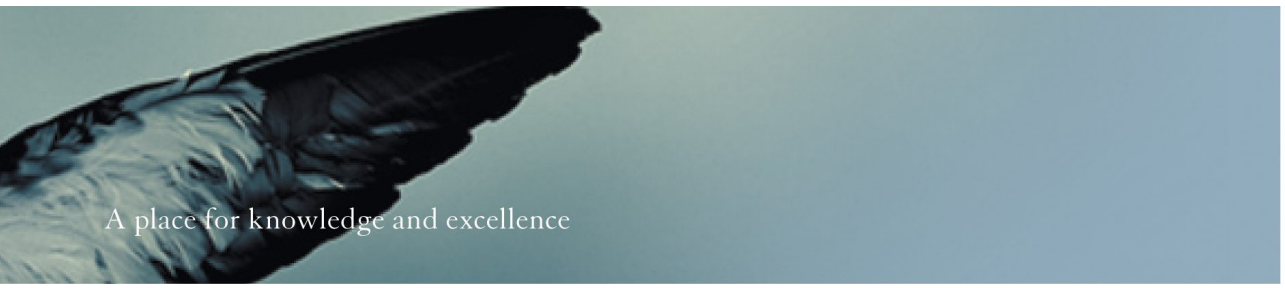

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TE APĀRANGI

The Future of Science Education in New Zealand: Summary

Introduction

Developing a smart economy is central to the government's strategy for New Zealand's future. This paper explores the implications of that strategy for science education. It argues that it requires a paradigm shift in our approach to learning. The paper sets out the kind of science education needed at each level of schooling, and how and why it should be reconfigured.

The full paper is available at: http://www.royalsociety.org.nz/publications/policy/

Educating for innovation

A knowledge and innovation-oriented country needs professional scientists, engineers, technologists and mathematicians who can think and work in today's organisations. But it is not a matter of producing more people who have been 'filled up with' existing knowledge. We need people with a different *orientation* to knowledge, people who have enough knowledge to be able to do things with it. Having relevant knowledge and being able to do things with it is what innovation means. An innovation-oriented country also requires an engaged and scientifically-literate public and that too, is a function of science education. We now have much more research evidence about how to nurture those skills and dispositions and about the kind of long-term learning that is required. We need to draw on that evidence as we rethink our approach to science education.

Science education today

New Zealand's top science students do very well in international studies of achievement. However most students' interest in science declines as they move through their schooling and around the middle secondary school years science is one of the least enjoyed subjects. Many of the students studying science at senior secondary level appear to be doing so for utilitarian reasons, such as needing it for the university course of their choice, rather than for interest or enjoyment. Many are not well-informed about the career choices available to them, and relatively few see themselves going on to study 'advanced science'. Three recent New Zealand studies confirm that here, as in other countries, students are making up their minds about science and science careers well before age 15, when they can choose not to study it. These early choices dictate who enters our future science workforce and they have an impact on the general population's understanding of and attitude towards science.

Rethinking science education

We need science in schools to produce a supply of tertiary graduates who have the knowledge, skills and dispositions needed by today's science workforce. However, science in schools will also need to produce a population that is interested in science, has some understanding of the 'big ideas', and is ready, willing and able to participate in public discussions of science-related issues.

This requires as many students as possible to be engaged in learning science at school and wanting to go on learning science after they have left school. They need to be getting experiences designed to build the dispositions and knowledge that make long-term learning possible.

We could easily do this. We know *how* to do it—the science curriculum already provides a framework for learning-centred programmes based on what we now know about learning. But this is not just a mission for teachers. These principles need to be understood by the wider public because teachers need their support to attempt what is effectively a paradigm shift in practice.

Science education: A map

Drawing on the science curriculum

Our approach to rethinking science education draws on the latest research evidence and on the existing framework for science in the New Zealand national curriculum.

Science in the New Zealand Curriculum (NZC) has five 'strands'—Living World, Planet Earth and Beyond, Material World, Physical World, and Nature of Science. The core of the curriculum is in the Nature of Science strand, for this is where students learn what science is and how it works. The other strands provide the content and contexts for that learning.

NZC gives clear signals of the need for students to have opportunities to develop knowledge of science; knowledge that will prepare them for entry to tertiary courses that will lead to science-related careers as well as knowledge that will enable them to participate as citizens. It calls for knowledge-and learner-centred teaching approaches.

NZC is favourably regarded by teachers and others in the education sector. They like the permission it gives for a range of different approaches and its emphasis on future-focussed issues and so-called "21st century learning". Nothing in NZC itself hinders

What we now know about learning: the principles

There is a vast body of research on learning; how people learn in general, how young people learn, and how young people learn science. A consensus is emerging that learning:

- Is much *more* than simply adding new concepts to one's existing repertoire.
- Involves *thinking:* learners need knowledge to think *with* and they need to think *about* knowledge to remember it.
- Requires rich *experiences* to 'think with': learning and knowledge deepen with a wider range of experiences to draw on.
- Requires development of *in-depth* knowledge in some areas: experts access deep structures and underlying principles that allow them to transfer what they know to new situations more easily than novices.

the possible implementation of science programmes that take account of what we know about learning and the needs of young people and the country. However, the curriculum document on its own will not produce the paradigm shift needed in educational thinking. To achieve that shift, the way the curriculum is implemented needs to be fundamentally different at the primary, middle and senior secondary stages of schooling and all involved need to be absolutely clear about the differences.

- Involves *active engagement:* learners need to be *doing*, *thinking* and/or *saying* something that requires them to actively process, interpret, and adapt an experience to a new context or use.
- Has a meaningful *purpose:* learners can see how this learning will allow them to contribute to something beyond themselves.
- Is *personalised* not standardised: learners have to feel 'in charge' of their own learning and to experience the right amount of challenge.
- Usually needs *structure* that directs attention to certain aspects of experiences and helps the learner orient themselves.
- Involves interaction: trying out and testing ideas with others happens when learners feel they are part of the 'culture' of a learning context.
- Takes *place* in a wide variety of settings, not just at school, in a classroom.
- Assumes the more people learn, the more they are able to learn, and that this should be the key function of an education system

Primary school science

The central aim of primary science education should be to nurture children's interest and curiosity in the world around them and to develop positive attitudes towards science. This would mean building on the experiences children bring to school and providing a broad range of engaging experiences designed to help children explore the natural world

Schools can provide such experiences in many ways. "Nature tables" and "science discovery centres" in classrooms create opportunities for students to experience the natural world, to observe closely, ask questions, look for patterns etc. For deeper learning schools could bring in 'experts', visit science centres or participate in virtual fieldtrips which are all ways teachers can bring the expertise and passion of others into their programmes.

All children should have the kind of wide-ranging, engaging experiences that foster an interest in the world around them and that lay the foundations on which positive relationships with science can develop.

Intermediate and early secondary science education

Years 7–10 (intermediate and early secondary) programmes would continue to focus on providing a wide range of experiences while also ensuring students have the opportunity to study some topics in depth. As students continue to learn, they need to have more, deeper, and increasingly complex experiences so that they have the ideas to think with.

At this level students should also be encouraged to explore and debate socio-scientific issues at increasing levels of complexity. During early adolescence, young people often begin to think more

deeply about the world around them and their place in it so it's a good time to get them thinking about relevant issues such as diet, health and the environment. To do this well they need knowledge, and they need to develop certain intellectual tools - skills in research and reasoning. Known as 'science literacy', this combination of knowledge and skills and the willingness to use them is at the core of the curriculum and considered a key part of people's preparation for life and for their participation in society. It includes science knowledge, knowledge of how science 'works, knowledge of science's relationship with society and how it affects and is influenced by society. Students at this level can begin to understand science as a body of knowledge and a way of thinking and they can also start to see how that knowledge has meaning and usefulness in their lives.

Senior secondary science education

Science study at Years 11–13 has three different functions. These are to:

- continue to develop students' thinking and learning capacities
- continue to develop their capacity to participate as citizens in a society in which science plays an important role
- prepare some students for post-school study or training for science-related careers.

The third function involves different goals and is likely to require different teaching methods, expertise and resources. This should be taught in courses specifically designed as pre-professional education.

This would mean two explicit pathways in Years 11–13.

1. A 'citizenship' focus aimed at deepening and strengthening the knowledge and skills that have been developed in the earlier levels.

2. Explicit preparation for science-related careers. This would involve students delving into specialist subject areas and building their knowledge by working on complex practical problems.

At all levels of education, the focus would be on challenging students to develop deep understanding via strategies emphasising student questioning, and active engagement with science's 'big ideas'. Students at all levels need a wide range of active experiences, and support to use those experiences to build deep knowledge in selected areas.

Getting to a consensus

This provides a framework for greater clarity about what needs to be achieved in school science at each level, and why. These ideas need to be *explicit* so that everyone - teachers, scientists, parents, politicians - can work together to promote the kind of science education our young people need at the different stages of their schooling. Greater clarity and consensus would also enable the multitude or government agencies, NGOs, community groups and individual experts who are actively supporting science programmes to target their support purposefully.