Talking to effective teachers of primary science

By Russell Tytler

Bruce Waldrip

Michele Griffiths

What do effective teachers of primary science do? What do they believe? A central part of School Innovation in Science (SIS) in Victoria are the SIS Components: a framework for describing effective teaching and learning in science (Tytler, Sharpley and Tsatsias, 2001; Tytler, 2001). As a team, we were already well aware of the literature on science teaching and learning, but in developing the Components we were keen to make sure they represented ‘on the ground’ best practice. We therefore sought out teachers with a reputation for effective science teaching and learning, and asked them to talk about their practice. The stories they told are the basis for this article.

The underlying premise of this research is that if we can produce valid descriptions of the practice of effective teachers, then we have an opportunity to improve teaching and learning in science classrooms.

Thinking about effective teaching and learning in science

The recently released Australian Government report The Status and Quality of Teaching and Learning of Science in Australian Schools (Goodrum, Hackling and Rennie, 2001) provides a contemporary, informative and disappointing picture of the current state of science education in Australia. This applies to secondary as well as primary schools, and the view is echoed in research carried out in many countries. Many studies highlight the inadequacy of traditional teaching in developing and changing students’ science understandings. Constructivist perspectives on learning help us understand the reason for this (Fensham, Gunstone and White, 1994). Research has highlighted the lack of confidence of many primary teachers with teaching particular aspects of science, partly through lack of knowledge, but also, we believe, because of a lack of exposure to models of how science can be productively taught to primary school children.

The teacher is the most significant factor affecting student learning and achievement. From the beginning of SIS we understood that to support large scale improvement in teaching and learning we must develop a clear vision of how teachers should operate in the classroom. In the research literature you can find a variety of methods people have used to study effective (or ‘exemplary’) teachers and programs: Survey methods and student questionnaires (but these lack detail about teacher practice and beliefs); interview and panel discussions (eg. Goodrum, Hackling and Rennie 2001); and direct observation of classrooms (eg. Hameyer, van der Akker, Anderson and Ekholm 1995, Treagust 1991) have been used. Each method leads to a different type of description of effective classrooms. We felt that interviews, followed by panel discussion, would provide a description that teachers themselves would find meaningful and that would support improvement in practice. That was how the SIS Components were developed.
We interviewed 19 teachers from three states, each identified as effective by science teacher educators or government curriculum advisors who had worked with them. The case descriptions in this article are a selection from these.

Case descriptions of effective teachers of primary science

We used the interview data to develop a rich description of each of these teachers' practice, beliefs and commitments. Each teacher was then invited to comment on this analysis and the descriptions were refined.

**Sarah (P-6)**

Sarah is a teacher in a small community school with a Preparatory-6 class. She is a science enthusiast and schedules science and technology two afternoons a week. She organises a number of science excursions or incursions each year, such as space lab, or scienceworks, and she enlists science/technology minded parents to support some of the program and some years runs family science nights.

Her science program is strongly conceptually based. She groups children flexibly to support concept development. With younger children she tends to begin with concrete experiences; that arouse curiosity and are designed to challenge understandings, and this is followed by a process of reconstruction whereby understandings are discussed and further activities grow out of children's specific interests, questions and suggestions. While the specific activities are negotiated and flexible, often involving mess and noise, the general direction is controlled to focus on meaningful understandings. Assessment is central to this process. Children's questions, which are encouraged through a number of specific strategies, are put up on the board and revisited as necessary, sometimes up to months later. Samples of children's work, either written or diagrammatic, are kept, and there is a strong focus on what they've learnt rather than product development.

Sarah appreciates science for the sense it makes of daily phenomena and the satisfaction of being able to explain what's happening. She believes that curiosity and questioning are deeply embedded in science, and part of the reason science is central in her program is its capacity to promote questioning, and the opportunity it provides for children to engage with and enjoy that sense of owning ideas. Doing science in this exploratory yet focused way allows the teacher to engage with children in ways not possible with other curriculum areas. Sarah believes that teaching science raises fundamental questions about how children learn. In order to support children's deepening knowledge the teacher needs to be able to draw from a deep and close understanding of the individual child.

Science demands that the teacher engage with children and develop a feel for the classroom energy needed to sustain learning.

**Melanie (Years 4-6)**

Melanie's school has developed an enormous range of science and environmental education initiatives, including local environmental monitoring and intervention. These have involved local experts, local businesses and the local community as well as more widely based competitions.

Classroom science is focused on the development of conceptual understandings through teacher challenge and support using and encouraging open-ended questioning, focus questions, and exploratory discussion. The classroom environment is non-threatening; children are encouraged to explain in their own words and supported gradually to develop scientific explanations. They are encouraged to question and respond to each others' ideas, and to discuss and analyse results. There is a focus on cooperative learning and sharing of findings. Children are encouraged to reflect on their learning and their cooperative skills.

Her view of a good learning environment involves motivational strategies, a knowledgeable teacher, a non-threatening but challenging environment with varied resources, emphasising questioning and prediction and interaction, and sharing and reflection. The purpose of science is for children to understand the world they interact with, to develop their investigation skills, and to encourage enjoyment of investigation in science. She is excited about observing children coming to grips with their world by questioning, hypothesising and testing their thoughts and understandings.

**Ron (Years 6/7)**

Ron, while he doesn't claim significant science knowledge, has worked as a science advisor and talks about significant shifts in his science teaching strategies. Ron emphasises giving maximum responsibility as a way of motivating and engaging difficult children, keeping them on task. Sharing of resources and ideas are valued, and a sign that children are engaged in significant learning. Ron believes quality teaching and learning involves having the confidence to hand over control to children, without imposing tight knowledge constraints.

Ron talks of enthusiasm, structure and direction as the essence of a good learning environment, where 'we know where we're going and what we want to do', but in a general sense only. He emphasises the importance for him of being open to ideas and to operate as a learner in the classroom. Ron uses real life activities and things to
involve and motivate children so they learn, and sees the
main purpose of science as demonstrating its
interrelatedness with life. He uses 'simple household stuff'.
He is excited about science because of 'the opportunities is
provides for children to learn. I have never seen kids so
keen to learn and learn so much as when you do that and
provide science as the basis, and make it open ended'.

Carla (Years 3/4)

For Carla, 'a good learning environment is one where
children are encouraged to ask questions, to discuss ideas,
give opinions, and understand that they have to provide
substantiation for their opinions'. She has a strong focus
on questioning, and on encouraging and supporting higher
order critical thinking skills, 'what if' scenarios, teasing
out relationships and thinking laterally. She takes 'every
opportunity' to run with expressions of interest and
children's questions about science. Children should feel
secure enough to take risks.

More so than the other teachers, Carla believes it is
important that children have access to contemporary
science ideas, that they bring along and discuss newspaper
reports, ethical issues, and realise the importance and
relevance of science to contemporary life. She wants
children 'to see science as a means to understanding
nature, that science produces theories and models which
are modified, that there's a need to even abandon ideas if
the evidence is not sufficient, or if new evidence comes to
light.'

Myra (Years 3/4)

Myra is the science coordinator at a large primary school.
A major focus of the science program has been to involve
children in state-wide science challenge projects. The
school's successes in these projects have been widely
publicised in local newspapers.

Myra strongly emphasizes interrelating science with other
areas of the curriculum and immersing children in the
topic. 'When I am doing a science topic it crosses into
language and maths. There is a constant embedding all the
time ... the information and concept building and so it's
not just a science lesson... I tend to immerse them and if
we are on a roll we continue'.

Myra understands that children learn in different ways,
and sometimes they work individually, other times in pairs
or larger groups. She regularly uses brainstorming before a
unit, as well as concept mapping, formal and oral reports.
'Within our projects we break it up into many areas -
research component, model building, oral presentation - it
gives children the opportunity to express themselves in
different ways'.

Imogen (Preparatory Year)

Imogen's science teaching is strongly influenced by
constructivist principles. She describes a very active
classroom based on hands on activities, with a variety of
strategies and a clear focus on interest and engagement,
and on exploratory activities. She uses strategies to
develop children's awareness of their own learning, such as
revisiting and appraising earlier work. She talks of
children taking responsibility for such activities as growing
plants and designing measurement procedures.

She probes children's prior understandings using open
ended, problem solving type questions, and uses this
information to plan, or to sort by ability groups so she can
push children at the appropriate level. She develops
activities to continue to challenge children's thinking,
until she is satisfied most achieve some understanding.
She plans key interventions to stimulate student thinking.
She plans around children's interest, and grasps 'teachable
moments'. Like Carla, she will modify the course of a
lesson to follow such opportunities, to 'keep the kids
engaged in their learning.' For Imogen, a good learning
environment is a relaxed one where children feel they can
make mistakes without being threatened, where they can
explore, and be creative.

Imogen encourages children to feel they can become
scientists: 'I think people so underestimate children's
ability to think critically ... and that really excites me
when you see just the depth that some little kids can go to
.... to be able to help them learn some of that is really
exciting, to start somewhere with them, and to give some
meaning to all those questions'.

Analysing the case descriptions

There are both commonalities and differences in the way
these teachers talk about their classrooms. The analysis
represents an attempt to identify what is the core nature of
these teachers' practice, commitments and beliefs, and
also their distinctiveness.

Knowledge and learning

The first thing one notices about these teachers is their
commitment to student engagement with ideas, and to
deeper levels of knowledge and understanding. All these
teachers emphasise their commitment to an inquiring
classroom where children are stimulated to question and
explore and think critically. Most also emphasise their
delight in the levels of reflection and understanding
children can achieve in science, given appropriate
challenge and support. These teachers, however, express
their views about thinking and knowing and learning in
different ways.
Sarah, for instance, emphasises more than some of the teachers the particular conceptual directions she plans for children, but her view of the nature of the way children learn embodies the constructivist insight that children must actively engage with and question phenomena and ideas, so that the process and product are strongly linked. Melanie makes similar links, but her core emphasis tends to be on student questioning, hypothesising and testing, and enjoyment of this process. Ron tends to emphasise the open ended nature of activities, linked with encouraging children’s autonomy and interest, as a way into learning.

**Individual and community**

Another dimension represented in these teachers’ core commitments is that concerning the role of community in learning, learning as a collaborative activity, and the individual learner. Each teacher clearly saw learning as a collaborative activity in which children expressed their ideas and moved towards shared understandings. For some, cooperative learning strategies were important features of their classrooms. Each teacher, on the other hand, emphasised the role of individual learners either by focusing on assessment and differentiation, or emphasising the development of student autonomy as a core concern. Sarah’s emphasis is on differentiated activities and sensitivity to individuals’ understandings, but she also talked of community projects and parental support. Melanie’s focus is more strongly on community. An important hallmark of the effective teacher is the ability to operate at both the individual and community level, but we can see in these teachers’ accounts different emphases.

**View of the learner and learning**

All these teachers view the learner as an active sense maker who engages with phenomena and ideas in order to construct knowledge. They all arrange their classes and strategies to stimulate and be responsive to student learning needs. They saw the purposes of teaching science within the wider context of educating the whole child, and their practice in science sometimes related to generic critical thinking and orientation to learning, at other times to other learning areas, particularly language. A number of these teachers, however, explicitly argued that science offered unique opportunities to challenge and support quality learning behaviours. A number of these teachers emphasised that a fundamental purpose of education was to develop a sense of autonomy and responsibility in children for their own learning. They are all ‘student centered’ in the sense that children’s ideas and interests are given serious attention and often determine the direction of classes, but they also have a strong sense of their own intentions and direction. They differ in the extent they have carefully structured programs over the longer term, but all projected a strong sense of conceptual coherence in the way they organised their units of work.

**Discussion**

Figure 1 is an attempt to capture these teachers’ core commitments and practices using two dimensions. One dimension contrasts process (the development of

![Figure 1: A model of effective teaching and learning centered on the notion of active engagement](image-url)
The interpretive analysis of the teacher interviews indicated that the SIS components that were central to these teachers' concerns were: engagement with ideas and evidence, development of meaningful understandings, and recognition of children's individual learning needs. How do the stories reflect on your own teaching practices? Do they provide you with confirmation that your own practice is indeed in many ways effective? Do they inspire you to think about what you might work on as a professional learner and teacher?

References


References


References


References


References


References


References


Acknowledgements

The research described in this paper was undertaken as part of the Science in Schools Research Project, funded by the Victorian Department of Education and Training, and this government support is gratefully acknowledged.