introducing and expanding a futures focus in science classrooms

The New Zealand Curriculum requires schools to include a futures focus as a foundational principle in curriculum design and implementation. *Cathy Buntting* from the University of Waikato introduces a conceptual framework and online resource that can be used to incorporate futures thinking into a range of science education programmes.

Futures thinking involves a structured exploration into how society and its physical and cultural environment could be shaped in the future, and the development of possible, probable and preferable scenarios. The following perceptions are important: the future world will likely differ in many respects from the present world; the future is not fixed, but consists of a variety of alternatives; people are responsible for choosing between alternatives; and small changes can become major changes over time (Cornish, 1977). A strong argument for exploring these concepts in classroom programmes is to empower individuals and communities to envisage, value, and work towards alternative futures. In science education in particular, there is significant scope for including futures thinking as part of students' exploration of socio-scientific issues. Arguments for doing so include increasing student engagement, developing students' values discourse, fostering students' analytical and critical thinking skills, and enhancing students' key competencies. This paper presents a conceptual model that can be used to help move students from being intuitive problem solvers to being better able to use scientific understandings to articulate and justify choices for a preferred future.

Developing a futures thinking model

A widely cited British meta-analysis of thirteen core futures studies carried out by governments and business (DERA, 2001) found that most futures work incorporates input data, trends, drivers, outcomes, predictions, and explorations. Scenario models of possible, probable and preferred futures are also often developed. This process appears to require at least five elements:

- an understanding of the current situation
- an analysis of relevant trends
- identification of the drivers underpinning relevant trends
- identification of possible and probable futures
- selection of preferable future(s).

Key trends identified by UNESCO (2002) as shaping society include: increasing cultural differences; globalisation (where all countries are integrated into a global system of economic interdependence and cultural uniformity); increasing gender equity (leading to changes in social priorities and the way society is organised and functions); religious revival; decreasing poverty; changes in technologies (where the increasing spread of computers in homes and workplaces is changing the way people live, work and play); and advances in biotechnology (including the use of genetic engineering to create new plant and animal breeds, as well as alter human genes). That both 'cultural differences' and 'cultural uniformity' can be included as trends exemplifies the complexity of the issues that need to be considered. In addition, whilst there may be a broad consensus about some likely future trends, the cumulative effect of even small uncertainties means that the range of plausible future worlds is very large. A consideration of the social milieu – which both shapes trends, and is shaped by them – is also critical. Other significant drivers include demographics, environmental change, economics, science and technology, national and international governance, perceptions, beliefs, values, and attitudes (DERA, 2001). Many of these are, of course, interrelated. Similarly, the interactions between drivers and trends tend to be multifaceted and complex.

In order to demonstrate how the elements listed above can be explored in a classroom environment, a model of inquiry was developed by a team of us to help students identify relevant scientific and technological understandings in order to:

- understand the current situation: *What happens now, and why?*
- analyse relevant trends: *How does what happens now differ from what happened in the past, and why? Are the changes desirable? Who benefits? Who loses?*
- identify key drivers underpinning relevant trends: *What is causing the changes? Why are they occurring? Are the causes (drivers) likely to continue into the future?*
- identify possible and probable futures: *Are current trends likely to persist? How might they affect the future? What might change them?*
- select, with justification, one or more preferable future(s): *Based on answers to the earlier questions, what do you want to happen in the future? What needs to happen for this preferred future to be realised?*

Each of these components can be contextualised to suit a particular topic. Thus, for a study on future foods, understanding the current situation would require an investigation of contemporary patterns of food consumption: what we eat, where we get our foods from, how our foods are packaged, and why we eat these kinds of foods.

In addition, each question is considered in relation to personal, local, national, and global perspectives. For example: *What is eaten in our home, in our local community, in New Zealand, in other places around the world?* The intention of this is to encourage students to think beyond how the issue affects them personally. It also emphasises the critical role of social, political and economic contexts in futures thinking, and raises awareness of the existence of multiple perspectives. An example of some of the variables that might be considered as part of a 'future foods' learning context is presented in Table 1. The number of variables possible within each area of the matrix, for example 'local trend' or 'global driver', provides scope for a wide range of possibilities.

Examples of classroom activities

A range of teaching and learning activities can be used to enable students to explore the components of the futures thinking model. This flexibility means that different activities can be selected to engage and motivate students, clarify concepts, identify relevant scientific and technological knowledge, and foster values' clarification and debate. Students also need to experience activities that challenge and extend their current understandings, and to be made aware of the multiple perspectives that may exist.

Students' abilities to use, critique, and adjust their thinking are also important (Conner, 2003).

Examples of some of the futures-focused classroom activities used in two science programmes are presented below. The first example is based on the experiences of a Year 4 class investigating the future of farming as an extension to a science unit on the dairy industry; the second draws on a 6-lesson programme on future foods that was implemented as a stand-alone unit with a Year 10 class.

Future farming

One of the key activities used by the Year 4 teacher to help students identify key trends and drivers in the dairy industry was a timeline obtained from the New Zealand Biotechnology Learning Hub (www.biotechlearn.org.nz). Each student was issued with a flashcard with a date and key event in dairying development, and the class arranged themselves chronologically. The subsequent discussion focused on the changes that had occurred (the trends), and

Table 1: Variables that might be explored as part of a 'future foods' learning context

Futures thinking components	Settings			
	Personal	**Local**	**National**	**Global**
EXISTING SITUATION *What do we eat now, and why?*	Nutritional needs for age and/or lifestyle Personal health Beliefs and values – vegetarianism, kosher	Available choices – shops, restaurants, farmers' markets Cultural influences	Cultural-specific preparation/choices of foods Regulations relating to food availability (e.g. imports) Regulations related to labelling Need for foods to improve national health	Concern over inequitable access to food Nutrient deficiencies Retail dominance of large corporate structures (buying policies impact on food production, 'just in time' marketing determines availability)
TRENDS *How does what we eat now differ from what was eaten in the past?* *Who benefits?* *Who loses?*	Changes in where we get our food (bought versus homegrown; fresh versus pre-packaged and/or processed) Increased variety the choices that are available	Increase in the number and variety of restaurants/ take away places Rise in popularity of local farmers' markets	Increasing choice of what is available, and from where Shop buying policies influence what is available Greater availability of 'convenience foods' Homegrown versus bought Fresh versus pre-packaged Popularity of organically grown foods Larger number of cooking shows on television Government initiatives promoting healthier lifestyles	Increased emphasis on 'convenience' – a rise in fast food outlets and ready-to-eat pre-packaged foods Concern about 'food miles' Globalisation – increased exposure to foods from different countries/cultures Fad diets promoted by celebrities Increased emphasis on 'convenience' – a rise in fast food outlets and ready-to-eat pre-packaged foods Concern about 'food miles' Globalisation – increased exposure to foods from different countries/cultures Fad diets promoted by celebrities
DRIVERS *What is causing the changes?* *Are they likely to continue into the future?*	Family lifestyles – cost, convenience Values – beliefs about what is healthy for you Awareness of personal energy and nutritional needs	Local deficiencies, e.g. Se Cultural influences/beliefs of a community Sustainability of food production and transport processes	Increasing diversity – different consumer groups want different foods Increase in food-related diseases (obesity, heart disease) Sustainability of food production and transport processes	Economic costs of food production and packaging Environmental costs of food production and packaging Population demographics – more mouths to feed Greater cultural diversity
POSSIBLE FUTURES *How might current trends affect the future?*	Ability to make an informed choice regarding what is purchased and eaten Ability to afford healthy food options Individualised nutrition - foods targeted to genotype (nutrigenomics)	Availability of specific dietary requirements in cafes and restaurants (e.g. for glucose intolerance, etc.)	Regulations affecting fast food outlets Food subsidies – e.g. no GST on fresh food/a sugar tax Regulated control of school lunches, e.g. only healthy options available for sale Increased role for foods traditionally used as medicine – Māori rongoa in NZ	Functional foods for specific purposes Novel foods developed Liquids versus whole meals Increased reliance on genetically modified foods Ability to deliver medicine through foods
PREFERABLE FUTURES *What foods do you want to be able to access? What about around the world?*	Students to make personal decisions			

the implications for farmers. For example, one student pointed out: "Tankers were good; the farmers didn't have to take their own milk to the factory," and another explained that being able to use a rotary milking shed: "Makes the job easier because you don't have to move." These trends were then explored in terms of possible drivers: Why can farms have more cows than they used to? Why can a farmer now milk more cows in a day than previously?

The students' ideas about possible and probable futures focused on the lifestyle of the farmer (reduced manual labour because of technological advancements to assist milking; greater economic advantages from being able to milk more cows) and the welfare of the animals (e.g. using video cameras in the paddocks to monitor cow behaviour and well-being). Similarly, preferred futures focused on the lifestyle of the farmer, alongside improved animal monitoring and welfare. Students' thinking was extended and reinforced with a writing activity in which small groups moved around the class and contributed ideas in a cumulative fashion to five questions representing each of the components of the futures thinking model:

What is dairy farming like these days? How has dairy farming changed? Why has dairy farming changed? What might dairy farming be like in the future? What would you like dairy farming to be like in the future?

The responses suggested that the following key concepts had been considered. Firstly, dairy farming is labour intensive, this has implications for the lifestyle of farmers; there is also a shortage of farm workers. Secondly, over time, dairy farms have become bigger in size and in number of cows. Inventions such as the herringbone and rotary sheds mean that farmers can milk more cows per day. This is good for profits. Thirdly, it is in a farmer's best interests to keep the cows healthy. Fourthly, future changes that might make dairy farming more profitable will tend to focus on ways to enhance milk production in cows, and technologies involved in collecting the milk.

Although 'trends' and 'drivers' were not terms that the 8-year olds were familiar with, the teacher was comfortable with how she was able to introduce the language and felt that the learning would become even more powerful if the futures terms and concepts were used consistently in subsequent units. The learning could also have been extended to include political and environmental dimensions, for example, environmental impacts of increasing cow numbers on farms (e.g. effluent run-off into waterways and increases in methane gas production), and the political implications of this (e.g. the Government's commitment to reduce greenhouse gas production). This would have allowed the viewpoints of a wider range of stakeholders to be introduced and considered, expanding the notion that a 'preferable future' is a personal choice, to one in which 'preferable futures are viewed as having global implications.

Future foods

A Year 10 class that engaged in a six-lesson unit on future foods was introduced to the five components of the thinking model via a range of activities. For example, a whole-class brainstorm was used to elicit students' ideas about the existing situation (foods that are currently available). Students were then required to transform this information into mind maps or fishbone diagrams and to identify trends in food over time (see Figure 1 for an example of one student's work). A whole-class discussion facilitated by the teacher helped the students to identify key drivers – factors that may have led to, or resulted in, the identified trends. Students' responses reflected an understanding of the concepts of change, the rapidity of some changes, and what change might/can/will bring, with ideas focusing on:

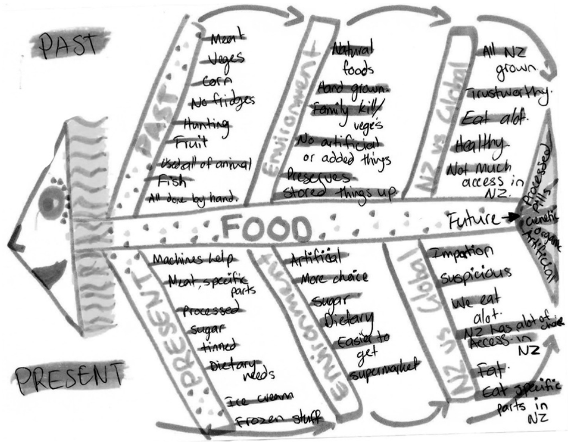

Figure 1: Work produced by a Year 10 student in response to trends in eating habits and food availability.

- increased access to fast food outlets and reasonably-priced restaurants
- increased access to convenience foods (suiting busy lifestyles)
- a greater variety of foods being available, including greater exposure to foods from other countries
- better systems to transport food nationally and globally
- health issues and greater awareness of diseases associated with poor eating habits
- advertising of food products
- popularity of cooking shows and recipe books
- increased population growth and subsequent impact on food availability.

To introduce a values-based discussion about possible and probable future foods, students were presented with 15 examples (e.g. eggs with omega-3 added to reduce the risk of heart disease and arthritis) and asked to make a judgement about the desirability of each option. The potential to genetically modify foods using modern technologies generated particular interest. Students were then given a scenario situated in 2040 in which they were required to promote the development of a future food they had designed. Presentation guidelines helped focus group discussions on the underpinning science: describing why the food product is needed; what it is; how it works; and the benefits and risks of its development.

The teacher concluded the unit by facilitating a whole-class discussion about factors that would shape the development of foods in the future, linking the presentations to the overall aim of developing futures thinking skills. Examples of drivers, introduced by the students, included: new technologies, such as genetic modification; future research, such as identifying useful genes; the sharing of such new information; public support for these new technologies; and needs, such as feeding a growing population. This discussion highlighted the central role of drivers in shaping technologies of the future. As such, they sit 'in the middle' and are a key component of discussions focusing on both the existing situation and possible/preferable futures. However, there was limited exploration of wider environmental and political issues, such as environmental sustainability of food production and transport processes, and government policies related to food safety and labelling. Trends such as eating fewer refined foods for health reasons were also largely ignored. Time constraints also meant that genetic modification as a process was not explored in detail, including the complexity of the genetic modification process and the potential for unforseen (and unforeseeable) side-effects (see Hipkins, 2009).

Although the teacher of this class indicated that she had incorporated futures ideas into her teaching in the past, she said the unit took her "a stage further" and was "highly effective in enabling futures thinking in these Year 10 students." She was particularly pleased with levels of student engagement, and liked the range of interactive tasks that could be used to facilitate meaningful discussion. Positive learning outcomes, as reported by the teacher, included thinking that "was at a high cognitive level as they articulated and justified their positions on preferable futures", "tolerance of other people's viewpoints and an awareness that there are [sic] a range of views when thinking about possible and preferable futures", and an increase in students' understanding about the role of scientists in developing new foods.

The futures thinking tool on the Science Learning Hub

The futures thinking tool on the Science Learning Hub (http://www.sciencelearn.org.nz/Thinking-Tools/Futures-thinking-tool) provides an interactive environment in which students can consider all five elements of the futures thinking model at the personal, local, national and global levels; and a record of their thinking can be inserted and saved for future visits (see Figure 2). A final screen asks students to consider their responses and explain their thinking by responding to three final prompts:

- My preferred future is…
- Three reasons I think this are…
- Three reasons why others might not agree with me are…

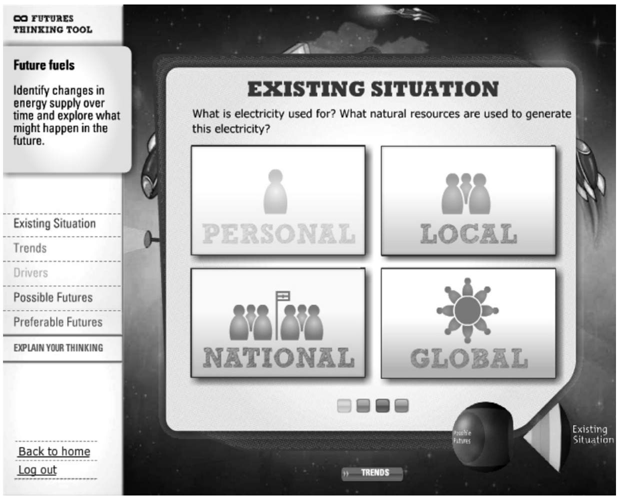

Figure 2: The futures' thinking tool, an interactive tool to encourage student exploration of futures' issues (www.sciencelearn.org.nz).

Teachers can insert a futures issue designed to suit specific classroom programmes, or use the default issues: future foods, future fuels, and future medical care. In order to customise the tool to display an issue of your choosing you need to ensure that you indicate you are a teacher when you register.

The inquiry model, focusing as it does on open-ended questioning, also offers students opportunities to present and evaluate their ideas, weigh up evidence, detect bias and present and justify their decisions. Because futures thinking is inherently values-laden, it is also important that a safe and structured learning environment is created in which students can learn about the multiple perspectives that may exist; they should feel empowered to share their views, listen to one another with respect, and balance the competing needs of multiple stakeholders.

Discussion and conclusion

Futures researchers help communities to envision their preferred futures and compare those visions with current trends and scenarios of possible futures (Schultz, 2003), emphasising transformational change rather than simply trend extrapolation (Burton, 2005). Such thinking is increasingly regarded as a valuable approach to dealing with a world characterised by uncertainty, with the aim being to gain knowledge and understand alternatives (Slaughter, 1995).

Important factors affecting futures thinking and learning include an understanding of the relevant science and technology; the social, political and economic factors that influence decision making; and recognition of multiple perspectives. The conceptual model presented here outlines how these might be brought together to incorporate a futures focus in science classrooms, especially where socio-scientific issues are used as the basis for the learning programme. In particular, the conceptual model can be used to form the basis of an inquiry through which students can examine issues that impact on their own and society's future in a structured way. Having first focused student attention on the existing situation, trends, and drivers, this information can then be used to explore possible and probable futures in a manner that reduces guesswork whilst still encouraging creativity. A consideration of the social context within which the changes might take place – how people respond, react, and adapt to change – is also critical, as reflected in the multiple social levels – personal, local, national, and global – built into the model. These multiple dimensions provide an important scaffold students can use to consider the complexity and interrelatedness of systems. The two examples presented above demonstrate that a range of engaging strategies can be used in this process. There is also scope within the model for additional aspects, such as environmental and political factors and health and equity issues, to be articulated and considered, moving decision making from an egocentric activity to one valuing the welfare of the planet as a whole.

It is our hope that the model can be used to extend traditional approaches to science topics by linking relevant scientific and technological understandings with key futures concepts and creative thinking, and that students will be encouraged to develop critical, reflective, and flexible responses to future-focused issues that affect them as individuals and as residents in local, national and global communities.

For further information contact: **buntting@waikato.ac.nz**

Acknowledgements

This work was part of a larger project carried out by Anne McKim, Cathy Buntting, Lindsey Conner, Rose Hipkins, Louise Milne, Kathy Saunders, Michael Maguire, Paul Keown, and Alister Jones (2006) and funded by the Ministry of Research, Science and Technology. We are grateful to the teachers and students who trialled these ideas in their classrooms.

References

Burton, L. (2005). The fascinating future: Futures studies - past, present, and future. *Futures Research Quarterly*, 21(1), 69-74.

Cornish, E. (1977). *The study of the future. An introduction to the art and science of understanding and shaping tomorrow's world*. Bethesda, MD: World Futures Society.

Conner, L. (2003). The importance of developing critical thinking in issues education. *New Zealand Biotechnology Association Journal*, 56, 58-71.

DERA. (2001). *Strategic futures thinking: Meta-analysis of published material on drivers and trends*. (London: Performance and Innovation Unit, Cabinet Office)

Hipkins, R. (2009). Complex or complicated change? What might biology education learn from disciplinary biology? *New Zealand Science Teacher*, 122, 33-35.

McKim, A., Buntting, C., Conner, L., Hipkins, R., Milne, L., Saunders, K., Maguire, M., Keown, P., Jones, A. (2006). *Research and development of a biofutures approach for biotechnology education*. Report commissioned by The Ministry of Research, Science & Technology. Wilf Malcolm Institute of Educational Research, University of Waikato.

Schultz, W. (2003). *Infinite futures*. Retrieved June 20, 2010, from www.infinitefutures.com/aboutif.shtml

Slaughter, R. (1995). *Futures tools and techniques*.(Hawthorn, Victoria: Futures Studies Centre.

UNESCO. (2002). *Teaching and learning for a sustainable future*. Retrieved June 20, 2010, from http://www.unesco.org/education/tlsf/

Copyright of New Zealand Science Teacher is the property of New Zealand Association of Science Educators and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.