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The community's contribution to science learning: Making it count

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Underpinning the title of this address are two assumptions. The first is that the community should contribute to science learning. To justify this assumption, I describe a little of what we know about the outcomes of learning science. The second assumption is that the potential community contribution needs some assistance to 'make it count'. To explain this, I outline community-based opportunities for learning science, meld this with what we know about learning outside of school, and then use case studies to illustrate how we can make it count.

Outcomes from learning science at school

A major driver for this conference theme is declining enrolments in science at all levels of education where it is not compulsory and the consequent shortage of people pursuing science-related careers. Research suggests that a significant reason for this is that science at school does not engage the majority of our students. Why might this be so?

Several years ago, Denis Goodrum, Mark Hackling and I surveyed the quality of teaching and learning science in Australian schools (Goodrum, Hackling, & Rennie, 2001). Our review of international trends made it clear that the aim of science education is to assist students to achieve scientific literacy. We defined this term by stating that scientifically literate people are interested in and understand the world around them; engage in the discourses of and about science; are able to identify questions, investigate, and draw evidence-based conclusions; are sceptical and questioning of claims made by others about scientific matters; and make informed decisions about the environment and their own health and well-being. Yet Denis, Mark and I found that, in most cases, current science education was unlikely to produce the outcome of scientific literacy. For example, in our survey of students in a stratified random sample of secondary schools, less than 20 per cent told us that, very often or almost always, science at school was useful, dealt with things they were concerned about, or helped them make decisions about their health. Sadly, these findings are consistent with a large corpus of research findings: 'A recurring evidence-based criticism of traditional school science has been its lack of relevance for the everyday world' (Aikenhead, 2006, p. 31). As a result, many students are simply disenchanted with the school science curriculum on offer because the culture of school science, with its traditional emphasis on what Aikenhead termed 'canonical science concepts', is at odds with students' self-identities, and they find science at school unimportant, unengaging, and irrelevant to their life interests and priorities. For them, science has little personal or cultural value.

Of course, this is not true for all students. There are some for whom the rather abstract canonical science concepts are a comfortable fit. These are the students most likely to study further science, but they are the minority. The majority seems to be disinterested, even alienated, and many able students give science superficial attention by memorising information for assessments, for example, rather than achieving meaningful learning that will last. Over the last 30 or so years, an incontrovertible accumulation of research on learning in science indicates that 'most students tend not to learn science content meaningfully (i.e., do not integrate it into their everyday thinking)' (Aikenhead, 2006, p. 27).

Our challenge is to turn around this disinterested majority by making it worth students' while to learn science in a meaningful way. This requires changing the science curriculum so that it has demonstrable relevance and value to these students. A powerful avenue to achieve this involves bringing school science and the out-of-school science community much closer together. In this way, the nature and content of school science is exposed to scrutiny, for students to judge whether or not it is worth their while to engage with it, and if they do, achieve a useful level of scientific literacy or even build a science-related career in adult life. In other words, we aim to develop in students not only the ability but also the desire to learn science meaningfully at school and thus have a disposition to engage with, and use, science long after school. We aim to prepare them for life-long learning in science.

Community-based opportunities for learning science

Within our community is a range of institutions and services that deal with science. Some relevant to school-age children are outlined in the following (incomplete) list.

> The *students' families and friends* – the people with whom they spend most time – are important models for learning. Teachers need to understand the roles these people play, engage their support and avoid possible conflict when dealing with controversial science-related issues.
>
> *Institutions*, such as museums, zoos, aquaria, environmental centres and similar places that have an educational aspect to their mission, are significant community resources for science.
>
> Many *community and government organisations* endeavour to educate the public about science-related issues, including health (e.g., skin cancer, smoking, obesity), safety (e.g., fire, electricity, chemicals) and conservation (e.g., recycling, water resources, pollution, quarantine).
>
> *Media*, particularly television and the internet, but also radio, newspapers, magazines (especially related to hobbies) and advertising, are pervasive sources of science-related information, but of variable quality.

These resources provide almost continuous opportunities for students to learn about science, explicitly or implicitly. Consequently, students come to school informed (and sometimes misinformed) by their experiences in the community. Teachers need to be aware of what students have already 'learned' from these sources in order to harness their potential and engage students' interests.

Learning science from community resources

In the context of learning science outside of school, it is helpful to consider learning as a personal process that is contextualised and takes time (Rennie & Johnston, 2004). Understanding these characteristics enables us to see how extending learning beyond school science and into the community multiplies learning opportunities. First, because people have different interests, backgrounds and motivations, learning is a personal process. Catering for people's different learning styles and prior experiences requires a range of different learning opportunities. Using community resources to complement those in school increases the variety of stimuli and sources of information, and thus increases the likelihood that students will want to engage in meaningful learning.

Second, learning is contextualised according to where, when, with whom, and how it happens. Falk and Dierking (2000) articulated the personal, social and physical contexts that interact to shape learning outcomes. Using community resources extends the variety of physical environments where learning may occur, and also extends the range of people and social and cultural circumstances available to stimulate learning. Further, placing opportunities for learning in out-of-school contexts enables science knowledge to be demonstrated in the everyday world, thus aiding transfer of learning to new situations.

Third, meaningful learning requires the assimilation of new experiences with previous experiences to revise and reconstruct understanding. Learning takes time because it is cumulative. Linking community resources with science at school means that learning occurs in circumstances or places that students may continue to experience or visit after they have left school, so the likelihood of subsequent learning is enhanced when familiar circumstances jog old memories to help assimilate new experiences.

Readers will recognise the socio-constructivist perspective that underpins these characteristics of learning. If students choose to learn, they will construct their own knowledge and understanding from the experiences and sources of information available to them. In fact, if the ultimate aim of science education is scientific literacy, then the best school science can do is give students a repertoire of experiences that can be retrieved from memory to aid interpretation of new situations and provide direction for making decisions about them.

Using scientific knowledge in real-world contexts – a caveat

Research shows that, in the context of real-world issues, individuals need to transform (i.e., deconstruct and reconstruct) the information they obtain into a form that is usable to them in their own personal circumstances; that is, construct 'knowledge for practical action' (Layton, Jenkins, Macgill, & Davey, 1993). Students must do this same transformation in order to use the science knowledge available to them to make decisions in new situations. But attempting to use science learned in school to resolve science issues in the real world is complicated. Here is an example.

Academically talented Year 9 students were challenged to make a solar-powered boat as part of an integrated science, technology and mathematics curriculum (Venville, Rennie, & Wallace, 2004). Students needed to construct an electric circuit incorporating solar cells and a small electric motor that was affixed to a hull. The motor operated a winch to wind up fishing line and hence pull the boat through the water. During science lessons, students learned about series and parallel circuits, Ohm's Law, and the relationships $V=IR$, $P=VI$, $P=W/t$ and $W=Fs$. From the second equation, students could see that for maximum power output, high voltage was needed (favoured by a series circuit) together with high current (favoured by a parallel circuit), so there was a trade-off in designing the circuit to incorporate the solar cells. Further, the resistance of the motor varied according to load, and the load (pulling the boat through the water) depended mainly on the design of the hull, but also on the location and efficiency of the winch, among other things, and could not be calculated. Students used trial and error, rather than application of the science concepts (which provided algorithms to get the 'right' answer, but could not be used because other variables came into play), to get their boat to 'work'. The complications of 'real-world' contexts were amply illustrated, and students' boat-building and circuit construction knowledge eventually drew from a range of sources (friends, parents, watching other students' efforts) rather than the science concepts. Solving their task required students to 'repackage' their canonical science knowledge to fit an imperfect, but real, context. Such experiences are invaluable because they encourage deep thinking in science, and a realisation that although scientific knowledge may be a useful starting point, decisions for practical action must be made in context.

Aikenhead (2006) concluded from an extensive review that 'when the science curriculum does not include the difficult process of transforming abstract canonical content into content for taking action, canonical science remains unusable outside of school for most students' (p. 30). Science curricula can only do this by moving beyond the textbook, using community resources to explore community issues, and keeping three things in mind. First, there are so many uncontrollable variables that the canonical science concepts taught in the traditional science curriculum rarely have immediate practical relevance in real-world situations. At best, they provide only abstract explanations and imperfect predictions. Second, it is often the case that 'the science knowledge featuring in everyday contexts is characterised by uncertainty and dispute amongst scientists' (Ryder, 2001, p. 37). Third, there are often competing social and cultural values that provide conflicting interpretations of how to use science knowledge. Teachers must become aware of these issues and help students learn to cope with uncertainty and risk. Doing so is an important part of becoming scientifically literate.

Using community resources requires time and effort to ensure worthwhile outcomes. Organising a successful field trip, for instance, involves overcoming administrative and financial hurdles, as well as careful pedagogical planning. In the short space remaining, I will concentrate on the challenge of developing school–community partnerships, briefly describe two examples and identify their successful characteristics. Readers seeking further information are referred to a review of research in the field of out-of-school learning (Rennie, in press) and guidance for teachers in using the other community resources mentioned earlier (Braund & Reiss, 2004).

Successful school–community partnerships

Monitoring Air Quality – a science-awareness raising project

Poor air quality with smoke haze, especially in winter, was a recurring environmental problem in a mill town. A local science teacher led his Year 9 academic extension class on a project to raise community awareness and understanding of the problem, establish a website so that current meteorological information would be available online, and erect air monitoring equipment on the roof of the police station as a tangible outcome of the project.

The major contributor to poor air quality was suspected to be the (foreign-owned) paper mill. However, students found that it was not a simple matter to blame a company that employed many of their parents and sponsored the local football team. The company even donated the expensive air-monitoring equipment to the project! When students inspected the mill, they concluded that it was operated responsibly and was a trivial contributor to the haze. They soon realised that the smoke haze resulted from domestic wood-fired stoves and heaters, many of which were poorly maintained. Students surveyed the community about their knowledge and use of wood burners via the local newspaper and published their results there. Community interest was so high that at one time students had to be rostered to answer telephone calls to the school. A town meeting organised a petition for the local member of parliament requesting that the government implement a buy-back scheme to reduce reliance on wood burners. Not all went according to plan, however. The launch of the monitoring website was postponed due to difficulties in coordinating bureaucracies to obtain a continuous stream of meteorological data to publish on the website, and there were ongoing software problems. Nevertheless, evaluation showed very high levels of community awareness about this project and positive changes in people's ideas about science education (Rennie & ASTA, 2003).

Class lessons dealt with science issues (combustion, smoke haze settling in valleys, etc.) and this science content was given relevance by the context of the project. Risks, benefits, trade-offs, social interactions between various community members and groups, and communication and understanding of the science and technology issues in the dynamic social context that was central to the project provided significant opportunities to develop scientific literacy.

Living with Tiger Snakes – a wildlife science partnership

The Manager of Herdsman Lake Wildlife Centre led a project involving the cooperation of Years 4–7 students and teachers at a nearby school to develop a community educational program to reduce the indiscriminate killing of venomous tiger snakes. Over approximately six weeks, at the Lake and at school, students enjoyed a presentation by a snake expert on snake identification, behaviour and first aid; endeavoured to observe snake behaviour and activity; and collected samples of organisms from the Lake to learn about food webs and food chains in the context of the ecology of the area. In addition, students prepared, conducted and analysed a community survey regarding awareness about tiger snakes, and they designed and made snake safety posters, badges and wallet cards. The project culminated in students demonstrating the outcomes of their work at a community night at the Wildlife Centre, with PowerPoint presentations, role-plays of administering first aid, dioramas, and information signs for the lake perimeter.

Evaluation of this project revealed that participants worked together to explore a science-related problem and generated new understanding of the snakes' role in lake ecology and ways to promote safe living with tiger snakes.

Reasons for success

Living with Tiger Snakes was one of 24 School Community Industry partnerships in science (SCIps) projects across Australia (ASTA, 2005), an initiative built upon the Science Awareness-Raising Project (Rennie & ASTA, 2003), which included the *Monitoring Air Quality* project. Both projects were led by the Australian Science Teachers Association (ASTA) and supported by the Department of Education, Science and Training. Together these projects validated the following guiding principles for effective school-community projects. Successful projects:

- are based on some *issue/stimulus that comes from the community* and is not imposed;
- require *local knowledge* to ensure input of community members;
- are *educative*, because they:
  - focus on science as a way of knowing, thinking and acting, and
  - model science inquiry (working scientifically);
- are *integrated into science at school* and so legitimise participation by students and teachers;
- *involve negotiation and decision-making with the community* in regard to
  - social, political and economic factors,
  - differing perspectives from different groups, and
  - information collected (both local and science-related);
- have a *tangible outcome* to indicate when the project is complete and has achieved something worthwhile.

In addition to these characteristics, these projects had something else in common – some funding. A small amount of money provided seed funding and the impetus to get the projects underway, but the outcomes were far in excess of what money could buy.

Making the community's contribution count

If the major aim of school science education is to assist students to achieve scientific literacy, then the focus must be on developing the skills that underlie that concept. In Table 1, the components of scientific literacy referred to earlier have been separated and matched with the skills and abilities that underpin them.

Table 1 Components of scientific literacy and underlying skills and abilities

Scientifically literate people	**Underlying skills and abilities**
Are interested in and understand the world around them	Apply science knowledge and skills in daily life Seek information to explain new phenomena or solve problems
Engage in the discourses of and about science	Feel comfortable to listen to, and to read, write and talk about science in everyday situations
Are able to identify questions, investigate, and draw evidence-based conclusions	Think through issues and identify, obtain and use needed information Understand the meaning of 'fair test' Defend an argument
Are sceptical and questioning of claims made by others about scientific matters	Distinguish between fact and opinion Assess quality of evidence
Make informed decisions about the environment and their own health and well-being	Recognise and cope with risk and uncertainty in decision making Choose to act responsibly and ethically

The outcomes of the partnership projects described above are consistent with research findings about effective excursions, incursions, and many other kinds of school–community links, because they encouraged development of the skills and abilities identified in Table 1. An essential characteristic is that they were built into, not added on to, the school science curriculum. In fact, if there were three simple rules about using community resources successfully, they would be:

1. **Integration:** Experiences with community resources are integral, not peripheral, to science at school;
2. **Preparation:** Teachers and students understand what the tasks and expected outcomes are and what needs to be done to achieve them, and
3. **Accountability:** Teachers and students are jointly responsible for ensuring task completion.

Learning in the community, away from the constraints of the school curriculum, has been described by the National Association for Research in Science Teaching's Ad Hoc Committee on Informal Science Education as 'learning that is self-motivated, voluntary, guided by the learner's needs and interests, learning that is engaged in throughout his or her life' (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003, p. 109). This is the kind of learning we need to encourage at school, to boost learning and interest in science. Involving community resources promotes opportunities for learning science that students perceive as relevant and worthwhile, so that learning is meaningful and lasting. By using experiences in the community to help students develop and practise the skills and abilities that contribute to scientific literacy, we will make the community's contribution count.

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