the nature of science in schools

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The 2010 SciCon Conference in Nelson was a success in many ways such as precipitating a fundamental debate between teachers about the 'Nature of Science'.

The Nature of Science is now a compulsory part of all science teaching in New Zealand secondary schools, and yet the expression is controversial in science itself, in philosophy, in curriculum documents, and in teaching practice. The influence of the first collection of papers directed at the nature of science in science education – Bill McComas' edited book T*he Nature of Science in Science Education* (1998) – was apparent in some of the presentations. Thus, people sought to identify what students and teachers think science might be with some emphasis on the relationship between science and society.

There are at least three ways that the phrase 'the nature of science' gains expression with teachers: it may refer to the virtues or characteristics that allegedly scientists exemplify; to the methods that scientists adopt; or to the philosophy and/or history of science. As each of these three expositions of the expression itself admits of many interpretations, it is hardly surprising that some teachers at the Conference expressed frustration and asked for clear guidance on the intentions of the curriculum.

If the 'nature of science' refers to the virtues of scientists, then science teachers run the risk of having their subject disappear in wider school curricula. Being truthful, systematic, tidy and open to new ideas are virtues necessary in science, yet they are hardly virtues unique to science. Our colleagues in geography, business studies, physical education, and the language subjects all subscribe to these virtues, and they incorporate them in their work with students. Such virtues are important in the community beyond the school gate. In business, on the sport's field, and as the qualities of an employee, these virtues are momentous. An advantage of supporting these virtues is that they enable the claim that schooling is relevant to lives lived and the workplace. Somewhat more disturbing is that New Zealand only three decades ago rejected proposals to include moral education in the curriculum, whilst in one elaboration the inculcation of virtues is a task in moral education (Committee on Health and Social Education, 1977). Any proposal that science teachers are now required to inculcate moral virtues has profound implications well beyond the school laboratory. We should not underestimate the strength of belief of many New Zealanders who consider science to be the opponent of true religion or culture.

Those who interpret the 'nature of science' as a reference to scientific method gain strength from their assertion that there is a distinctive method which is especially the province of science. The science teacher has something unique to contribute to the school curriculum. It might be said that the method of experimentation is the province of science and definitive of its nature; this entails the formation of hypothesis, the design and execution of experiments, and the writing of research reports. Many in schools adopt this stance. Since Sir Isaac Newton this account of science has been hotly disputed: Newton himself anguished over it, and libraries are filled with descriptions and explanations about how scientists actually proceed with their work.

Presentations at SciCon in Nelson continued to provide examples of science advancing in other ways, specifically nanotechnology, cryogenics, and space science.

Finally, we come to the 'nature of science' cast as the philosophy of science. This rendition is today closely associated with the history of science. Mention to science teachers the importance of the history of science and there are at least three interpretations extant. Some lay much store on science as an historically developing discipline. They often point to the theory of scientific paradigms which Kuhn popularised, or to Toulmin's theory about the evolution of science (Kuhn, 1962; Toulmin, 1972). The walls of their laboratories feature Newton, Einstein, Crick, Franklin, and Watson. Other teachers believe that it is important to teach science historically; they give Democritus credit for his atomic hypothesis before they introduce Dalton and eventually arrive at Rutherford. In this they follow some of the classic textbooks of chemistry. Their walls show science growing like a tree. A third group of teachers associates the history of science and the philosophy of science. They struggle to find in the history of science something that they can account for in (or explain through) the philosophy of science.

This brings us to the philosophy of science: if this is what people mean by the expression the 'nature of science' – and for many reasons I think we must mean this – the new curriculum asks a great deal of science teachers. Science is not able to question itself, and consequently science teachers *qua* scientists are not trained to enquire into the nature of science. Presenters at the Conference developed three accounts of the philosophy of science: positivism (often called the received view), constructivism, and hermeneutics. They associate with important theorists (Babich, 2002; Eger, 1992; Heelan, 1977; Matthews, 1998; Suppe, 1974).

With this diversity of opinions about the meaning we may afford to the expression 'the nature of science', it is little wonder that teachers confront a substantial task when they first come to offer an interpretation of the science curriculum. As always, I would hope that ultimately teachers determine for themselves how to interpret the syllabi and prescriptions. This is the professional judgement of the educated and trained teacher at work. Our country will make a grave mistake if it returns to the command model for curriculum that we surpassed fifty years ago. Science teachers cannot look to others – politicians or professors – to resolve the nature of science.

New Zealand warrants no particular credit for bringing the expression 'the nature of science' into the science curriculum guidelines. We may find this topic in the curricula of many Western countries, and in the main it has entered those documents as a reaction to debates about social responsibility, the nature of the theory of evolution, and limitations of modern physics.

The Nelson Conference prompts these thoughts and I look forward to further explorations into the nature of science. I suspect that when teachers reflect on the nature of science it strengthens their teaching. There is also the exciting possibility that reference to the nature of science in the formal curriculum will take science teaching in new directions.

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the students explained that the metal spoon sparked like the grapes and CDs. They concluded that if the microwave had stayed on longer the sparks could have started a fire and this could have caused the school to burn down. This entire session took just over an hour.

The class then went back into their working groups, and each group was asked to illustrate and describe what had happened in one part of the demonstration. In this class the students record their experiences in 'books' they create. The senior students lead the younger ones so that they all participate and contribute to the book. This also gave the classroom teacher and the initial teacher education instructor a chance to discuss what had happened and where to go next. The classroom teacher felt her students needed more opportunities like these to express their 'thinking' about what they were doing and how this connected to what they already knew. Although she knew that her class had problems with written literacy, she was happy about how well and enthusiastically they expressed themselves in oral language. Whānaungatanga, which refers to relationships, is practised daily in the school so the teacher expected the students to be able to demonstrate 'relating to others' and 'managing self'. The teacher liked the idea of the demonstration as it gave the students the opportunity to 'participate and contribute' without having to write down what she referred to as the 'scientific procedure' (title, hypothesis, resources, procedure, observations, and conclusion) she normally utilised. She noted that the students began to contribute more and their depth of insight increased once they realised the science lesson was not the usual process of watching the teacher conduct a brief 'experiment' they would then spend a half-hour writing down.

Final thoughts

This paper addressed the three issues of definition, relevance and assessment that Barker (2009) raised in regard to the New Zealand Curriculum and science education through a practical demonstration of how the Key Competencies can be combined with relevant, useful and meaningful learning experiences to construct an authentic and meaningful learning environment. In particular, the students who participated in the demonstration were given an opportunity to connect what they already knew (about microwaves) to what they were currently exploring (electricity, electric circuits) and to make sense of this new knowledge. To achieve this, they had to participate and contribute by sharing ideas and discussing opinions with each other and the whole class. The initial teacher education instructor kept the discussions relevant, useful and meaningful without having to go into the physics or the chemical changes behind what was happening. At the same time, the students remained engaged and not only excited about what they saw.

By the end of this demonstration, the classroom teacher concluded the students had gained an age-appropriate level of understanding of the dangers of microwaves and what happens when certain items are placed in them. More importantly, one of the four groups was able to connect the session on electricity, microwaves and safety to a healthy food unit that was delivered nearly five months previously. Possibly one of the most important statements came from one Year 5 boy who stated, "So that is why you don't put metal in a microwave, it can start a fire like those commercials on TV and burn down your house". This short statement presents an excellent example of a child being able to connect the content of a classroom demonstration to their personal experience to develop a new and personally significant insight. Rather than the usual edict of 'do not do because I say so', this child gained an understanding of why something should not be done.

Furthermore, the classroom teacher realised that, instead of focusing on science learning, she was able to approach learning from a science context that her students are able relate to. She plans to explore more areas of science to engage students in their learning. In fact, she followed this lesson with further enquires into what happened to the soap and how air expands when heated.

This article demonstrates how science education is a vehicle for the Key Competencies in teaching practice. The students were exposed to activities that surprised and engaged them. They were provided opportunities to explain not only what was happening but also how they understood why it was happening. These activities were deliberately chosen to build upon an event they were already discussing so as to link their home life into school life. As this article has shown, the Key Competencies are about what the teacher and students do as well as what they know.

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Readers are referred to articles written by Dr Philip Catton, Canterbury University in issues 113 to 125 for a scholarly understanding of the history and philosophy of science – Ed

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