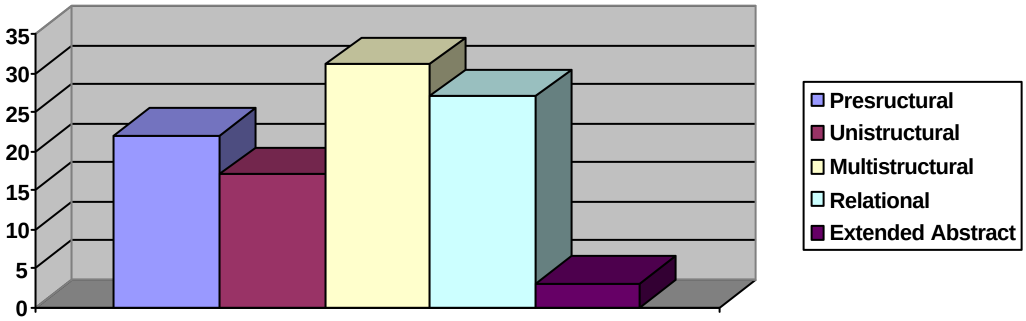

Fig 4.2:DAY 1 Responses classified according to the SOLO taxonomy

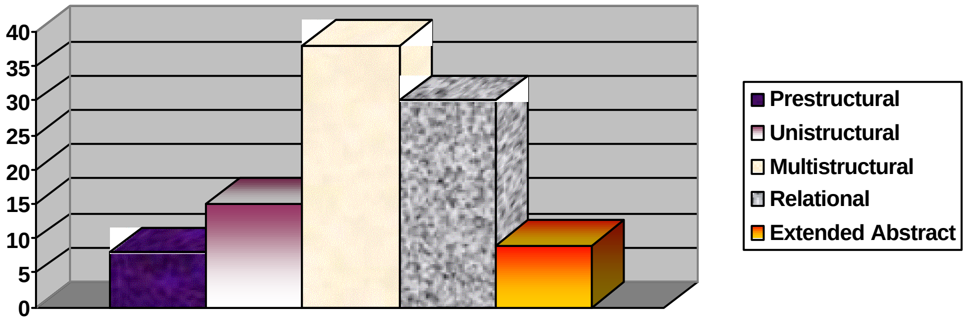

Fig 4.3: Day 1 responses on paper, classified according to the SOLO taxonomy

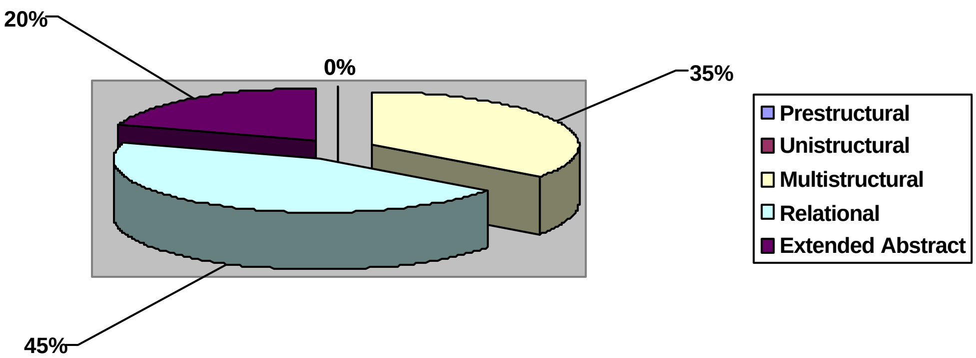

Fig 4.4: Day 1 responses through enactment or oral presentation, classified according to the SOLO taxonomy

Day 2 responses, during interview

Following the Day 1 presentations, the researchers worked through the children's responses and selected approximately ten children from each class to follow up with interviews on Day

2. Children were chosen for interview because what they had presented was unclear and/or looked interesting.

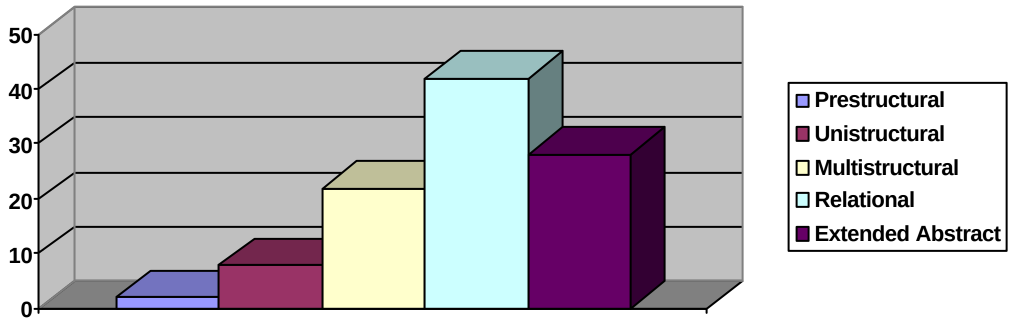

Fig. 4.4: Responses on Day 2, during interviews about their presentations

As the children built on their Day 1 presentations, their responses usually moved to higher levels in the SOLO taxonomy, with the effect that the majority of responses were relational and extended abstract. Examples of relational and extended abstract responses were provided earlier. At the relational level, children fit ideas together into a coherent account; at the extended abstract level, they understand a model or theory as an abstraction. As the focus of the interview, learners most often used diagrams they had drawn, explaining and elaborating them. They often went into great detail, gaining confidence as they went. They sometimes spoke in their mother tongue, with the teacher or fellow learners translating to English.

Discussion

Our analyses show that in their written and oral presentations, about 60% of children demonstrated multistructural and relational understanding – in other words, they provided a number of propositions related to the topic of their presentation, often relating those propositions into a coherent account of the concept, model or theory in question. During follow-up interviews, children demonstrated higher levels – multistructural, relational and extended abstract. In short, the assessment task shows that children have learned something from their science classes, and are able to talk about it in detailed and insightful ways. Just as importantly, the assessments affirmed for the children their worth and achievements as learners, their enjoyment of science, and the confidence that their teachers had in them.

The affective dimensions of the children's work should not be underrated – affective outcomes may well be more important in the long run than cognitive achievements. Those of us who were involved in the testing programmes in 2001 and 2002 – teachers, researchers, and children – have clear memories of the children working conscientiously, deeply and long (in some cases 1½ hours) over 3-4 questions on one theme or another. Compare that with their experience in 2003, where they worked with pride and excitement on their drawings, enactments, explanations, and interviews.

The kinds of learning the children demonstrated – in the cognitive as well as the affective domains – are not the kinds that can be readily tapped through tests – especially 'short answer' objective tests. And though the children often shied away from extended answers in their presentations, they had no hesitation in producing extended answers in the follow-up conversation. What is more, in their conversations, the children chose to communicate in English (in the Cape Flats, even though their first language was isiXhosa) or Afrikaans (in the deDoorns area): the poor results on tests are not simply a matter of language and knowledge, but some complex combination of language, knowledge and the requirements of tests.

For the teachers, the extent and accuracy of the children's answers were a relief – the teachers, like the children, felt that considerable learning was taking place in their classes, but our written tests had not been able to tap it. At the same time, we and the teachers are well aware that the presentations and interviews, by design, were bound to manifest examples of learning: the children chose one thing they felt they had learned from the module that was interesting to them, expressed it as they chose, and talked in detail about it. The aspects of choice and personal interest account at least in part for the high levels of understanding they demonstrated. This is a quite different thing from a test, or a set of tasks intended to canvass achievement across various aspects of the module. At the same time, there is no more reason to believe that the learning they presented was their only learning than to believe that what they presented is typical of their general achievement. Doubtless, the 'truth' is somewhere in between; more such tasks are required to find out.

Assessment within a single module

In Chapter 4, we describe a module we designed collaboratively with teachers, children and parents in three schools in the Cape Flats area, intended to build on the children's lives, interests and concerns. The module was called *Fire in our lives*. It included a wide range of teaching activities and tasks, all of which provided information on children's learning and achievements. We also included a number of 'special' tasks towards the end of the module, to try to summarise the learning that had occurred. We complemented this information with a written test at the end of the module. This choice was made largely in relation to our assessment project as part of the general study of schools. There we had found that the children did poorly, with one possible explanation that those tests were 'standardised' across schools and did not fit well with the curriculum actually presented in any school. The Fire module gave us an opportunity to design a test that suited the module we had taught, the ideas we had tried to emphasize, and a single class, whom we knew well. Our test focussed on conceptual understanding, exploring children's abilities to apply knowledge more than recall factual information. It consisted of seven questions.

In the test, as in the other tasks, a key question for us was: Does learning through 'relevant science' enhance children's conceptual understanding or does its value lie more widely in children's views of themselves, science and feeling affirmed that their everyday knowledge is part of the classroom?

The results, overall, showed that children could apply everyday knowledge from the module across a range of situations. They were able to describe changes when a house burns down, and had a generally good understanding that energy transfer causes change, and there are various forms of energy. However, the children's grasp of the formal science knowledge varied widely. For example, in explaining fire, many children had difficulty conceptualising air as something material that is necessary for fire. Very few could explain how sand and blankets put out fires. At the same time, we were aware that these questions were difficult: the 'necessary and sufficient' conditions for fire are not easy to disentangle, and not as easily justified as we usually claim.

In comparison with the open tasks, the tests proved difficult. The ways questions were phrased seemed problematic, echoing the difficulties we had in designing 'standardised' tests (discussed earlier). For example, children did not seem to know how to respond to questions such as: " How does this help?" or "Why do you say so?" The answers required are in one sense open, but in another sense clearly evaluative. By comparison, in open tasks as part of the teaching, the children wrote extensively on open questions that were creative (such as in the class task 'finish this story'). The difficulty seemed to be with the idea of having to justify their thinking. Our test also raised an issue of what constitutes an explanation or answer to a question. For example, a substantial number of children responded to the question: "Why are they doing this [putting a blanket on the fire]"? with: "to stop the fire", instead of: "to keep air (oxygen) away from the fire". This is in part a matter of 'training' in the nature and expectations of test questions: interviews with the class teacher indicated that the children rarely write tests and when they do usually fill in missing words etc. They are seldom required to give reasons for their choices or explain their answers. In this, reading and writing in English are added problems – the children's answers showed that they misunderstood some questions, and in others their responses were difficult to interpret. This fits with our observation, during classes, that the children preferred to draw.

Overall, children fared poorly on our test, in spite of all they seemed to have learned and demonstrated during the activities of the learning programme. Hence we tried designing a second test, in which the questions were simplified and more multiple-choice questions were included. The children performed only a little better. The practical, everyday knowledge that they demonstrated in the first test was still applied, but, as then, it was difficult to find evidence of conceptual development in formal science.

These results have to be seen alongside the assessment project in the general study: it appears that the problem in the general study was not simply that the test had been standardised across classes, but that the children do poorly on written tests even when the tests fit closely with the taught programme. Further, in this case as with the standardised tests, there was evidence from classroom observations and students' work in class that learning was occurring. In other words, written tests are not assessing the learning taking place for these children. Alternative assessment strategies are required to determine what children take away from their science lessons. Indeed, as in our 'tell us something important you have learned' task, classroom activities and the children's engagement during activities were a better indication of learning than the written tests.

Conclusions

Our studies of assessment point the way forward. First, it emphasizes the greater validity and opportunity of assessment through tasks that are part of classroom work. Such tasks, especially if well constructed, are more likely to show not only what the children are learning, but errors and difficulties that can be followed up 'on the spot' to assist their further learning. This is the standard mantra of continuous formative assessment. Second, it points to some of the desirable aspects of such tasks:

- They should be varied – drawing, talking, writing, reading, investigating, summarising; done sometimes in groups, sometimes individually.
- Many of them should be 'open' in that they encourage children to respond in different ways, using their own words. The children respond well to drawing, enactment and

narrative expression – even when they are talking about the location of the planets or electrical circuits or the life cycle of frogs.

- It is important to allow children to talk about what they have presented. This does not need to be done in the intensive ways that our research required: teachers can keep an informal 'roster' that ensures that they talk to different students from one week to another. It does require some systematic planning, and keeping records.
- Alongside the open 'tell us about something you found interesting', there needs to be tasks that are used systematically to assess particular ideas and outcomes at points during a module. This should include short quizzes and monitoring tasks as well as more open tasks. In all of these tasks, emphasis on conceptual development and complex skills should sit alongside attention to basic vocabulary, knowledge recall and specific skills.

There remains an important place for tests, especially short tests: they can be an efficient way of monitoring children's progress. From our data, we are convinced that part of the failure of our tests was that, for one reason or another, they provoke test anxiety and paralysis. To overcome this, teachers need to talk with the children about tests – perhaps treating them as a game (which they surely are!) and helping the children to 'play them' and play well. If the concept of 'test' is the stumbling block – not the children's knowledge – then it is the idea of 'test' that has to be tackled.

Chapter 3
Judging standards

In Chapter 2, we analysed children's work using the SOLO Taxonomy. Its concern is the Structure of Learning Outcomes – the extent to which children's responses to a task introduce a number of related ideas and constructs, and put them together in coherent and abstract ways. Our analysis of presentations that the children made of learning they wanted to talk about showed high levels of relational thinking: many children were thinking deeply about the topics and ideas they presented, and were able to articulate their insights.

In this chapter, we turn our attention to 'content' – especially as prescribed in the Revised National Curriculum Statement. We address two aspects: achievements consistent with the Science Learning Outcomes (science processes, science knowledge, and science-society), and levels of achievement consistent with the prescribed Standards in the outcomes. Our purpose was to use the Revised National Curriculum Statement as a tool for analysing the content and standard of children's presentations. Our hope was that the Standards would provide accurate ways of describing levels of achievement in the outcomes.

Focus on outcomes

As noted in Chapter 2, many of the children, especially during interviews, demonstrated abilities to propose and explain ideas that were related. At this relational level they were able to incorporate knowledge and recall of scientific facts, theories, concepts and terminology. These responses express particularly Learning Outcome 2:

> *The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.*

None of the children chose to give presentations related to investigation skills and Learning Outcome 1:

> *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.*

We see this, in part, as a reflection of weaknesses in the PSP modules (see the 2002 Report, Malcolm et al, 2003): designing and conducting investigations (as against making observations and measurements, or using particular equipment) are not emphasized in the modules.

The third outcome is:

> *The learner will be able to demonstrate an understanding of the interrelationship between science and technology, society and the environment.*

A number of children provided evidence of this – for example, in the ways that electricity can be dangerous, and ways it can be helpful, or methods of purifying water. However, in general, the focus of their presentations was the conceptual knowledge (LO2). Again, as we noted in the 2002 Report, this is in part because such 'science' is usually the focus of the PSP modules.

We will consider the children's work especially in relation to LO2 (science knowledge), because that was usually what the children wanted to present. They often showed their conceptual understandings with simple clarity, usually supported by drawings and enactments:

1. *If you put the battery in the radio it will get the sound. You pour petrol and oil into the car and the car will move….*
2. *When the light shines in America in South Africa it's a night time,*
3. *The earth takes 24 hours to complete a rotation*
4. *When the sun is at the back that is day and this side is night, when we rotate that side (front) is the day, and this side is night (back). When the earth is facing the sun we get daytime and the night the earth is away from the sun and we get the night time.*
5. *Because of the sun like rise in Africa in Northern America it is night time and when the sun like rise in Northern America in Africa it is night time.*

Some students enjoyed grappling with related ideas, such as the fact that day and night only arise because light travels in straight lines:

6. *The spinning of the earth is round like a ball but when the earth is moving the sun is not moving. The light is not moving. The light does not bend because if it is day on one side the light won't go around to be day on the other side where it is night. It will be day when the earth moves around day and night will change.*

On the concept of energy, children's explanations ranged from simple to complex:

7. *The rooster eat the mealies and the rooster has the stored energy. The wind blows the windmill and the windmill will turn.*
8. *The sun must burn the plants and the plants will get the energy. No, the plant will die because the sun has the strong heat. The sun gives light and heat energy when it heats and when it rises in the morning.*
9. *You burn the wood, the wood will bring fire and then you put your pot and it will boil. The fire makes the pot to boil. In plants the energy is stored in the leaves. You pour water in the plant and it get energy in the leaves. The plant keeps the water and makes its own food. If there is no sun and water the plant will not make its own food and it will die. Cows get energy because it eats the plants and then it gets the stored energy and then it will make a move and we will get milk from the cow and we drink the milk and get energy.*
10. *Condensation is important because when you want something to change into a liquid eg. a gas change to liquid and the sun boils the water and the water makes the vapour and vapour makes the clouds and the clouds makes the rain. The sun boils the water makes the vapour and the vapour rises up and makes the clouds.*

In explaining the planets, the children enjoyed the linkage of planet's distance from the sun with prospects of life on the planet, the availability of water on Earth, and ideas of gravity, again usually communicated via drawings or role play.

11. *Pluto is far away from the sun and Jupiter is close to the sun, in Pluto its cold. In Jupiter it's hot because it's close to the sun.*
12. *Earth consists of two surfaces ie. water and land. There is more water than land of the surface.*
13. *Because the force of gravity pulls the desk down and the force of gravity pulls the desk down. There are some things like birds and planes that overcome the force of gravity.*

Assessing standards

The Assessment Standards defined for Learning Outcome 2 are reproduced in Fig 5.1. The Revised National Curriculum Statement promises:

> *The Assessment Standards are ways in which learners demonstrate the achievement of the Natural Science Learning Outcomes…. Learners' progress on each Assessment Standard is seen in their increasing ability to perform at higher levels. These ways of demonstrating the Assessment Standards are policy and learners are to be assessed against these standards.*

Thus the Standards do two things. First, they define progression in the outcome, and hence 'what progresses'. In that sense, they make clear what the outcome means, and what it means to express the outcome at higher levels. Second, they provide standards against which learners' achievements can be measured, enabling descriptions of a child's current progress.

Fig. 5.1: Standards of achievement in Learning Outcome 2: The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.

Grade 4	**Grade 5**	**Grade 6**	**Grade 7**
Recalling meaningful information when needed			
Learner, at the minimum, uses own most fluent language to name and describe objects, materials and organisms	Learner, at the minimum, uses own most fluent language to name and describe features of objects, materials and organisms	Learner, at the minimum, describes the features which distinguish one category of things from another.	Learner, at the minimum, recalls definitions and complex facts
Categorising information to reduce complexity and look for patterns			
Learner sorts objects and organisms by a visible property	Learner creates own categories of objects and organisms, and explains own rule for categorising	Learner categorizes objects and organisms by two variables.	Learner compares features of different categories of objects, organisms and events
Interpreting information			
No AS	No AS	Learner at the minimum interprets information by using alternative forms of the same information	Learner interprets information by identifying key ideas in text finding patterns in recorded data, and making inferences in various forms, such as pictures, diagrams and text
Applying knowledge to problems that are not taught explicitly			
No AS	No AS	No AS	Learner applies conceptual knowledge by linking a taught concept to a variation of a familiar situation

We analysed children's presentations (such as those offered above) using the Standards, expecting to assign, somewhat unambiguously, a standard to each presentation. Our starting point was not the Standards as such, but the understanding the children were expressing; our strategy was to identify the features of their answers, then seek to locate them against the Standards. The children in our project were in Grade 5, so we might expect that most of them would be at the Grade 5 Standard, some at Grade 4 or even 3, some at Grade 6 or even Grade 7. It quickly became clear that the Standards are not adequate for the use we wished to make of them: the definitions of 'what progresses' in the outcome are more restricted than the children's answers, and the Standards are hard to interpret and apply.

If we take the first 'strand' – that learners can 'recall meaningful information when needed' – all of the examples we offered earlier demonstrate this ability, some through unistructural answers, others through sophisticated relational answers. From Fig 5.1, all of the children we have quoted are beyond the Grades 4 and 5 Standards. However, the Grade 6 Standard turns out to be somewhat irrelevant because its concern is for "features which distinguish one category of things from another", and the children didn't recall information from such a perspective. From Fig 5.1, it is not at all clear how to classify recalled propositions such as:

1. *If you put the battery in the radio it will get the sound. You pour petrol and oil into the car and the car will move….*
2. *When the light shines in America, in South Africa it's a night time.*

The temptation is to move to the Grade 7 Standard, even for simple responses such as these. But many of the children – especially in relational responses and extended abstract responses – went beyond "recalling definitions and complex facts" as indicated at the Grade 7 level. For example, consider responses (9) and (10) above. (9) brings together energy chains and food chains (including the fact that plants produce food and animals consume food), takes for granted ideas of energy transfer required for change of any kind (including growth), and hints at energy conservation. (10) incorporates concepts of liquids, gases and phase change, the reversibility of phase change (condensation and evaporation), the energy required for evaporation (from the Sun), and hints of 'hot air rises' to where the temperature is lower. Both children are using a complex of concepts and principles to present a process or model. On the Standards, these abilities are described by the Grade 9 level: "Learner, at the minimum, recalls principles, processes and models". Does this mean some of the children in Grade 5 are operating at the Grade 9 level? The problem with this judgement is that the children are not talking about the specific content listed for the Senior Phase.

The second strand – that learners can categorise information to reduce complexity and look for patterns – is about classifying objects, events, organisms, and materials. None of the children's responses in our study illustrated this strand, except by inference (for example in talking about 'planets', 'liquids', 'gases', and 'forms of energy'). In terms of 'science' the children chose to present, categorisation and classification were not favoured topics. In talking about their favoured topics, they took in their stride classifications of objects and events, but they were not on the 'learning path' defined by the Standards for 'categorising information'.

The third strand – interpreting information – is relevant to the children's presentations: the essence of our task was that they should present science 'in their own words' – through drawings, text, enactments, conversations. This is surely interpreting information, and many children did so in exciting and sophisticated ways. In Fig 5, there are no standards in this strand below Grade 6. The Grade 6 Standard is roughly appropriate for the presentations the children made, but allows no discrimination between unistructural, multistructural, relational and extended abstract responses. The Standards above Grade 6 do not help: the Grade 7

Standard is about text, and making inferences; the Grades 8 and 9 Standards are about graphs and data. In short, all of the responses we obtained have to be classified as Grade 6 level, in spite of the wide range of abilities the children showed in interpreting and presenting information!

Finally we turn to the fourth strand, 'applying knowledge to problems that are not taught explicitly'. In this, there are no Standards below Grade 6, and arguably, none of the children in our study demonstrated this ability – the children were essentially concerned with recalling information. A number of children talked about 'science in our lives', pointing to safety issues, health issues and ways that science makes life easier. Such responses, in the Revised National Curriculum Statement, belong not to 'applying knowledge' but to 'undertanding the impact of science and technology on the environment and on people's lives' as part of Learning Outcome 3. They fit with the Grade 5 level.

Our analysis highlights weaknesses in the National Curriculum Statement and its Standards. The Standards are hard to apply, so that often the children's responses have to be 'forced' into the structure. Sometimes the Standards discriminate too much (as in the Grades 4,5 and 6 Standards in 'recalling meaningful information'); sometimes they do not discriminate enough (as in the Grade 6 Standard in 'interpreting information'). We also wondered about the extent to which the Assessment Standards actually represent progression in competency or are simply a game in semantics with no real conceptual development involved. (Consider, for example, the Grades 4,5 and 6 standards in 'recalling meaningful information').

We have tried to use the Standards in a particular way: we have begun from what children said about important learning they had done, and understandings that we saw as 'good science'. Such achievements should be able to be mapped into the Standards. They can be mapped into the Outcomes and strands, but often do not fit well with the Standards. This mismatch can be seen as a failure of the Standards, or a failure of curriculum to directly address the standards (or in our case, of the children's choices of interesting science). We believe that most science teachers reading and listening to the children's responses as we did would see them as exciting, sophisticated and 'good science', so the problem at least in part is with the Standards.

In terms of the standards, our analysis shows that very few of the children's responses were below the Grade 5 level in any of the outcomes and strands to which their work related. Many responses were considerably above the Grade 5 standard – with some reaching perhaps into Grade 8-9 levels in 'recalling meaningful information' in LO2. As in Chapter 2, this is a reminder at least of the range of abilities and levels within a Grade 5 classroom. This has deep implications for teaching and assessment, emphasising differences in knowledge as part of differences amongst children. It has implications also for policy: the WCED's intended rubric of reporting simply whether a child is at or above the given Grade Standard hides from the classroom the wide range of children's achievements, and encourages teachers to focus on children below the standard at the expense of children above it. Yet all children have a right to learn, to progress from their current Standard.

Finally, the question has to be asked: How are teachers to use these standards and outcomes as tools for analysing and reporting children's achievements? In our judgement, the Standards are hard to use: teachers will require extensive training and find much frustration.

Teachers' judgements of progression

One of the tasks we set ourselves in the Evaluation was to have three teachers follow their class from Grade 5 to Grade 6, and map the children's progress from one year to the next. We asked the teachers to pay particular attention to about ten children in the class, and keep portfolios and journal notes to chart their progress. The task proved too burdensome and too difficult – in part because none of us had satisfactory definitions of 'progression' beyond that defined by successive PSP modules. In the PSP moudles, as we noted in our critique in our 2002 Report, the implicit conception of 'progression' centres on concepts in increasingly complex situations rather than increasingly sophisticated understandings of particular concepts. The assessment tasks for the higher grades are similar in purpose and style to those in lower grades, calling for keywords and accounts of activities in the new context and content rather than deeper, more extensive theoretical understanding.

The teachers, on the other hand, tended to notions of 'progression' linked to children's social and personal competence – children's abilities to manage their lives, cope with their problems, take initiatives and responsibilities, care for themselves and others. As one teacher put it: "How much do you expect children to 'change' in six months? And how do you account for those who slip back – usually as a result of some new crisis in their family life…." Perhaps as a consequence, the diaries the teachers kept – somewhat sporadically – were a mixture of reports on children's performance on classroom tasks, their general behaviour, and shifts in their confidence and relationships.

When we turned to the portfolios the teachers sent us, the insights offered into children's achievements were limited by the tasks that were set and kept (many of them direct from the PSP materials): the tasks showed a strong prejudice on recall, with requirements, for example to: complete sentences, label drawings, fill in missing words, choose the correct word, or say where particular materials come from. Occasionally, the teachers used tasks in the form of word searches, but the demands were not necessarily in a science framework and seldom invited multistructural, relational or extended abstract responses. When more open tasks were set, answers were often superficial.

Our intention had been to seek progression by judging early and late examples of children's work in their portfolios against the standards of the Revised National Curriculum Statement. This proved fruitless, mostly because the tasks provided too little information on what children were thinking. In this, our position accords with the classroom teachers', quoted earlier: use of a larger number of scientific words is an unsatisfying definition of progression, especially compared to progression in personal and social skills in the classroom and life generally.

Our findings, yet again, underline the strong links required between assessment, teaching, curriculum design and published materials. In our observations of classrooms, throughout the Evaluation it was clear that children were often working at higher levels of competence than the set tasks required. This was shown dramatically in Chapter 2, where children frequently explained their science, in their own words, at relational and even abstract levels. The teachers and children know they can do this, but typical assessment tasks give the children little scope to show it. The same proved true of our tests.

The problem is summarised in “The MacNamarra Fallacy” (Handy, C, 1995, *The Empty Raincoat”, Arrow Books, London):*

> *In assessment, the first step if often to measure whatever can be easily measured. This is okay as far as it goes.*
> *The second step is to disregard that which can’t be easily measured, or to give it an arbitrary quantitative value. This is artificial and misleading.*
> *The third step is to presume that what can’t be measured easily really isn’t important. This is blindness.*
> *The fourth step is to say that what can’t be easily measured really doesn’t exist. This is suicide.*

There is much work still to be done in improving the design and use of assessment tasks, and inferring from them the Standards of children’s achievements.

Chapter 4
Relevant Curriculum

The communities that PSP works with are poor communities in the Cape Flats area of Cape Town and rural areas in the Boland, Worcester and Paarl districts. The communities are not homogeneous – not within districts, not across districts. In the rural areas, some schools served essentially suburban communities in provincial towns, others served satellite township communities, and some were in small rural communities. However, most of these communities were very poor, with families dependent on meagre incomes from seasonal farmwork, domestic work, or pensions. Often children walked long distances to school, shoulders hunched against the cold. In one school in the wine district, the principal reported that 60% of the children express Foetal Alcohol Syndrome, which he attributed to the past system of 'paying' farm workers with alcohol. Within the Cape Flats, most schools drew students from local informal settlements as well as townships, with proportions varying from school to school. Languages too varied in important ways. In the rural towns, Afrikaans was widely spoken by teachers and children; in the farming areas, English and isiXhosa were often the languages of the children, but the teachers spoke Afrikaans; in the Cape Flats, isiXhosa and English were the typical languages for children and teachers.

The lives of the learners in the Cape Flats are more complex in some ways than lives in the rural communities, characterised not only by poverty, illness, death, and absent parents, but violence, substance abuse and 'life on the streets'. This is especially so for children from informal, shack settlements, many of whom have immigrated from rural areas. Homes are mostly small, whether as part of informal settlements or low cost government housing. Typical houses in the informal settlements have two rooms and accommodate about seven people, often fragments from various families. The houses usually have electricity but not piped water. They are close-packed and often made of flammable materials, contributing to fires that sometimes destroy entire districts. Flooding and the cold of winter are also problems. The formal settlements are better placed, with houses serviced by electricity and piped water, more community services and higher levels of income and stability, but here too poverty, illness and life on the streets are characteristic. By Grade 6-7, teachers feel that many of the boys have given up on the idea that schooling can help them, or that they will get jobs. Many of the girls see a 30-year old boyfriend as the way forward. Sporadic attendance at school and drop-out increase as the children get older. As one teacher put it, "Kids tend to be interested in school and do well, or not interested and achieve very little; they can read or they can't; they can do maths or they can't…." In these circumstances, teachers battle to decide where to put their priorities.

Yet the schools we visited were happy places, with laughter and banter aplenty, and children prepared to talk to us about their schooling, their homes and their interests. In the Cape Flats area, as in the rural areas, the levels of children's engagement with activities and classwork overall were high, and children almost unanimously reported that they liked their science classes. All of the schools we visited were equipped with electricity and water, telephone and photocopier, and class sizes were usually around 40. Schools, especially in the Cape Flats, provided children with a basic lunch, often sponsored by private businesses. Schools required uniforms, although many learners were not in uniform, and this was not made an issue. All of the teachers we worked with seemed to care deeply for the children, and spoke with insight about the lives of the children and their families.

In this context, we embarked on a project to define aspects of science curriculum that were learner centred as promoted in the 1995 White Paper on Education:

> *Educational and management processes must therefore put the children first, recognising and building on their knowledge and experience, and responding to their needs. (Department of Education, 1995)*

This position is reiterated in the revised NCS:

> *The outcomes and assessment standards emphasise participatory, learner-centred and activity-based education. They leave considerable room for creativity and innovation on the part of teachers in interpreting what and how to teach.(Department of Education, 2002)*

The policy commends not only learner-centred pedagogy (how to teach) but also learner-centred content (what to teach), within the limits of the critical outcomes and the learning outcomes defined for science. However, while "building on learners' knowledge and experience" (learner-centred pedagogy) is straightforward in principle, "responding to their needs" (learner-centred outcomes) is much more complex and difficult. Should curriculum respond to children's immediate needs, or long-term needs in some likely or hoped-for future? Should it address instrumental purposes (to help with survival, day-to-day life and further schooling), philosophical purposes (to make sense of their lives and the world at large) or critical purposes (to change the world through individual and collective actions)? All of these purposes are referred to in the critical and developmental outcomes of the Curriculum Statements. The common response – in published materials and in teaching – is simply to stay close to building on children's knowledge and experience, choosing from the practical contexts of their lives to address content from traditional science. This, however, reduces learner-centred education to pedagogy and fails to acknowledge children's educational purposes and the range of their backgrounds and interests. For example, it is well established, in all cultures, that young children are deeply interested in moral questions of right/ wrong, good/ bad, safe/ dangerous, and enjoy exploring such questions through folk-tales, fairy-stories and myths. Children of 10-12 years are more concerned with the limits of human possibility, nature and technology: dinosaurs and ice-ages, space ships and sailing ships, heroes and amazing feats, fabulous cities and parched deserts, the workings of radios, human bodies and rain. The scope of children's interests and purposes stretches way beyond chemicals in the kitchen, stages in human growth, and the cultivation of cabbages.

Module Design

With so many possibilities, the central issue of 'what to teach?' has to encompass 'who decides what to teach?' In answer to the second question, we turned to the children, their families and teachers jointly, within the guidelines provided by the National Curriculum Statement. During 2002 (Malcolm, Kowlas and Stears, 2003), we interviewed groups of children, their parents and teachers in order to better understand their backgrounds and needs; we added information from questionnaires and inventories, and experimented with 'relevant science' lessons (some which we and the participating teachers designed together, some which the teachers designed). In the 2003 study we took this further and involved the learners more deeply, seeking a 'topic' that the children saw as especially relevant. Some of the topics and concerns that the children raised were:

- African culture eg initiation
- The importance of plants

- Fire
- Plant names
- How to make safe medicines using plants
- Animal reproduction
- How to make cars
- How to fix and repair damaged goods
- Cooking
- Volcanoes
- Solar system

The range of topics showed us that the scope of children's interests did, indeed, stretch beyond their immediate environment. However, the topic that emerged as the one that most children were interested in was fire. This proposition was discussed with the teachers and they agreed that children are very interested in fire as a major influence in their lives. They experience it not only as part of cooking and heating: everyone has direct experience of homes burning down, whether their own or homes belonging to friends and family. They have practical knowledge of how most fires start and most know how to put out fires.

The study was guided by the question: How can teachers and learners contribute to the design, implementation and evaluation of a personalised and relevant curriculum and how do they respond to such curriculum?

The children took the lead in identifying particular issues about fire. Examples of their questions were:

- What causes people to die without burning?
- How do fires burn people?
- How does *uvutha* cause fires?
- Is the sun a fire?
- How does a bomb produce fire?
- What makes a volcano?
- Why does an electric fault cause a fire?
- Why do people allow children to play with fire (matches)?
- Why do people watch when there is a fire and not help?
- What can you do to stop a shack from burning?
- How does a fire extinguisher stop a fire?
- What is the purpose of fire?
- Is fire important?
- Where does fire come from?

Most of their questions related to the social and cultural aspects of their lives, rather than fire as a natural or scientific phenomenon. For instance, the connection between fires and their social circumstances are a major concern for these children. They were concerned about the fact that the effect of fire on their lives was due to human behaviour and not Nature. Nevertheless although humans were mostly responsible for the devastating effect of fire, the children had very little control over fires in their lives.

As we wished to have a deeper understanding of what interested children most about fire, we asked the teachers to allow the children to write about fire. They could write stories about fire or write about experiences with fire. When the classes were visited to collect the written stories, we asked the children also to talk about fire. Most children spoke about what they had written, but some had different stories to tell.

Many interesting accounts emerged:

- *I went to visit my cousin who lives in New Race in the shacks and I was going to sleep over, my cousin lived with two other guys and one of them was drunk, and he warmed food on the stove then he slept and forgot about the food……….*
- *I was fast asleep when my parents woke me up and told me that the house on the other side of the road was burning……………..*
- *On Saturday morning at home everyone left, and when they left there was a burning candle and that candle fell on top of the table and everything in the house was burnt – even the house we live in……….*
- *It was a late Saturday night, my sister's boyfriend and her ex-boyfriend were fighting over her. Then her ex-boyfriend threaten to burn our house if my sister does not get back together with him. My sister rushed to report the matter to the police, but when she came back her ex-boyfriend had already burnt down the house, I cried and cried seeing that our house was being destroyed by fire……*
- *My next door neighbour has six small children. One hot summer day she was busy cooking with a gas stove, she left the house for a few minutes to go fetch some water in the river nearby because there wasn't enough water in the house. The children then noticed that there was a bottle of water which was on the table, they then took the bottle of water and pour the water into the stove and the stove blew up. The children quickly ran off the house, but there was a small baby who was lying on the floor……….*
- *One afternoon my mother, my sister and brothers were just relaxing and chatting to each other. My mother had a pot of samp on the stove, she left it there because it takes time for samp to cook. Then all of a sudden my father who is an alcoholic came and he was very drunk that day and demanded my mother give him food, my mother told him that the food was not ready and he got very angry and kicked the stove, The stove fell and caused a huge fire, we cried and rushed out of the house……………*
- *In 1999 Mr X was sitting in his house drinking beer when he suddenly fell asleep. He was suffering from a headache and forgot that he was cooking. While he was asleep his pot fell and the whole house burnt down……..*
- *My father was drunk. He went out to buy the insides of a cow and came back and put them on the stove and fell asleep. When he was asleep the fire broke out, when one of my younger sister saw the fire she quickly went to tell my other big sister………..*
- *My mother told me a story about 'uvutha'. She said that if you want 'uvutha' you must go to 'ugqigha' (herbalist) and tell him that you want 'uvutha' to be sent to someone. You will have to pay the herbalist some money to cast 'uvutha' onto another person. What happens is that the person or his clothes ignite spontaneously……..*
- *My story is about 'uvutha'. My mother was sleeping when she suddenly saw her clothes getting burnt, but she did not get burnt. Then she went to 'ugqigha' (a herbalist) and he told her that someone wanted her to die…………*
- *I live with my uncle in Khayelitsha. One evening when he was coming from work and he was drunk that day, it was dark inside the house and then he lit the candle and fell*

asleep………the room was on fire. I tried to wake him but he could not wake up then the fire got him on his head……….

Although the stories varied and involved different people in different contexts, two themes emerged :

- Fires are mostly caused by irresponsible adults and learners are powerless to influence adult behaviour.
- Fire is used as a tool for revenge.

These responses have implications for science curricula design. Children are preoccupied with the fact that the effects of fire on their lives are mostly due to the social conditions they live in. Can these issues be ignored in the science class and science taught without the consideration of the social context in which the children have to learn science? The responses from the children indicate what they regard as relevant in their lives.
We used their input to develop a module on fire. Teachers critiqued early drafts and suggested improvements. The presentation of the module itself was highly participative, with children given considerable freedom to ask questions about phenomena presented, talk about their experiences and write stories about them. Our intention was to allow children to shape the module during the teaching as well as in the overall design, and to make use of their knowledge and interests as part of the teaching and learning.

The design of the module was based on conceptions of curriculum as story. Stories can address complex issues, fold in multiple themes, connect to different realities and be interpreted at different levels (McEwan and Egan, 1995, Malcolm, 1997) Through the use of plot, they provide for coherence and development. The fire module not only used the story for its underlying structure, but centred on a story of three children from the Cape Flats and their experiences with fire. Different teaching strategies were employed throughout the module to allow for the development of a range of outcomes and to accommodate different learning styles. The strategies included investigations, experiments, drawing pictures and bar graphs, writing, oral accounts, and completing diagrams. Social and personal issues that children regarded as important were incorporated into the module. Our approach to curriculum design is discussed more fully in the next chapter.

As part of the development of the module, and as part of teaching it, data were collected by:

- Interviews with the teachers. These interviews took place over a period of time; sometimes with individual teachers, and sometimes with a group. The purpose of the interviews, in the first instance, was to obtain deeper insight into the everyday lives of the children, and include teachers' input into the design and content. In the second instance, it was to build more deeply our knowledge of the children and their learning, as the children responded to the module.

- Learner input: The process described earlier provided input to the content for the module.

- Video-taping: One class was selected in which the researcher taught the module, with PSP staff and the teacher working mostly as observers and evaluators. The lessons were video-taped. This helped us to observe levels of participation and the ways the children were thinking about and using ideas. Segments of the module were presented in two other classes, with the classroom teachers taking the lead and PSP staff as observers.

- Learner–interviews: Groups of children were interviewed subsequent to the teaching of the module, to determine the extent to which they related their lives and interests to the module – both in terms of conceptual development in science and their perception of the usefulness of the information in their everyday lives.

- Teacher-interview: The teacher who was present when the module was taught, participating and interacting with the learners, was interviewed subsequent to the teaching of the module. The purpose of this interview was to hear how she evaluated the module and the learners' response to it.

Observations during teaching of the module

The module was taught over four days, a total of 12 hours. The long sessions provided valuable flexibility in managing the activities and developing knowledge and skills. They also required variety in the pace and style of the activities, with cycles of divergent and convergent activity. Seven work sheets were used to help give structure to the module. As indicated earlier, a variety of strategies was used to accommodate various learning styles, and this also provided a means of sustaining interest over a number of hours.

The structure of the module was as follows:

Day 1. The concept of flammability

Children told stories of fires in homes, and listened to stories about fires, both in their homes and in the veld. Fire as a tool for revenge and as a form of 'magic' was mentioned, but most children seemed reluctant to recount experiences in this regard. They enthusiastically engaged in drawing pictures of the stories they had heard, and an activity where they predicted materials that would burn more easily than others. Going outside to burn materials and test their predictions caused great excitement.

These activities were part also of an assessment principle: that strategies other than written test could be used to assess children's learning. For example, the drawing activity showed that children understood the story and could respond in meaningful ways. Their drawings indicated what they regarded as important with regard to fire, and what they understood from the lessons.

In the prediction activity, children showed that they were able to make accurate predictions, using their personal experiences. Predicting and hypothesising are important skills and this activity showed that the children were able to master these skills. The fact that they could then test their personal hypotheses served to develop the skill at a deeper level. As a follow-up activity the children were required to apply the knowledge acquired in the previous activity, but identifying 'problems' from photographs of different types of houses. Again most children were competent in this skill.

Day 2. The concept of energy transformation and how we used it

The activities in this segment drew on children's knowledge and experiences, such as different fuels used in their homes, and sought to place them in a formal conceptual structure of 'energy and change'. Although most children could make connections between their everyday experiences and the science concepts, a number had difficulty. Largely this seemed to be because they were totally absorbed in the problems of fire they were forced to deal with at home, and such problems took precedence over theories of energy. By this time, the children had been exposed to a number of different teaching strategies and were responding well to the 'new rules' of the classroom, and the variety of ways in which they were being asked to work.

Day 3. Different ways of putting out fires and explanations for each method

Children engaged actively in discussions about extinguishing fires, as they had direct experience of this. They knew that water, blankets and sand can put out fires, but had difficulty in understanding why this happened. As before, the practical aspects were of paramount importance and 'scientific' explanations less so. As well, we were quickly aware of the number of variables involved and the complexity of explanation: lowering the temperature, removing fuel, stopping the supply of oxygen, stopping supply of energy (perhaps through and electrical fault). The most difficult idea proved to be that fire needs air to burn. The children carried out the traditional candle and jar experiment to demonstrate the concept, but the demonstration is not entirely convincing. Smothering the candle with a 'blanket' was for many students more convincing, but still depended on the teacher's authority as explanation. In spite of typical insistence that experiment is the test of science, the authority of the teachers' knowledge remains a major factor in science learning!

The children participated enthusiastically when required to draw a bar graph based on data related to fire. They enjoyed drawing, rather than writing, and demonstrated their abilities to manipulate information. Similarly, in another drawing activity in which they indicated the path of air into the lungs, the children drew and discussed arrows with enthusiasm. Most children completed the task successfully and accurately.

Day 4. The different causes of death from fires
Children were very interested in this aspect, as we expected from their earlier questions. Everyone understood that a person could literally burn to death in a fire, but not why people die without any outward signs of burning. We used a jigsaw strategy, a co-operative technique by which children bring together knowledge from different domains, to teach these concepts. The children, in focus groups, studied particular ways that people die in fires, then taught each other across groups. The activity was not very successful. One possible reason is that the children were too unfamiliar with learning from each other in a formal way. It is more likely however, that the fact that in their focus groups they had to read a paragraph in English and then explain it to their peers was too difficult. Indeed, throughout the module they were uncomfortable with reading and writing. Skills such as these take time and practice.

An activity in which children wrote what they found positive, negative and interesting about fire, generally produced a good response, though some children responded poorly. The problem of writing surfaced again.

However, the last activity also required children to write and this produced a positive response. This time, part of a story was read to them and they were asked to finish the story. They were encouraged to be creative. The children finished the story in many different ways, but their endings incorporated their understanding as developed throughout the module. A point of particular significance perhaps was that a large number of their stories had unhappy endings. At every point, it seemed, the reality of their lives with fire intruded into their learning about fire.

Analyses of the video-material, children's work sheets and interviews supported findings from previous research that children are deeply engaged when they use their knowledge and everyday experiences in the classroom, in a topic they see as relevant. They engage actively with each other and the teacher as well as the ideas and activities. We found that they were less interested in natural fires and their causes (except for 'exotic' fires, such as volcanoes) – their interest lay in fires in their homes caused by irresponsible adults. The video showed too that children took advantage of the variety of learning strategies included in the module. Most children preferred to draw rather than write and they generally participated well in groups. Their engagement with activities seemed to be a complex mix of task, content and organisation. They enjoyed learning about things they could use in their everyday lives, such as selecting materials to build a house.

While the children said that they often use school knowledge at home, it seems seldom that they talk about that knowledge with others. Perhaps the converse is just as important: the children found it very exiting to use their everyday knowledge in school. There may be not much interest at home in what they learn at school, but school can easily incorporate their knowledge from home, if it chooses. Extracts from interviews with groups of children illustrate the point:

R: *When you drew your house today did you use knowledge from home?*
L3: *Yes.*
R: *Do you learn things in class you use at home?*
L2: *We learn about house building.*
L1: *We learn what is flammable.*
R: *Are people at home interested in what you learn in science?*
L1: *No ,not really.*

R: *What did you enjoy learning about today?*
L1: *We learnt how to help people that are in fires.*
R: *What else did you enjoy?*
L1: *What to do when a house burns.*
L2: *What burns easily?*
L3: *We learn about chemical energy. We learn that fire has energy*
R: *Why is it important to know what burns easily?*
L1: *We built (drew) a house. We know what materials to use.*

L3: *Learning today was fun.*
R : *Why?*
L3: *We like to draw*
L4: *We like to burn things outside.*

The outdoor activity was very popular. The outdoor environment – whether in a the school-yard as in this case, or via a walk up the street looking at houses – could be used more often as part of teaching.

When children start activities based on their existing knowledge and interests it seems to create more enthusiasm than when they start with a topic they are completely unfamiliar. At the same time, the children also made clear that they wanted to learn about things beyond their experience, such a volcanoes, planets and tornadoes. Though our modules did not stretch into these topics (because of our decision to set it into the context of local fires), their expressed interests confirm the point made previously that the curriculum should not limit itself to immediate lived experience. Different modules can take different approaches.

A curriculum issue that is widely debated is the tension between ‘everyday knowledge’ (which is usually highly specific to context) and structured scientific knowledge. This has been resolved differently in the different versions of Curriculum 2005, with the 1997 version emphasizing ‘horizontal integration’ (across learning areas, and from school to home) and the Revised National Statement shifting more towards ‘vertical integration’ (in which structured, discipline-based science knowledge is built up over time). There is no question that children have to be helped to move back and forth between everyday knowledge and structured scientific knowledge, and this requires activities designed for the purpose. As we progressed with the work sheets in the module it became clear to us that children were able to link formal and informal concepts more easily if they were familiar with the concepts in everyday use (as they were, for example, with the concept of flammability). As soon as we moved away from the everyday knowledge (for example in identifying the requirements for combustion), difficulties and differences became more obvious. While some children made the transition from the everyday knowledge to formalised knowledge easily, many struggled. This points to the need for frequent and well-structured approaches to making the connections.

Many of the children referred often to adults who are drunk or absent when fires break out, and children who are not supervised and cause fires. The children's socio-economic circumstances permeate everything they are. Can science teachers ignore their pleas? Does it help if the teacher and other children engage such problems in the classroom and, if so, on whose initiative? What useful advice can the class or teacher give? To what extent should school be a 'safe haven', a tree-house, where children enjoy being removed from their day to day problems, and to what extent a place where their 'real needs' are addressed? Science education has always been confused about this issue. On the one hand, it imposes the idea that technical skills will eventually help the child get a jog and participate in adult life (especially the kind of life available to university graduates), but on the other hand it has made taboo personal troubles, social issues and children's immediate purposes and needs. In our module, we struggled with the issue. We offered the children immediate technical solutions – how to prevent fires, how to extinguish fires, the importance of calling in adults who could help. But we were unable to go beyond allowing children to share their problems of power relationships with adults and irresponsible behaviours over which they could have little influence. Perhaps the important finding is that the children so earnestly wanted to raise their social conditions. Our one module could only be a beginning to helping them: such help must extend over years, not hours.

The same arguments can be made in relation to the children's interested in fire as a result of spells and magic (*uvutha*). Although few learners claimed to have seen it, all were aware of the phenomenon, and generally seemed to accept the truth of it. This acceptance did not appear to interfere with their ability to explain phenomena in a 'standard scientific' way. Indeed, they already seemed to have a prejudice that *uvutha* was not 'science', and, accordingly, were often reluctant to discuss it in class. However, during interviews they showed they are intensely interested, talking freely about the phenomenon that a *sangoma* or other person who has the power can start a fire from nothing. For example, during the interviews, the following emerged:

R: *How does a fire start?*
L1: *The sangoma can start a fire.*
R: *Where does this fire come from?*
L1: *From nowhere – it is uvutha.*
L2*: It is a gift from God*
R: *Is uvutha a gift from God?*
L2: *Yes , it is.*
R: *So does God give the gift to the Sangoma?*
L2: *Yes.*
R: *But what if it kills people?*
L3: *No. witches do uvutha*
R: *Have you seen uvutha?*
L1: *We have heard stories.*

This raises questions about whether and how to introduce cultural aspects into science lessons. The children expressed a need for it, in that they wanted to talk about it in interviews, but – perhaps because it does not often happen, or because they suspect it is 'not science' – they were reluctant to raise it in class. Again, there were limits to what we could achieve in a single module: to build in their ideas about *uvutha* required levels of trust and some clarity of outcomes and consequences that we were unable to achieve in just the few hours we had. As with children's personal circumstances and private troubles, techniques for using and building on their lives and needs have to be developed over time. This is grasped in the Revised National Curriculum Statement, which exhorts teachers and curriculum designers to incorporate indigenous knowledge into the science curriculum and explore different ways of knowing, but concedes that we don't yet know how to do that. PSP and the teachers we worked with are in an excellent position to provide national leadership in this area.

The inclusion of children's everyday experiences and knowledge, such as the social problems that they experience and *uvutha*, undoubtedly had a positive influence for all children. For many, perhaps the fact of inclusion was more important than any enhancement of their understanding. Although the class may not solve their problems, it became a place where the conditions of their lives might be understood. They felt encouraged that their knowledge is useful in class, and that the science they learned in school was useful at home, at least to some extent. Having children present and discuss their knowledge and concerns is not merely a jumping off point for formal science, and nor is it merely 'trading ignorance'. It makes 'invisible knowledge' visible, holding it up for affirmation and critique, making it discussable, encouraging systematic reflection and analysis. This in itself is a vital outcome, highly consistent with the critical outcomes of the Revised National Curriculum Statements. At the same time, science curriculum has to proceed with that critique, helping the children towards deeper understanding through the formal knowledge that science provides. All of these goals require attention over years, not just one module.

In summary, when children's experiences and interests were used as a basis for science lessons, the children engaged deeply both in framing the module and its implementation, although some had problems with conceptual understanding, focussing more on their personal experiences and practical implications. The children responded well to the variety of outcomes, content, pace and activities in the module, made possible through the conception of curriculum as story. They offered testimony and examples of ways they had used their learning in the module in their lives beyond school, and the value of bringing their knowledge into the classroom.

This study has attempted to build children's experiences into a science module and as such was designed for children in this particular environment. Relevance can be readily defined at the local level, through the involvement of the children and teachers. Given the complex of activities, themes and contexts used in the module it is not clear which aspects were more important, which ones less so. It is likely that different things were important for different children – in other words, outcomes are somewhat individualised, according to individual differences and interests. Further research is required to determine the extent to which children continue to reflect on and use ideas from the module – at home and at school. When life is brought into the classroom, complexity comes too.

One of the classroom teachers captured nicely this mix of culture, language, life and science learning:

> *The most important aspect of learning that I have strongly witnessed is 'Language development'. Children cannot learn successfully if they do not understand language (ie the second language). This leads to the fact that if they know nothing about the concept in their own primary learning environment, it is difficult for them to*

comprehend and put meaning to it in a second language. Natural Sciences as a subject becomes in a way 'alien' to them if they cannot put meaning and sense into it.

Cultural interpretations of certain aspects of Science are a need for concern, for some of them cannot be proved. Children understand concepts better in things that they have witnessed and / or 'hands on things'. We need to make sure that whatever concept we teach them, we make much use of their senses and imagination.

The research findings highlight the tension between a curriculum that is universal and one that addresses local needs. The Fire module sought to bring these two aspects together, supporting each other: universal concepts of flammability, energy and combustion were linked with local concepts arising from living with fire in the Cape Flats. The local aspects went beyond choice of contexts through which to develop universal concepts: they introduced local knowledge (of fires in this community and their causes and effects) and, in that sense, localised the content and outcomes. Further, they are highly consonant with the critical outcomes and science learning outcomes of the National Curriculum Statement: 'local' and 'universal' are not in conflict, and 'learner-centred education' is about choices of content and outcomes as well as pedagogy. In responding to children's needs and interests, the curriculum need not be at odds with a global science curriculum, but can be more useful for children, both in the use they make of it and in concept development.

The findings have implications for the PSP with regard to materials, as well as for conventional views of what primary science education entails. While much has been written about children using concepts learnt in the school environment in their daily lives, it is clear that using everyday knowledge in the science classroom is just as important: it results in greater engagement and responds to children's needs. Children experience content as relevant but at the same time refine their science knowledge; the children influence not only teaching methods, but what to teach, what is 'worth learning'. This localising of curriculum requires learning materials that provide general guidelines on content as well as pedagogy, rather than specific learning programmes on universal topics.

The research also produced evidence that social and cultural issues require more attention in the science classroom. The children appreciated the opportunities to articulate social knowledge as well as cultural knowledge. The discussions of *uvutha* indicate of the central roles that their culture plays in their lives. Exploring African culture as a way of knowing has a number of possibilities, including deeper understanding of the nature of science and stronger conceptual knowledge. Further aspects of culture are the social conditions of children's lives, such as poverty, the construction of shacks and the irresponsibility of adults with whom the children live. In fact, as noted earlier, we made only a little progress in addressing pleas such as: "What do you do when fire breaks out and every adult in the house is drunk?" Over time, as trust builds, questions such as this can be addressed. Teachers have to have the relevant competences, and see such questions as 'part of science'. PSP can provide leadership in these developments.

Chapter 5
Designing curriculum

As a follow-up to our 2002 report (Malcolm, Kowlas and Stears, 2003), we promised to work in 2003 with the PSP staff and with teachers, to extend and build skills in curriculum design. In Chapter 4, we reported our work with three teachers and their classes in the design of a module on "Fire in our lives". This chapter reports on a workshop conducted with the PSP staff. Beginning from the critique of PSP modules and the evaluation framework in the 2002 work, we explored relevant theoretical ideas and how they can be expressed in the design of curriculum modules. This chapter provides a summary of that workshop.

The workshop itself was an instance of curriculum design, containing implicitly and explicitly particular perspectives of curriculum, design and learning. The perspective presented was largely that of the workshop leader, derived from experience as a researcher, writer, curriculum designer and policy developer, but mixed with the views and experience of the PSP staff. A central idea in the workshop was that curriculum design is ultimately creative writing, and many perspectives and approaches are available.

The workshop had the following segments:

- Review of our evaluation of the PSP modules, as summarised in the report from 2002 (Malcolm, Kowlas and Stears, 2003). This was to elaborate the criteria we used in the evaluation, talk about the results, and encourage PSP use of such approaches.

- "Do you know the students in your class?" This activity was a reminder of the variety of individual differences in any class, and ways the differences might be addressed. It focussed especially on learning preferences represented by '4 selves' discussed below.

- "Some teaching and learning methods". This was to expand the 'toolbox' of available teaching methods, elaborating their purposes and ways they can be used to enhance learning. Examples were presented especially from the Australian *PEEL Project*[1], which has developed literally hundreds of teaching/learning strategies that are relevant to the critical outcomes and science outcomes of the National Curriculum Statement.

- "Why do we teach the way we teach? Ask Phoka and Elsie." We analysed two approaches to teaching Energy in Grade 4, both ostensibly addressing the same content and science outcomes, yet done in vastly different ways, with different underlying theories of children, education and science, and, in fact, different outcomes.

- Approaching the design process. The metaphor of curriculum as story, and the curriculum designer as story writer/teller was used as a basis, with reference to Phoka

[1] See, for example, Baird, J. and Mitchell, I. 1986, *Improving the quality of teaching and learning,* Monash University Press, Melbourne, Australia, and Baird, J. and Northfield, J., 1992, *Learning from the Peel Experience,* Monash University Press, Melbourne, Australia.

and Elsie and modules published in South Africa and Australia that use the story approach.

- Designing assessment. The emphasis was on continuous formative assessment (including the design of special tasks as well as assessing learning as part of learning) and the importance of using children's ideas (understandings, misunderstandings, experiences and imagination) as part of teaching.

Some of the activities and key ideas from the workshop are summarised below.

Reviewing the PSP modules

The review used specific examples from the PSP materials, and criteria of curriculum evaluation outlined in the 2002 Report. Discussion centred on outcomes (from the National Curriculum Statement), module structures and activities to advance the outcomes, perspectives on science and learning, theories of assessment, and approaches to learner-centred curriculum. We gave particular attention to philosophies of science, science-society-culture interactions, the value of a clear rationale and focus for a module, the critical outcomes, and responding to children's knowledge and needs. We also explored the conception of Technology Education in the Revised National Curriculum Statement, and the potential for integrating its 'design-make-appraise' and context-based philosophies with Science (a matter of policy for Grades 1-6).

Do you know the students in your class?

The activity listed a number of personal characteristics that students might have, and invited us to identify, by name, children who demonstrate each characteristic. The list derived from personality traits (such as introversion, conscientiousness, and closure), learning styles, abilities and interests. For each child listed, we proposed how that child would like to learn and thence how different needs could be accommodated in a large class. Two conclusions follow: there must be a variety of teaching methods, and much of the management of learning should be devolved to the children. It follows too that discussion of different learning strategies and interests should be a part of classroom activity, encouraging children to respect variations and to experiment with their own learning. In these ways, a balance can be found between individual and group concerns, individual and group identities.

We gave particular attention to the "Four selves" or "Four brains" theory developed by Herrmann[2] (1995). The theory is well supported by empirical studies and brain physiology. It postulates 'four selves' that are part of each of us, associated with four quadrants of the brain. In the front left quadrant is the logical rational self, who enjoys prepositional knowledge and the use of logic and argument. This self is well represented by the scientists and engineers. The back-left quadrant is the ordered, structured self, who likes to follow rules and procedures (the accountant). The rear-right quadrant is the empathetic, feeling self, who likes to connect with other people and their stories and depends often on intuitive knowledge (the nurse or social worker). The front-right quadrant is the creative, imaginative self, who likes to juxtapose ideas from different places, question norms, and invent new metaphors and theories. This self is represented by the cartoonist, the writer, the inventor. The Herrmann model is especially helpful in thinking about science curriculum because science curricula, traditionally, have concerned themselves almost exclusively with the left-brain functions of

[2] Herrmann, N (1995), *The creative brain,* Kingsport:Quebecor

rationality and ordered thinking, downplaying the creative self, and ignoring almost completely the feeling, intuitive self. The Herrmann model exhorts curriculum design, firstly, to cater to all four quadrants (which are all active in all of us, but with individual 'preferences' and 'profiles' widely distributed), and, secondly, to encourage respect for and development of all four 'selves'.

A variety of teaching and learning methods

We considered methods such as:

- Brainstorming, fantasy and games
- 1-3-6 Consensus
- Jig Saw
- Role play, to enact processes/systems/explanations; represent stakeholders, values and ways of thinking; take responsibilities within the group.
- Predict-explore-explain
- Working with text: reading the headings and guessing the text; inserting headings, writing on the reading
- Translation activities: graph to story, story to flow chart, cartoon, concept map, play, interview, table, set of instructions, other language, oral presentation….
- Test questions: Making them up, answering them, analysing class responses to them, preparing marks memos, assigning 'value' to the knowledge…
- Concept maps – drawn, enacted, modelled….
- Reviewing and reflecting: Diaries, concept maps, flow charts, creative pictures, writing letters, talking to a friend, contributing to a class 'comments book'…
- Learning through work: learning happens as part of a project, or the generation of a 'product'– a drawing, newspaper article, letter, scientific report, research report, story, play, model…..

We noted the mix of 'cognition' and 'metacognition', feeling, thinking, imagining and doing that are involved in most of these activities, and considered at some length notions of 'divergence' and 'convergence' in curriculum structures. For example, 'brainstorming' is by nature divergent, as children propose ideas and offer experiences that may of may not be cogent. It needs to be followed by a convergent activity, that looks for ways of structuring and evaluating the information – whether to propose or explore a scientific theory, or to propose a procedure or plan. In the same way, when children complete data gathering (from activities in class, or from projects beyond class), a convergent activity is required where the data are structured and built on, to form a point of 'closure', no matter how tentative. Ideas of convergence and divergence are especially helpful in assisting children to move back and forth between everyday experience and formal science.

We browsed through examples of Australian curriculum modules, to see how a wide range of activities can be used, how waves of divergence and convergence might manifest, and how children's existing knowledge and formal science knowledge can be brought together through the design and sequencing of activities.

Why do we teach the way we teach? Ask Phoka and Elsie

We considered two stories of teaching: Phoka's and Elsie's modules on "Energy" with their Grade 3-4 classes (Malcolm, 2003)[3]. While the science content and outcomes were ostensibly similar in both modules, the two teachers taught in vastly different ways. Elsie represented traditional approaches, Phoka progressive ones. The stories are reproduced below.

Phoka *introduced ideas of energy through a game. "What happens if the cow runs out of grass?" The students responded easily: "It dies". "Yes, it stops", said Phoka. "What if the car runs out of petrol?" It stops too, the students replied. This started the game. The students had to think of other situations where something runs out, and causes the animal, object of machine to stop. Phoka asked them to draw pictures, and write below: "If ___ runs out of ___ it stops". Their pictures showed animals and people running out of food, machines running out of fuel, appliances running out of electricity, plants running out of sunlight and water, soccer players running out of energy. (Indeed some of the students used the word energy.) As they worked, Phoka moved among them, talking with them, helping with words, checking that they had pencils.*

Some students explained their pictures to the class. The class talked about different ideas, and Phoka introduced some words: fuel, food, electricity, sunlight. He explained that these were different sources of energy, and that scientists would summarise the results by saying that "If __ runs out of <u>energy</u>, it stops". Energy can make things grow, make things move, and produce heat or light.
He asked the students to go to three corners of the room with their drawings, depending on whether, in their pictures, the energy was for growing, moving, or making heat/light. In their groups, the students checked each other's pictures. Phoka asked them, within their groups, to say what was 'running out'. Was it fuel, food, electricity, sunlight? The students saw that different sources of energy could sometimes have the same effect. They regrouped according to sources, rather than effects. Finally Phoka asked the students to write answers to two questions: What were some of the sources of energy? What were some of the things energy did? Phoka moved around, looking at what students were writing, helping students who didn't understand.

The next day Phoka took the students on a walk through the nearby shops. They had to identify instances of "If __ runs out of energy, it stops." They saw buses, bicycles, walkers, grass, shops, cash registers, lights, radios. They talked about possible sources of energy in each case, and were amazed at the idea that almost everything that happens around us depends on energy. They also realised that buying energy was one of the important things people did with money. During the walk, Phoka talked to students about what they were finding, and helped them understand about energy and energy sources.

Back in class, Phoka showed some pictures from magazines and newspapers. In some places, cows are running out of grass, cars out of petrol, people out of food, trees out of sunlight. He asked the students to choose a picture they felt strongly about, and write a sentence about that picture. The students talked about the importance of sharing and saving energy.

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[3] These stories were developed by Malcolm and Glover (1999) as part of the *Imbewu* project. Phoka's module is based on two units developed by Fleer et al (1995) as part of the Australian Science Curriculum and Teaching Programme. Both Phoka's and Elsie's stories are 'real' in the sense of composites derived from observation of teachers and classrooms, and the implementation of a variety of curriculum approaches developed since the 1960s.

To end the unit, Phoka raised with the students that they could take steps to share energy and save energy in their own houses. He set them into groups of four, and asked each group to design a poster that could be put up in the school, to help everyone think about saving energy. They made a variety of posters – put on a jersey instead of lighting a fire; eat fresh fruit rather than cooking; don't waste; walk to the shop instead of going in the bus. Some of the posters were put up in the school foyer, some in the corridor, and some in the classroom. Phoka looked through the posters carefully, to see which students seemed to understand about energy and energy sources, and made notes on a checklist.

***Elsie** wrote the word "Energy" on the board. She explained that Energy was what you needed to 'make things happen'. She led whole-class discussion on what the learners might want to 'make happen'. Elsie selected some of the best ideas, then wrote a definition of Energy on the board: Energy makes things go, grow or glow. She explained the meanings of these words, inviting the learners to offer examples.*

With equipment she had prepared, she demonstrated that electricity could be used to make things go, grow or glow, and so could fuels. She explained different kinds of fuels, including the idea that food was a fuel – people 'burn' food in their bodies in something of the way that a candle burns wax. She demonstrated by burning some sugar on a spoon held over a candle. The learners laughed at the idea than their bodies burned sugar, even meat or icecream! They had seen burnt meat, but not burnt icecream! Was the meat burnt in their stomachs? Elsie laughed with them.

Elsie wrote on the board a summary of the demonstrations, explaining sources of energy and how energy could be used to make things go, grow or glow. The learners copied the summary into their books. She had written a little song she called 'Go, grow, glow', and taught it to the learners, getting them to clap out rhythms to accompany the song. She gave the learners a worksheet, on which they had to classify different words, to say whether that word represented a source of energy, or an effect (go, grow, glow). She marked the worksheets and entered the marks in her workbook.

Next she wrote on the board the word "Conservation". Who knew what it meant? Some of the learners did, and offered examples such as conserving water, conserving rhinos, conserving trees, conserving energy. Elsie used their good ideas to explain about conserving energy. She wrote a definition on the board, and made a list of ways that people could conserve energy, focusing especially on the costs of electricity, paraffin and petrol. The learners copied into their books. She showed them a table, giving the relative costs of different ways of moving people – walking, cycling, taking a car, bus or plane. She told them stories about people who had wasted energy, and how their energy bills were much higher than other people who saved energy.

Finally, each learner wrote a letter that they could take home to their families, explaining what energy was, why it was important to conserve energy and ways that could be done. Elsie collected up the letters and marked them. She was pleased with what the learners wrote.

Clearly, Phoka represented Curriculum 2005 and Elsie traditional approaches, and, in their different ways, both teachers were highly competent, well organised and had sound knowledge of 'energy'. As stories, Elsie's module was essentially linear story, while Phoka's was complex one, weaving outcomes and themes and leaving somewhat open the definition of 'energy'.

We compared the two approaches in terms of beliefs about the nature of 'resources' (because time and the children's experiences and imaginations are resources), the ways in which the teachers acknowledged and used individual differences in the class, the underlying beliefs about children's capacity to know and learn, power and power sharing, theories of learning, and approaches to assessment. As one of the staff suggested, Phoka assessed the children's work; Elsie assessed her own work.

Perhaps the most striking difference though was in relation to the Critical Outcomes of Curriculum 2005 – problem solving, critically evaluating information, working in teams, children managing their own learning, communicating in a variety of ways, and so on. Phoka addressed these, Elsie didn't. Phoka also promoted as outcomes beliefs that anyone can do science, that science is all around us, and that children's inputs to the curriculum are important.

We applied Herrmann's 'four selves' theory to the two modules. Phoka's module begins with the feeling-self (children told stories of how things stop when they run out of energy), then moves to the creative-self (finding patterns in the children's pictures), the logical self (articulating and testing those patterns) and the ordered self (applying the ideas developed). Elsie, on the other hand, stayed close to the logical rational self and the ordered self.

The process of curriculum design

A compelling message from the Phoka and Elsie stories is that curriculum design is a creative writing task, not a rational-scientific one: both teachers were strongly guided by science outcomes of concept development, process skills and science-society relationships; both sought learner-centred pedagogy through the use of activities. Why then are the two modules so different? One reason is that the two teachers had different belief systems, another is that they had different creativity. When Phoka invented the opening image for his module – "When the cow runs out of grass she stops" – the die was cast; when Elsie invented the opening image for her module – the word 'Energy' and a definition of it on the chalkboard – a different die was cast. Mrs Mbhele[4], one of the PSP teachers we observed in 2002 and whose module on Energy we described in some detail (Malcolm, Kowlas and Stears, 2003), offers a third approach. She began by having the children jump, move about, clap their hands, and asked them to describe 'what was happening'. Again, the die was cast: she would move to forms of energy, energy and change, sources of energy, uses of energy…

The metaphor of story-telling can be a liberating and powerful one for teachers: suddenly there is no 'one right way', no 'best place to start', but simply a wish to write a good story. Having said that however, one way of another, all writers have to make certain decisions. For example: What is this story about? What points does it wish to make, what ideas or experiences does it wish to explore? What contexts will be useful: an historical setting, a social setting, a personal experience, an imagined world, a philosophical perspective? How will these contexts be merged? What events, characters and activities will be involved? What will be the essential 'plot' that gives the story integrity and enables ideas and characters to develop? How will interest be sustained (ie, how will ideas of conflict, tension, journey, breakthough, achievement, resonance be used)? Phoka, Elsie, and Mrs Mbhele made different choices in creating their stories.

[4] not her real name

Furthermore, modular approaches such as PSP advocates permit different modules to be different 'stories'. One can be class project, centred on solving a problem or presenting an exhibition; another can be based around two or three fictional characters, who introduce their 'stories' and keep returning to help hold the direction of the module (as in our "Fire in our lives" module); a third might involve imaginary travel in time and space, a fourth might be essentially deductive, a fifth inductive. Further, the various modules can present different facets of science – this one emphasising technological development, that one the nature of investigating, another the problematic aspects of definition (such as definitions of 'living' or 'fire'). When the modules fit together as a collection, they provide a rich account of science, and rich experiences in learning science. They also cater to a range of individual interests, learning styles and talents.

Assessment

As the experience of this Evaluation shows (see Chapters 2 and 3), questions of assessment are profound and far from resolved. Even in the contexts of primary-schools and policies that advocate continuous formative assessment, complex competences and the localisation of curriculum, we have been under pressure to assess students' achievements through pen-and-paper tests, common across all participating schools, and capable of providing 'benchmarks' and 'league tables' of children's achievements, teachers' achievements, schools' achievements, PSP's achievements. Implicit in the idea of ranking and comparing are beliefs in a single construct (or perhaps a small number of constructs) called 'science achievement', which can be measured by pen-and-paper tests. At the other end of the spectrum are teachers' judgements of achievement (inferences, not measurements) against broad standards of competence and progression. But such continuous formative assessment – and its application to summative assessment – makes heavy demands on teachers' time and record keeping, perhaps to the extent that its relationship to learning is inverted: instead of assessment supporting learning, learning comes to support assessment. A classroom in which all energy is committed to assessment and recording is as limited as one in which assessment does not feature at all. Compromises are necessary. And just as clearly, teachers must be well equipped to conduct and use assessment as part of teaching and curriculum design. The problems are far from solved, and much of the workshop was given to exploring and agonising over ways forward.

We examined again some of the assessment tasks in the PSP materials, observing that many of them centred on low-level knowledge and skills rather than higher level ones. We noted too that the rubrics in the PSP materials (provided by the Western Cape Education Department) were not helpful: mostly the codes were general and normative/comparative ('basic level', 'needs more practice', 'can move on to the next level'). They provide no guidance on the knowledge and skills that define the standards for the various levels, or how higher levels constitute deeper understanding than lower levels. The Revised National Curriculum Statement provides sets of descriptive standards, based on Grades. However, as we have shown in Chapter 3, these Standards have conceptual weaknesses and are hard to use. Further, the revised WCED rubric asks merely whether children are below, at or above the relevant Grade Standard, wasting the opportunity to assess the range of achievements in a Grade, and 'holding back' children who are well ahead of the Standard (and that was the majority of children we studied in 2003).

PSP Responses to the workshop

As a result of the 2002 evaluation of materials and the 2003 workshop, PSP have revised their teacher workshops, so as to involve teachers more closely in curriculum design and the skills of curriculum design, and has re-developed some of the modules. The letter below summarises the response:

Just thought I would send you the first example of the rewrites of the booklets. We have tried to include many of the suggestions that you made about improving them i.e.:

- *Including divergent and convergent steps in the learning pathway as well as consolidation steps*
- *Including a rationale*
- *Including notes to teachers and example questions for discussion that problematise issues and concepts*
- *Writing contextualised assessment tasks to reach the assessment standards of the RNCS*
- *Including choices for learners when they do tasks and writing so that they can reflect their own culture and background*
- *Modelling questioning techniques that lead to higher order thinking*
- *Including a traditional story that has an interpretation relevant to the subject matter under discussion*
- *Providing fewer writing frames and more opportunities for learners to discuss and do free writing in the sense that learners will choose how to express their understandings in writing and drawing.*
- *Including assessment criteria that require the teacher to look for understanding as well as competencies. We have not gone the route of extended rubrics but we are working with teachers to develop their own in the cluster programme. We may include some examples in the booklets at grade 6 and 7 level where there are longer and more complex tasks.*

We are still well aware that this first booklet does not contain enough cultural stuff. We are working on finding sources of cultural and traditional knowledge and will include any material that we find and use them as readings in the booklets.

Our colleagues at SAILI have kindly agreed to trial each booklet and we will make changes where possible. They work very closely with a few schools and do classroom work with them. They will trial them in about 10-12 schools. We look forward to an outside opinion from teachers and teacher trainers in the field. We should get feedback at the end of March for this booklet. So we will be able to share that with you when you come.

So far we have used the booklet in the cluster programme to show how the assessment task is designed from the assessment standards and to illustrate how the learning pathway is designed to lead to an assessment task which 'measures' whether the child has reached that competency.

So far the feedback from our teachers in the clusters is that they feel the assessment is still too formal for primary school children and we also feel that that is probably true. So

I hope that these booklets and the ideas in them are not too formal now and that they remain as useful to teachers as the originals were.

We hope you find this edition an improvement. We include the original for comparison.

Cheers

Chapter 6
The Cluster Schools Programme

The Cluster schools project is collaborative one, involving the Education Department, TIP, PSP and the schools themselves. It is aimed to support whole school development, especially in curriculum, assessment and staff development. It draws on past experiences of GET Inset (in whole school planning), TIP's experience in management, and the PSP approach to curriculum. The Education Department invited schools to join the clusters, and required them to express clear commitment to the process. Science Teachers and the School Management Team are the key participants. Schools are expected to develop management systems and produce formal plans for curriculum and assessment. At the same time, teachers and school managers work together across schools, as part of the clusters. PSP works with the schools and the clusters, assisting, producing proformas and guidelines.

Like other schools that are involved with PSP, schools in the cluster project are impoverished but teachers and principals are generally highly motivated in accordance with the criteria for selection into the project. During 2002, PSP worked especially with three clusters, all in the greater Cape Flats area. One school from each of these clusters was visited as part of the Evaluation in 2002. The curriculum coordinator (an HOD), and science teachers were interviewed. In 2002, data were gathered about the cluster schools and their communities, how the schools went about curriculum planning, and perceptions of PSP's leadership in this area. Direct support for these schools ended in December 2002, and new clusters were formed for 2003. In 2003, we returned to two of the three schools visited in 2002, both in the greater Cape Flats district. As well, we interviewed representatives from two clusters established in 2003. The aim of the interviews, for the 2002 clusters and the 2003 clusters, was to investigate the operation of the clusters and their achievements.

In 2002 teachers and schools reported excitedly on the functioning of the clusters, the progress they had made in whole school development, and growth in their knowledge of curriculum and assessment. All of the schools had in place management structures and personnel to support whole school planning, curriculum and assessment. Regardless of the management structures, the planning processes were similar, following closely the PSP guidelines and proformas. The general pattern was that the whole staff met during school holidays to develop broad plans, including the choice of phase organisers and programme organisers for the various learning areas. Then, throughout the year, teachers met regularly in their learning areas, usually in the afternoon. These meeting occurred within the schools, and within the clusters. The process in science followed the PSP file, based around PSP materials and processes. Teachers brainstormed across grades, then designed developmental structures in the various themes, work schemes, and detailed activities and assessment. Development of detailed module plans was often distributed across the cluster, with all schools teaching the same modules. The PSP concerns for literacy and assessment were built in. Finding time for meetings at school was reported to be difficult, and staff recognized limits to how much of school-holiday time could be used.

The teachers and HODs felt that cluster meetings provided good ideas and support. They welcomed the teamwork as a way of maintaining links and motivation as well as providing ideas and designing modules. Most of the development, teachers reported, occurred around existing ideas – things teachers had seen before from published materials and workshops. Amongst major changes were changes to assessment, which moved to a combination of tests and assignments. There were no longer separate 'examination periods': tests were conducted as part of class work. The PSP proforma encouraged teachers to relate their assessment to outcomes, and to use a variety of communication modes in assessment tasks.

In general, the teachers interviewed in 2002 felt that the Clusters Project worked well, with many benefits. They provided expansive evidence to support this assessment (see Malcolm, Kowlas and Stears, 2003)

New Clusters, 2003

Our interviews with representatives from new clusters (established in 2003) yielded a similar picture to that obtained in 2002. The two teachers we interviewed (one from each of the new clusters) reported clusters that networked five schools in each case, generally from the same district (although sometimes a school may be from a different geographic location, with different socio-economic profile and mother tongue language). One cluster reported that they were put into a cluster with schools that were not in their immediate vicinity because they joined the programme late.

> *"…what had happened was that they had already put the schools together[for the cluster] and my school kind of missed the boat…".*

The other cluster representative indicated that schools belonging to his cluster were quite homogenous and close to one another.

As one teacher observed, the physical relocation of the PSP from the Uluntu Centre in Guguletu to Philippi, had created new opportunities for participation, resulting in a significant increase in involvement of teachers from non-African schools (many Coloured schools, and Afrikaans speaking). He felt that that having schools from varied socio-economic backgrounds and race groups with children and communities that are in many ways dissimilar had positive effects and promoted learning within the cluster.

> *"… because PSP has moved from the township to here, I see more people of other cultures mixing with us, I don't know whether it was because of the area, but I would like to see them coming and joining us also in the clusters to see the difference between my learners and their learners."*

Although both teachers reported that science teachers scheduled cluster meetings twice a week, the actual frequency of meetings depended on other commitments such as departmental meetings, school crises, school functions, WCED workshops etc. Consequently, during 2003, there were times when the cluster group did not meet for up to a month, greatly limiting planning and production.

> *"We meet on Wednesdays and Fridays every week. But, it depends on commitments. If there is something happening at school, like for the last three weeks at this one school where we go, we normally go because it is a quiet school with few learners, what has been happening is that they had these workshops that promote recycling. Now we have not met for 3 weeks. We're sort of back now. Last week, there was also a function at another school, so we could not meet for the whole week…"*

Even so, teachers in the 2003 cluster project feel that the clusters are working fairly well. They suggested that heavy workloads and competing demands in the clusters might be helped if PSP (or the cluster groups themselves) were to draw up a year plan of their meetings together with other NGO's and the WCED to minimize clashes.

Teachers participating in the clusters programmes work together, planning, writing modules, trading ideas, problems and solutions. They enjoy the opportunities to:

- Debate beliefs, understandings and teaching methodologies;
- Share experiences;
- Forge relationships;
- Spread the curriculum design work;
- Put pressure on each other to improve performance.

The representatives interviewed reported that teachers in the clusters have difficulty digesting policy changes and moving from traditional teaching to participatory learning. They see PSP as their major support in this:

> *"because it is quite a big issue, in fact it was something confusing this OBE when it started, but with PSP we managed to overcome."*

Teachers in the clusters relay information from their workshops and meetings to their school principals, HODs and colleagues. This information is re-contextualised in the schools, not only in science, but across subject areas. Principals also apply management skills derived from PSP meetings. Re-contextualising is not straightforward:

> "*Yes, there is definitely that danger … whereby people tend to generalize whilst in essence children tend to respond to learning situations differently. Care should be taken there should not only be school staff meetings there should also be school meetings, grade meetings, and one needs to be looking at the particular interests and needs of his/ her learners. We need to start somewhere. But this is not always possible – people become so burdened by the issues that come about. People are still starting to feel the balance as to what they should be teaching."*

Knowledge, ideas and materials acquired via PSP play a significant role in lesson and curriculum design – within schools as well as within the clusters. Teachers from across grades meet and identify links between subject areas, building modules according to themes. This strategy is helpful especially while most teachers are not specialist science teachers.

> "*You know when you teach in the primary, you are the Jack of all trades and the master of none, but now I am teaching science and that is why I am very much involved with them [the cluster teachers]. Now I am teaching science, I more or less know what's happening. I don't only teach science, I teach five learning areas altogether."*

The teachers interviewed reported that lack of resources such as photocopiers, paper and laboratory equipment in their schools remained an issue (though in our observations of schools in the PSP most schools did have photocopiers). They were grateful for resources such as maps, equipment and models provided through the PSP. They reported too that, because science teachers in the Cluster Project also participated in the PSP science workshops, they were able to carry knowledge between the two networks.

Old Clusters

We revisited two of the three schools visited in 2002 Cluster Programme. In their schools, we interviewed science teachers and HODs about how the clusters were working now and problems they were facing. Especially in view of the enthusiasm, structures and levels of activity reported in 2002, we were taken aback to learn:

> *"We do not meet anymore. I think that it no longer survives."*

Some of the teachers were unaware of or had forgotten about the Cluster Programme.

These were the same schools that spoke enthusiastically about the Programme in 2002: schools where structures were in place, routines and routine meetings were established, management and teachers were working well within schools and within clusters (Malcolm, Kowlas, Stears, 2003). The schools were somewhat at a loss to explain, attributing the decline to workloads, the loss of direct significant support from PSP, and shifts in priorities. They explained that teachers and school management felt tremendous pressures from WCED to meet requirements for school development plans, implementation of the Revised National Curriculum Statements and WCED meetings and workshops.

This must be an issue for concern for the WCED, PSP and the schools, especially because these schools were deeply committed in the first instance, had strong support for a year and strengthened their management structures to promote whole school development, curriculum and assessment. Neither do the teachers' explanations quite ring true. Firstly, the schools selected as new Cluster Schools in 2003 made no particular mention of the demands of WCED requirements (though they did speak clearly of heavy workloads, competing demands on their time and difficulties in getting to cluster school meetings). Secondly, the demands for school planning and curriculum development offered as competing demands are consonant with the Cluster Programme and supported by it. It seems most likely that the withdrawal of PSP involvement – with the pressure as well as support that that involvement implies – was the critical factor: the schools were unable to maintain their motivation without that external involvement.

This finding is important on two counts.

1. Prevailing theories of school improvement (from authors such as Hargreaves et al[5] (1996), and from Department of Education policies of school self-evaluation, whole school planning and teacher appraisal) assume that schools can (or can learn to) drive their improvement from within, given supporting documents and bureaucratic pressures. Further, research summarised in accounts such as Hargreaves et al (1996) give special cogency to teacher professional development that arises in the context of the 'day-to-day work' of whole school development, as a complement to relatively decontextualised teacher-education workshops. The Cluster Project in fact integrates these approaches: teachers working within their schools as part of school development; teachers (and managers) working across schools consistent with their areas of specialisation, and teachers attending workshops in science education more generally.
2. If these cluster schools, selected for their commitment and enjoying the advantages of a year's close support (including a wealth of proformas and materials) are unable to sustain their efforts when that support is withdrawn, it would appear nearly

[5] Hargreaves, A., Lieberman, A., Fullan, M., and Hopkins, D., (Eds) *International Handbook of Educational Change*, Klewer Academic Publishers, Netherlands.

> impossible for other ‘ordinary’ schools with ‘ordinary’ support to meet the demands of whole school development, teacher development and curriculum development expected in current Education Department policies.

The experience of the 2002 cluster schools – accepting their explanation that WCED requirements interfered with their previous approaches – suggests that schools respond *bureaucratically* to the demands for written plans and reports, but not necessarily in the deep ways that such reports and plans are supposed to represent, and not in the deep ways they worked when they were simply setting their own agendas, as schools and clusters. This points to a profound conflict within current Education Department policies. On the one hand, the policies promote devolution of authority (in management and curriculum), but on the other hand they tie down the allowable behaviours of teachers and schools through requirements for plans and reports in specific formats, and a plethora of performance indicators. On the one hand is a view of the moral, intellectual, creative, responsible professional working organically, intuitively, democratically, but on the other hand the reductionist specification of performances as the basis of school and teacher assessment. Added to that are tensions between curriculum integration (across subject areas, and of school with every-day life) and structured discipline-based learning, between local and global curriculum definition, between education for economic development and for social equity. The demands and responsibilities are enormous – and all the more on teachers who have come from a history of bureaucratic, mechanistic, private, teacher/ text centred delivery of syllabuses.

No wonder teachers are sceptical: by accepting devolution and responsibilities for school development and curriculum, they have not only opened themselves up as scapegoats if schools should fail, but accepted responsibility for their own failures (against criteria set externally, and in spite of school and community conditions over which they have little control). Mattson and Harley (2003) argue that the solution many teachers and schools opt for is one that ‘worked’ in the colonial past: mimicry (which, they add wryly, is not too distant from mockery). Teachers offer the trappings of the imposed roles and processes – written school plans and lesson plans, group-work, activity-based learning, attendance at School Governing Body meetings – often without embracing the spirit of the reforms. This shift from ‘real work’ to ‘mimicry’ seems to be the shift that has occurred in the cluster schools of 2002 as they moved into 2003. The bureaucratic demands of the WCED – and the support for them that the WCED provided – were no substitute for the essentially professional support and leadership provided through PSP during 2002.

Cluster Planning Meetings

We joined a PSP Cluster Planning Meeting held at the PSP offices in Philippa. It was well attended by approximately forty science teachers and a TIP representative, all of whom seemed enthusiastic and geared for discussion. The meeting was conducted in English, though most teachers were isiXhosa first language speakers. (We observed that language was sometimes an issue. For example, teachers often spoke to each other, aside, in isiXhosa during the proceedings, to help each other understand. During group discussions they often spoke isiXhosa, but reported in English.) Most of the teachers were from the Cape Flats area, mainly Guguletu and Khayelitsha with a scattered few from nearby Coloured townships such as Mannenberg. As noted earlier, PSPs relocation to Philippa has changed the profile of schools and teachers participating in PSP.

Some forty teachers attended, many arriving late. The venue proved to be poorly equipped to handle this number, in terms of ventilation, seating and visibility of the presenter and the presentations. Enthusiasm however was high, the workshop well prepared and well managed, and sharing the lead – among PSP staff and between presenters and participants – was standard. Throughout the meeting teachers were highly active, discussing, responding and expressing. The themes of discussion were:

- Biggest Gains from the Cluster Programme
- Noticeable Differences in school management
- The usefulness of school visits
- What is needed to make the Clusters work better

Consistent with our interviews with Cluster Schools, the teachers generally felt that being part of the cluster had helped them especially by allowing them to exchange ideas, materials and resources and produce better quality lessons. They said that their learners had noticed the changes, and identified lesson plans that are more thorough and often incorporate varied views. When teachers experienced problems, they said, they discussed them in cluster meetings and constructed amicable solutions. Teachers also identified as strengths the closer relationships they formed with colleagues (in and across schools) as a result of sharing ideas, thoughts and experiences in their classrooms, whether in mathematics, science or other learning areas. They saw important advantages in having principals involved in curriculum planning and the cluster meetings, giving principals better insights and allowing them to act accordingly. They reported that school staff meetings were held more often and teachers work as a team within a school instead of working individually. These reports are echoes of our own reports from the Cluster Schools of 2002, and again in 2003.

Teachers felt that PSP's school visits were necessary and helpful. PSP offers visions of success and practical advice. Teachers discuss problems with PSP staff and PSP responds. PSP also provides them with resources such as burners and globes. Without school visits by the PSP, schools felt that they would not have the direction and hope that they have (and they could point to their experience in previous years compared to this one in the clusters to justify their claim). Thus, even at the meeting, the fear is expressed that once PSP reduces its involvement, schools and teachers might loose momentum.

Teachers pointed to the need to be strongly committed to the Clusters. They felt that cluster groups should meet at least once a week, but acknowledged difficulties in maintaining this level of activity. They recommended that PSP, the WCED and other NGOs draw up a coordinated year plan, and follow it closely (a plan which PSP intends to consruct). As in our interviews, they expressed needs for more resources. They noted too that PSP curriculum and assessment materials are sometimes quite different from materials provided by the Department.

> *"Sometimes, PSP tells us one thing and the Department another. Who do we listen to?"*

Overall, the meeting was very constructive and gave clear insights into the processes, successes and needs of the Clusters, the sense of community enabled, the high esteem teachers and schools have for PSP, and the cooperative ways in which PSP works with teachers. Teachers rely upon PSP for support and showed their gratefulness through their attendance, discussions and comments at the meeting. They see that working in clusters has many rewards, but requires dedication from all concerned.

Chapter 7
Reviewing the Evaluation

This is the third and final report of our Evaluation of the Western Cape Primary Science Programme, conducted from 2001 through 2003. The three reports should be read together – this third one concerns especially with 2003 activities, with references back to previous work but without seeking to offer a full account of the three years. In this chapter, we will briefly review findings and processes over the Evaluation period.

PSP is an active, highly professional and well-managed organisation, deeply respected by the teachers and school principals with whom it works. It conducts workshops, demonstration lessons and school visits; produces materials to support learning, school planning and teacher development; interacts with other NGO's and the Education Department of the Western Cape, and takes care of the professional development of its own staff.

Teachers who participate in workshops and cluster groups and use the published materials speak highly of the PSP's programmes and accessibility, especially as they continue to redefine themselves consistent with Department of Education policies in curriculum and assessment, whole-school development, teacher appraisal and professional development. Teachers see PSP as providing practical and yet insightful guidance on the interpretation and uses of the policy documents, teaching, curriculum, assessment and school management.

Over the three years that we have worked with the teachers, we have been greatly impressed with their commitment and the quality of their classroom programmes. They were almost always well-organised, with clear lesson plans, variety in their teaching and good classroom management; they were accurate in their science and confident of their relationships with the children, easily sharing power through activities and conversations. They were less strong in connecting science to children's out-of-school interests and experiences (especially children's social and cultural knowledges), and promoting higher-order thinking skills, problem-solving and deep thinking about science. This showed up in three ways. First, classes often did the 'ground-work' for concept development, but did not adequately draw ideas together to close in on the learning available or the 'big ideas' of science. Second, assessment tasks often emphasized low-level knowledge and skills – recall and application of words, reporting on observations and measurements, presenting narrative accounts of activity. Third, classes made little use of open activities, such as designing investigations, exploring meanings and knowledge structures, and free writing.

Our evaluation of the PSP modules in 2002 showed that many of these weaknesses were present in the PSP materials – materials that the teachers used as the basis of their lessons and assessments. We provided detailed critiques of the materials in 2002 and, in 2003, led a workshop on curriculum design with PSP staff, aimed at building theoretical knowledge of curriculum and providing practical examples and models. As a result, PSP has since experimented with new approaches, both as a basis for their workshops with teachers, and the redevelopment of modules. This work continues.

In the light of our findings in 2001 and 2002 that teachers (and the PSP materials) generally paid little attention to the immediate socio-economic, cultural and personal circumstances of the children and their communities in the design of curriculum, we embarked in 2002 on a programme to describe in some detail the children's needs and interests, and to involve the children, their teachers and their families in shaping learner-centred, 'relevant' curriculum. Our focus was on three schools in the Cape Flats area, where poverty, instability, substance-abuse and child-abuse frame daily struggles for survival. We provided detailed descriptions of the children's lives, interests and hopes. Working with the participating teachers and their classes, we developed a module on 'Fire in our lives'. In 2003, we taught that module and, with the help of the teachers and PSP staff, collected extensive information on the ways in which the children responded. The results were exciting. The levels of the children's engagement, contribution and thinking were high. In this, there was an important affective outcome: the children saw their own lives and interests expressed in the classroom, their own efforts affirmed. They saw that 'relevant science' was a two-way process, not only promoting science knowledge they could use beyond school, but making their cultural knowledge (including cultures of poverty and street-life as well as isiXhosa culture) part of school. The results point up some of the tensions between local curriculum design (guided in the choices of content as well as pedagogy by the children's backgrounds and needs) and 'universal' design, but also show how both interests can be accommodated. The findings can make important contributions to make to PSP's work, and the module offers one example of how such modules might be developed.

While PSP works directly with teachers, its ultimate concern is children's learning. Thus assessment of learning was an important dimension of the Evaluation. Assessment proved to be a vexatious problem. Standardised tests we designed on the basis of the PSP materials and Curriculum 2005 proved inadequate – the children did poorly, in contradiction to the learning and achievement we observed in classrooms. Language and the very process of 'testing' seemed to be major obstacles. Accordingly, in 2003, we changed our strategy and set open tasks for some 400 children in 10 classrooms, then followed up with interviews of about 100 children. We analysed their presentations and interviews using the SOLO taxonomy, which offers five levels of achievement, defined by increasing expression of relationships and abstractions. The results were contrary to the test data, but consistent with the teachers' and children's beliefs about their classrooms. During the children's presentations, and even more during interviews, many demonstrated their abilities to recall and integrate related ideas, and often, to move to abstract levels of theory and generalisation. This finding raises serious doubts about the value of formal tests. It also highlights the problem that testing often addresses low-level skills (such as recalled vocabulary) and fails to give children opportunity to show their deeper thinking. The finding also confirms Education Department policies of continuous formative assessment as the basis for summative judgements of achievement as well as the design of teaching.

As part of the *Fire in our lives* module too we explored approaches to assessment. During the module, children produced a wide range of worksheets, stories, drawings, etc that provided insights into their learning. They showed that the children had good abilities to discuss and use 'everyday' knowledge, but often struggled in making the shifts to formal science knowledge. In part, this was because the practical knowledge of preventing and managing fires was more important to them than theories of combustion and energy. We followed up with a formal test. Here, unlike the general study, the test could be tailored closely to the module as the children experienced it. However, as in the general study, the children did poorly. They did little better on a second version designed to be 'simpler'. We offer in Chapters 2, 3 and 4 a number of suggestions on how PSP might proceed on these issues.

One of the purposes of assessment is to enable judgements of the standard or level of achievement. In our general study, as noted earlier, we used the SOLO taxonomy, but the taxonomy has the disadvantage that, while knowledge of content is obviously important in the children's responses, the taxonomy itself gives no information on the children's actual knowledge and skills. For this we turned to the Revised National Curriculum Statement, with its Learning Outcomes and grade-based Standards. The open-ended presentations we obtained from children in the general study provided rich and detailed information from which judgements of Standard might be made. Our analyses, while suggesting that the great majority of children were operating at or above the Grade 5 levels in outcomes on which we had data, also showed deep weaknesses in the Standards: progression and continuity from one level to the next were often too narrow, or poorly constructed, and often more a matter of semantics than progression in learning. This finding raises important issues for the Education Department, PSP and schools, when the system of outcomes and standards becomes the formal basis for assessment and reporting.

Coupled with this analysis from the general study, we worked with three teachers over two years, to have them keep track of 'progression' of selected children as they moved from Grade 5 to Grade 6. We collected portfolios, and analysed children's work from Grade 5 and then Grade 6 using the Revised National Curriculum Statement. Three major issues emerged. One, as above, was that the Standards were not well enough written for this purpose. A second was that the assessment tasks the teachers used (often from printed materials, and especially PSP modules) were too narrowly defined: to judge Standards, it is necessary that the children provide rich and detailed accounts of their thinking. Single words, short sentences, and labels on diagrams are not sufficient. Third, especially given the uncertainties (in the Standards and more generally) about what 'progression' means, or what progresses, teachers were ambivalent about what was important: for them, the children's progress in general ability, problem-solving, managing their lives, taking responsibility, looking after themselves and others were highly important outcomes. Being able to use more science words or more measuring equipment had to be seen in that context.

As part of our evaluation of the cluster schools project, we visited schools who had joined the clusters this year, schools that had been part of the cluster project last year but were not any longer, and a general meeting of teachers in the 2003 cluster project. The cluster project, in its design, is highly defensible. It combines three aspects: teachers and managers working on whole-school development and teacher development, meetings of interest groups (managers, or science teachers) across schools in the cluster, and general PSP workshops in curriculum, management and science education. Further, schools that join the clusters are carefully selected, on the basis of their commitment to the process and the outcomes. PSP works closely with the clusters. Teachers and managers in the cluster schools, in 2002 and again in 2003, spoke resoundingly of the good work that PSP does and the achievements of the clusters. However, we found from schools that were in the programme in 2002 and 'on their own' since, that cluster activity in 2003 has all but ceased, and much of the energy has waned. This finding has deep ramifications not only for the cluster schools project, but for WCED policy: if schools with the commitment, talents, structures and support that the cluster schools enjoy cannot sustain their efforts, what chance do 'ordinary' schools have?

Looking forward

Our evaluation raises a number of issues, discussed above, that will require continuing effort and creativity within PSP. None of these issues has a simple solution, none will be solved quickly. We have talked already about the needs for continuing work in curriculum design, assessment, judging standards, materials development – in ways that are closer to learner-centred, relevant curriculum, the critical and learning area outcomes of the Revised National Curriculum Statement, and continuous formative assessment. We have pointed to difficulties and further needs in promoting whole school development and clusters.

Beyond these goals, we see two important domains in which PSP should intensify their efforts operation. One is Technology Education – especially in the spirit of 'design-make-appraise' that underpins the Revised National Curriculum Statement for Technology. Technology is not applied science, nor merely a context for studying science; it is a field with its own purposes and 'ways of knowing'. Teachers need help with it. Further, it is policy that Science and Technology are integrated from Grades 1-6, in other words for almost all of Primary School education. It is imperative that PSP move more quickly into this area. The second need is for PSP to move more quickly in responding to changes in teacher-development policies, especially the requirement that all teachers are involved in professional development, and the incorporation of in-service education into the NQF and accredited courses. PSP has begun work in this domain, but needs to work quickly to fit into this context – whether through accreditation, or through treating informal courses as a special niche.

We believe it is time too for the PSP to grasp and assert more widely its leadership in Primary Science Education. Recent reviews of Science Education research in South Africa show that there is little research and little leadership in Primary Science arising from academics, and almost nothing in Technology (Malcolm and Alant, 2004). PSP staff, teachers, and children, through the ways in which they work together, have deep knowledge of science education, teaching and school management in primary schools. In many ways, they already work in 'action research' mode, though often without the support of theory and literature. We have tried to conduct our research and report on our work in ways that demonstrate relationships between theory, policy and practice. We urge PSP to capitalise more publicly on the knowledge and opportunities they have.

Reflections on the methodology

The design and conduct of this Evaluation have been challenging and interesting. Never far from the surface were three major tensions:

- between summative and formative purposes – whether our first concerns were to analyse, discuss ideas and work closely with PSP (and schools) or to describe and judge processes and achievements (with a view to accountability to funders). We favoured the former, but always aware of the tension.
- between insider and outsider positions – whether to be close and informal as participants in PSP's operation, or aloof and formal as 'external evaluators'. Here too we favoured the former, though in the middle ground: holding to an 'independent' role even as we knew that independence and participation were logically inconsistent.
- between positivist and socially critical positions – whether our study was to find 'truths' about PSP, schools and children and propose models of explanation, or whether it was to find meaning, raise discussion and critique, and work as agents of

social transformation for PSP, the schools and the children. We favoured the latter position, consistent with our choices to favour insider and formative roles.

These orientations to participation, critique and transformation, of course, were made difficult by the fact that the research team was in Durban and the PSP in the Western Cape. In large part we and the PSP staff were able to accommodate the difficulties, through emails and phone calls, and meetings when we could. It was much harder to achieve close relationships with the schools: it was simply impossible to 'drop in on them' for short periods when they or we might have wished to, so our visits were inevitably tightly managed, and infrequent.

One of the ways in which the tensions above played out was in assuming roles. We were as loath to present ourselves as consultants (offering advice, presenting solutions, making recommendations) as we were to be judges: we saw as our major responsibility to describe and understand what PSP and the schools are doing, and make those descriptions clear through data and theory. PSP staff, on the other hand, often wanted 'solutions' – what to do about assessment and reporting, how to write modules, what direction to choose in strategic planning. (It is interesting, for example, that most of the PSP staff saw the workshop we conducted on designing curriculum as one of the most valuable outcomes of the evaluation. Yet in that workshop, we assumed roles of expert, teacher and consultant in ways we did not for the Evaluation generally.)

We invited PSP staff and teachers to reflect on the Evaluation. Eight teachers sent in replies. Their responses show that 'participation' is a complex idea, as much about the quality of relationships (especially notions of concern, care and trust) as frequent visits and direct involvement:

- *Working with Cliff and Michelle has been exciting and inspiring. Through their research I've learnt quite a lot.*
- *I congratulate the programme because it has really made my life flexible.*
- *His evaluation made me feel that my ability as a Natural Science educator was valued. We enjoyed his presence and flexibility to choose from his experiences.*
- *Being involved in this project was of great exposure to me.*
- *The assessor was friendly and co-operative and I have gained … self-confidence to present a lesson to any outside observer…*

Interestingly, some reported that the school visits had direct value to the children:

- *His evaluation motivated my learners as they shared some knowledge, skills and values with somebody outside their school. The only thing which was a barrier to communication was the language. Yes, I teach my learners using English, but when it came to speaking with somebody else, they became shy.*
- *Daar was sekere leerwaardes in Mnr Malcolm se besoek waarby die leerders kon baatvind.*
- *I think the learners enjoyed and benefited a lot from the project.*
- *My learners are now active participants, physically and creatively. Their skills are being promoted from all angles.*

The ideas of participation and cooperation were taken up in some detail by PSP staff:

- *The way the evaluators interacted with the PSP staff during interviews and discussions and from what the teachers said alleviated some of my tensions. It was clear that the evaluators "understand primary school teachers and children."*
- *Firstly it was fortuitous for the PSP to have an evaluator who understands the context of what happens and what is possible in primary schools as well as someone who is really interested in developing alternatives methods of assessing learners.*
- *Cliff paid careful attention to including the PSP in all the strategic decisions and collaborating very effectively and I appreciated the fact that he always sent us drafts of reports in advance and took account of our comments before finalizing these – in fact I felt that the whole process was conducted in a very professional way and over the three years there were no serious crises or mishaps. However I did feel that the evaluators could have shown their appreciation to the participating teachers more promptly on occasion.*
- *I appreciated the opportunities that I had during this research process to have explanation about and input into the research design and methods. I found that the analytical reports were complemented and made real by the case studies and the description of the contexts of teachers and learners and education in general. I also appreciated the fact that the research was conceptualised carried out by practitioners who have experience not only in science but who also understand primary school teachers and children. I felt there was a shared philosophy and rapport*

At the same time, PSP staff pointed out a number of failures and weaknesses:

- *I certainly think that we would have learned more had we had better access to each other. This would have allowed much more sharing of ideas about the development of the learning programme for instance and we would have learned more from it….. There were things that at times we agonised about here at PSP and I think it would have added another dimension for you to have been witness to that.*
- *I feel that in this study [development of relevant science] we had almost no contact with the learning programme or its development and assessment. Unfortunately because we could not play a major role in the development ourselves, I got the feeling that this became Michelle's research study and not an evaluation of our programme, even in the formative sense. We would have appreciated being able to engage with it, ask questions about it and make suggestions before it was implemented.*
- *I believe that the teachers who were responsible for administering the test items should have been consulted much more in their development. The teachers could have given ideas about a variety of other ways in which to see what children's understanding is of what they have learnt. Even the kids could have been asked how they prefer to feedback what they know about what they have learnt. This consultation could have helped to structure the 2nd round of evaluation.*

Staff and teachers pointed to specific things they had learned as part of the evaluation, things they would like to have learned, and things we did which they felt were, after all, pretty ordinary. One of the staff pointed directly to the issue of attribution: if something was learned, who was responsible for that learning? If something was not learned, who was responsible?

- *It is hard to make very many specific points about the evaluation because so much of the process has been absorbed and it is hard to tease out which developments have arisen from the research and which from the needs of the teachers and education department.*

It is much easier for us, as researchers, to say what we learned, and our learning is public in three reports and a number of conference papers. It is easy too to identify the sources of our learning: PSP staff, the many teachers we worked with, more than a thousand children who gave themselves fully during classes and interviews, worked diligently on our tests and presented wonderfully their assignments on 'important things I have learned'. Three schools deserve special mention – the three who participated in our detailed studies: Lusuko Primary, Chumisa Primary, and Isikhokelo Primary, and the teachers, respectively Miss Noxolo Nonkonyane, Mr Zolile Ntelezi and Miss Lulama Matsaluka. We worked closely with all three schools during 2002, and especially closely with Lusuko in 2003. Miss Noxolo Nonkonyane, along with her principal and children, was always willing and open with us, and will stand in our memories as a woman of immense integrity, wisdom and strength. I hope she can see herself and her children faithfully represented not only in the chapters directly related to her work, but throughout the report.

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