CHRIS EAMES, JOHN LOCKLEY AND LOUISE MILNE

7. EDUCATION FOR SUSTAINABILITY IN PRIMARY TECHNOLOGY EDUCATION

This chapter focuses on integrating education for sustainability (EfS) into technology education in primary schools in New Zealand and Australia. The curricula of both countries have featured technology education as a learning area since the late 1980s and early 1990s (Australian Curriculum Assessment and Reporting Authority [ACARA], 2014a; New Zealand Ministry of Education, 1993). The development and use of technology is a key part of life in today's society. For students, studying technology at school can develop their thinking about and engagement with technology and its role in society, and provide them with access to technology-related careers (New Zealand Ministry of Education, 2007).

Technology education involves a focus on design, innovation to solve problems, and enterprise. It incorporates technological knowledge and practice and develops an understanding of the nature of technology. Because technology is a distinctly human-oriented activity, it has social (including ethical and political), cultural, economic and environmental dimensions. It is this multidimensional nature of technology education that provides clear opportunities to integrate it with EfS.

Technology and the development of society are closely linked. Technological developments have enabled us (human beings) to dramatically expand our natural capacities, allowing us to fly, move fast, gain greater physical power, farm other species, and expand the number of our own species beyond the carrying capacity of our environment. These developments mean that today we have significant influence over much of the natural and physical world.

This influence has had much benefit for our species as well as some general benefits for Earth. Examples of benefits for humans include improved medical provision and food production systems. Technologies that enable us to rectify damaging aspects of human activity, such as "cleaning up" after pollution spills and reclaiming land damaged by natural disasters, may be seen as positive for the planet. However, we have become increasingly aware of the many negative impacts that our technological abilities are also having on Earth. Examples of these technologies include mineral and fossil fuel extraction and production of synthetic materials that are not readily recyclable or biodegradable. If we are to continue our existence as a species on this planet, it is critical that we come to understand and then address these detrimental impacts.

Technology is fundamental to human development; so is sustainability. It therefore makes good sense to provide our children with education that enables them to make consequential links between these two important concepts. Technology-related learning in primary schools centres on designing and making tasks that generally readily engage young children. Such tasks allow the children to link the conceptual and the practical, so creating learning that they

N. Taylor et al. (eds.), Educating for Sustainability in Primary Schools, 121–134.

find meaningful because they can easily connect it to real-life contexts. Creative thinking and practical abilities may also be fostered.

Technology education encompasses three key ideas/outcomes. First, it requires development of technological knowledge underpinned by some of the principles on which it draws, such as aesthetics, efficiency and optimisation. Our students need to understand how and why things work, the role of design, and how enterprise relates technology to societal needs. Knowledge of materials and systems is also essential. Evident here is the clear link to the principles of sustainability, such as renewable resource use and waste minimisation.

Second, technology education requires our students to develop technological practice or skills, ranging from identifying needs (which includes technological and sustainability criteria) to developing a design brief, doing functional modelling to test ideas, evaluating the tests, making a product or system, communicating these outcomes to an end user and evaluating if and how the criteria have been met. Technological practice of this kind also requires consideration during the design phase of ethics, legal and safety requirements, and the impacts of the product or system on society and the environment.

Thinking about these aspects of technological practice makes clear an important point, namely that the decisions made throughout the technological process cannot be predicated on economic, social and environmental sustainability factors in isolation. Instead, each of these dimensions must be considered together. For example, individuals designing a product should consider the choice of materials from a cost and availability perspective and also the social conditions under which these materials were produced (e.g., fair trade, child labour) and the environmental impacts, including manufacturing and disposal, of their use. While some of these issues may contain concepts too advanced for young children, we can use simple examples to introduce them to these principles.

Third, technology education requires students to understand the nature of technology and its impact on society and the environment. Students can attain this understanding by exploring the role of technology in society and identifying, from a sustainability perspective, how beliefs and values can enable or constrain technological development. Students might, for example, investigate the difference between needs and wants in terms of how different levels—individual, community, nation or the planet—view various technological developments. From here, students could discuss the practice of consumerism and social justice between first world and third world countries and across past, present and future generations.

As a teacher, you can approach integration of EfS and technology education in several different ways. Two, however, tend to be particularly effective. The first would see you selecting an environmental or sustainability issue and then having students design a technological solution to the particular problem. An obvious environmental context, such as recycling or water conservation, will not only focus students' technological practice and learning on producing a technological outcome that will have positive effects for the environment but also help them see that technological practice can be applied to solving environmental problems. Using the second approach, you would focus on developing a technological product or service and ask students to consider sustainability matters through the development. Here, issues of sustainability are accorded the same priority as issues of aesthetics and function.

These two EfS-based approaches, or a mixture of them, typically bring together many ideas and values that can be overly complex for young students. When endeavouring to cover all aspects of your technology education curriculum, you may consequently find it difficult, perhaps impossible, to include all aspects of sustainability in your teaching. Instead, gradually integrate sustainability ideas into your technology teaching so that sustainability becomes a way of thinking for students and not just another thing to learn.

EfS emphasises knowledge, experience and action dimensions. Knowledge is relatively easy to cover and can be built into, for example, exploration of materials and how sustainable they are. Providing students, young students especially, with experiences directly pertaining to environmental issues is an important—and generally fun—way of helping them reflect on and build knowledge. Such experiences could take place in the school grounds, in the bush, or at the beach. Experiences centred on environmental issues that can be addressed or solved through technology include visits to waste disposal sites or degraded waterways. Just how you might bring sustainability practice into a technology education context is less obvious, but often revolves, in terms of direct actions, around waste-disposal systems such as worm farms and paper recycling. Many other options present, however, when indirect actions are considered, as we show at the end of this chapter.

Taking action is fundamental to learning in EfS, as was discussed in relation to the notion of action competence in Chapter 3 of this book. Technology education itself demands a form of action when its focus is on developing a product or system to solve a technological problem. This action-oriented aspect of technological practice offers a good linking point for EfS. At first glance, bringing in this further layer of complexity (i.e., requiring action for sustainability within technological practice) may seem a little daunting. Added to this is the realisation that young, primary-age students may find it difficult to know how to take self-initiated action for sustainability (see, in this regard, Eames et al., 2006). However, when action in an integrated technology education and EfS context is framed correctly, it can be viewed as students making an active and intentional choice to develop technological solutions in an environmentally sustainable way. So, for example, students might use a renewable material in their work or they might strive to ensure that the messages they convey or the pathways they offer for recycling their products when marketing them or in any other communication about them are clear. These indirect actions help to raise awareness about sustainability issues.

Thus far, we have made the case that technology education and EfS can sit comfortably together. We now examine the technology education primary school curricula of New Zealand and Australia and their potential for EfS. Table 7.1 provides a summary of the themes in each curriculum.

TECHNOLOGY EDUCATION CURRICULA

The technology curricula of Australia and New Zealand have developed over time. Focusing initially on students' technical endeavours, such as practical manufacturing skills in woodwork, metalwork, cooking, and sewing, the two curricula have progressed through phases of design, make and appraise to the contemporary approach of technology education based on developing students' technological literacy. The development of the Australian national curriculum (Australian Curriculum Assessment and Reporting Authority [ACARA],

Table 7.1. Comparison of themes across technology education curricula of Australia and New Zealand.

Country	*Areas of technology*	*Technology strands*	*Content structure*
Australia	Design and technologies	Knowledge and understanding	Use, development and impact of technologies in people's lives Design concepts across a range of technology contexts
		Processes and production skills	Critiquing, exploring and investigating needs and opportunities Generating, developing and evaluating design ideas for designed solutions Planning, producing (making) and evaluating designed solutions
	Digital technologies	Knowledge and understanding	How data are represented and structured symbolically Components of digital systems: software, hardware, network Use, development and impact of information systems in people's lives
		Processes and production skills	Collecting, managing and interpreting data when creating information, and when determining the nature and properties of data and how it is collected and interpreted Using a range of digital systems and their components and peripherals Defining problems and specifying and implementing their solutions Creating and communicating information, especially online, and interacting safely, using appropriate technical/social protocols
New Zealand	Biotechnology control Food Hard materials Information and communication structures Textiles	Technological knowledge	Technological modelling Technological products Technological systems planning for practice
		Technological practice	Planning for practice Brief development Outcome development and evaluation
		Nature of technology	Characteristics of technology Characteristics of technological outcomes

Sources: Australian Curriculum Assessment and Reporting Authority (2014); New Zealand Ministry of Education (2007).

2014b) out of the country's previous states-based curricula has seen the emergence of a dichotomous view of technology wherein digital technologies are kept separate from the other forms of technology, and are labelled respectively as "design" and "technologies"). This separation also exists in the New Zealand curriculum (New Zealand Ministry of Education, 2007), but perhaps to a lesser extent given that digital technologies in the guise of "information and communication technology" still reside alongside other areas of technological endeavour.

In both curricula, learning in technology is structured around knowing and doing through a technological practice approach. In the Australian curriculum, learning is separated into two strands—"knowledge and understanding" and "processes and production skills". A similar structure exists in the New Zealand curriculum, through the strands labelled "technological knowledge" and "technological practice" (see Table 7.1). The most obvious difference between the two curricula is the presence of a third strand, "the nature of technology", in the New Zealand curriculum. Here, students learn not only *in* technology but also *about* technology itself.

The approach to student learning in technology that these curricula imply is one where students learn while actively involved in technological practice. Such practice can be defined simply as "what technologists do", in a similar way to medical practice being described as what doctors do. Several models of technological practice have been developed that attempt to show the holistic nature of technology and the different dimensions of its interactions with human endeavour (see, for example, Kline, 1985; Pacey, 1983). In addition to delineating the technical aspects of technology, such as knowledge of skills and techniques, tools, machines, and manufacturing, the models identify the dimensions of technology. These encompass knowledge of cultural and organisational aspects, such as goals, values, beliefs, ethics, creativity, economic ideologies, and users and consumers.

When considering EfS in technology education, we gain opportunity to focus on issues of sustainability as valid dimensions of technological practice, alongside more traditional dimensions such as function and aesthetics. This more holistic view builds on the earlier models of technological practice and is useful for teachers as we grapple with the detail of curriculum expressions of technology while simultaneously trying not to lose sight of the big picture. This overview of technological practice in terms of its dimensions also allows us to identify the most obvious opportunities for linking EfS into technology education.

In essence, this approach to linking EfS and technology education takes a holistic view of technology relevant for the 21st century, with technological practice positioned not only as engagement with the technical components of technology, but also as appreciation of cultural, organisational and environmental aspects. As teachers, we should be mindful that if our technology programme is one of students simply making stuff, then we are probably not meeting all of the dimensions of technology education that we could be; we will also be significantly diminishing opportunities for EfS.

The curricula structures presented in Table 7.1 support an approach to technology education that provides opportunity to address EfS through authentic, practical, problem-solving technological practice. Adoption of this approach gives prominence to several consistent components of classroom practice. These include investigating/gaining technological knowledge, designing, producing/making, and critiquing/evaluating/reflecting.

Although this list is not comprehensive and although a wider understanding of technology education is not the brief of this chapter, other curriculum research has identified up to 13 components that could be addressed (see, for example, Johnsey, 1995, pp. 203–205). They include identifying, clarifying, specifying, researching, generating, selecting, modelling, planning, making, testing, modifying, evaluating and selling.

When approaching EfS through technology education, teachers can offer the following sorts of activities as a means of linking technological practice and EfS. These activities focus on concepts of environmental sustainability within technological practice. Again, the list is not exhaustive, or prescriptive. Also, depending on the age and previous experience of the children, some or many of the activities can be incorporated into the children's technological practice. Students can thus:

– Plan for environmentally sustainable technological practice by:
  - identifying authentic contexts (the technological problem/need/opportunity /scenario) where environmental and/or social sustainability issues allow possible technological practice
  - recognising characteristics of environmental sustainability in design, such as optimisation, product life cycle analysis, design for disassembly, design for repair, material recyclability, renewability of resources, carbon footprint
  - investigating and identifying the sustainability characteristics of existing technologies, and developing criteria around how these characteristics might be incorporated into or improved on in their own designs.
– Design environmentally sustainable solutions by:
  - identifying the stakeholder groups (including environmental) influencing the technological problem, and investigating their influences on design specifications
  - developing design briefs that take into account not only the technical requirements of the solution but also the views and concerns of stakeholders and environmental considerations, so facilitating culturally, environmentally and socially defensible products, processes and systems
  - planning, implementing, managing and evaluating the design process so that it is directed toward design solutions to technological problems that take into account sustainability as well as functional, aesthetic and production specifications
  - modelling and testing proposed technological solutions with regard to sustainability as well as functional and aesthetic specifications
  - considering the implications of production methods in relation to sustainability issues as well as aesthetic, cultural, ethical, safety and functional factors
  - developing an understanding that technological products are made from Earth-sourced materials and that these resources must be managed for sustainability, with the latter a process which includes consideration of their supply and disposal, their performance characteristics and the possibilities for renewability and recyclability.
– Realising technological solutions by:
  - matching the characteristics of resources with tools and techniques suited to making environmentally sustainable products that meet design challenges
  - selecting and safely using equipment and other resources to meet the requirements and constraints of design tasks focused on constructing technological outcomes,

including concepts, plans and briefs, technological models and fully realised products, to specified quality standards including environmental standards
  - understanding how production systems have changed over time in response to changing societal demands, including the change to environmental sustainability, and applying these ideas to their own production systems
  - evaluating the fitness for purpose of technological outcomes (product, process or system) against the original specifications and intent (including environmental sustainability) of the problem.
- Developing a greater understanding of the nature of technology by:
  - identifying the impacts, positive and negative, of new technologies on society and the environment
  - developing the understanding that technology is a human endeavour that influences people, communities and the environment in complex ways.

While this list of student activities can seem characteristic of a sequential approach to technology, in reality these activities exemplify a far more reflexive approach to technological practice. This is because students are asked to critique, analyse, value and appreciate the complex relationships between technology and society and to consider these when designing not just the technical aspects of a solution but all aspects of and throughout the process of technological practice. Instead of sequentially “marching” through the process of technology, students take a more iterative approach by asking questions about how the technology they are developing will work and affect other people and the environment. This “conversation” as a designer with respect to a design problem holds great opportunities for developing EfS within technology education and marks one aspect of students developing critical technological literacy and action competence. Donald Schön expresses this potential thus:

> A designer makes things. … This work occurs in particular situations, using particular materials. … Typically, this making process is complex. … The designer shapes the situation, in accordance with his [sic] initial appreciation of it, the situation “talks back’, and the designer responds to the situation’s talkback. … In answer to the situation’s talkback, the designer reflects in action on the construction of the problem, strategies in action, or the model of the phenomena. (Schön, 1983, p. 78)

In summary, the key to integrating EfS into technology education using a technological practice approach is to develop questions that reflect issues of sustainability and can be applied when developing the design brief that students respond to during their technological practice. These questions should identify the specifications of the intended technological product and provide opportunity to bring sustainability issues into the forefront of each student’s technology education experience. Such questions also frame the search for relevant knowledge and understanding about technology and how it interacts with society. They furthermore bring attention to how issues of sustainability can influence technological practice.

Whatever the context chosen for teaching and learning in technology, once the technological problem has been identified and students have become involved in technological practice, you and they can discuss and define the characteristics of a successful solution, with these eventually specified in the form of the design brief. Issues of sustainability can be included during development of the brief specifications and discussion of the characteristics of a successful solution. Traditionally, design specifications reflect functional, aesthetic and production issues. In technology education reflecting EfS, issues of sustainability are included during the process involved in designing and evaluating the criteria for success. We now provide some examples of how this process can be achieved in primary school settings.

PRACTICE IN TECHNOLOGY EDUCATION AND EFS

Here we present three examples. The first two begin with an environmental issue and then incorporate some form or forms of technology in the process of finding a solution. The third focuses on a technological problem that includes consideration of sustainability during attempts to find solutions.

1. Education for sustainability incorporating technology education

Learning experiences in technology education should be based on an authentic context that offers students and their teachers the opportunity to identify and address an appealing real-world need or opportunity. Student practice in this type of unit generally follows a process of planning, designing, realisation and evaluation, culminating in the development of a final outcome that is fit for its intended purpose. The following commentary relates to an instance of EfS that incorporated technology education. It tells the story of a group of nine-year-old students and their teacher who identified an environmental problem in their local area and then addressed it using a technological solution. This issue provided students with opportunities to gain experience in the environment, inquire into knowledge about the environment and take action for the environment.

Identifying an authentic context The story begins on the outskirts of a city in New Zealand where a gully system and stream runs behind a group of farmlets and lifestyle blocks. Although the gully is owned by the local city council, local residents maintain it on an ad hoc basis. The gully is bordered on the northern side by an animal research centre. In earlier times, this area provided a popular swimming hole and fishing spot for local families. However, it deteriorated over time, with the waterway becoming blocked with debris, which resulted in the swimming hole also filling up with rubbish and becoming stagnant. Local residents blamed the deterioration on run-off from an old silage (fermented cattle feed) dump located on the research centre's property and not far from the stream. A resident in the area wrote to the local newspaper in an attempt to draw attention to the damage and gain support to reclaim the area as one that families could again enjoy.

The resulting buzz of interest amongst the students and their parents provided a perfect platform from which teachers at a nearby school could launch a unit pertaining to the technology curriculum and the EfS curriculum. The problem provided an *authentic, real-world context* with an environmental focus that was challenging, motivating and provided extensive opportunities for learning in both curricula, as well as necessitating background research associated with bacterial action and the break-down of silage.

Planning for technological practice and EfS action Once the topic was introduced to the students, it quickly gained momentum and initiated animated discussion as students attempted to grapple with how they should proceed. The teacher's role was to ensure that students planned their project carefully by investigating and clarifying the problem, seeking expert help and remaining aware of the needs and interests of the various stakeholders.

Investigating the context The students identified several preliminary investigations during the planning phase. One of the key questions they addressed was whether or not rotting silage was in fact responsible for damage to the stream and, if so, what landowners needed to do in order to prevent further pollution and restore the stream to its original condition. In order to help students fully understand the problem, the teacher suggested they should investigate silage—its purpose, how it is made, and how it is most effectively stored.

A city council environmental specialist visited the class and explained that incorrectly stored silage can result in run-off. Should this run-off drain into nearby streams, it typically impacts on water nitrate levels, plant growth and the ability of animals (fish, invertebrates) to survive in the water. He emphasised that the quality of the stream water running through the gully needed to be confirmed, and he suggested that the students run a series of tests and then compare their results with those gained from a healthy stream. This approach provided the students with opportunity to experience working in a particular environment in order to gather data. The students sought the help of the city council officer to help them carry out the series of tests, first at the gully site and then at another stream known to have very good water quality. The tests included or focused on identification of pH levels, nitrate levels, water turbidity and velocity, plant life, animal life and features of the surrounding catchment area.

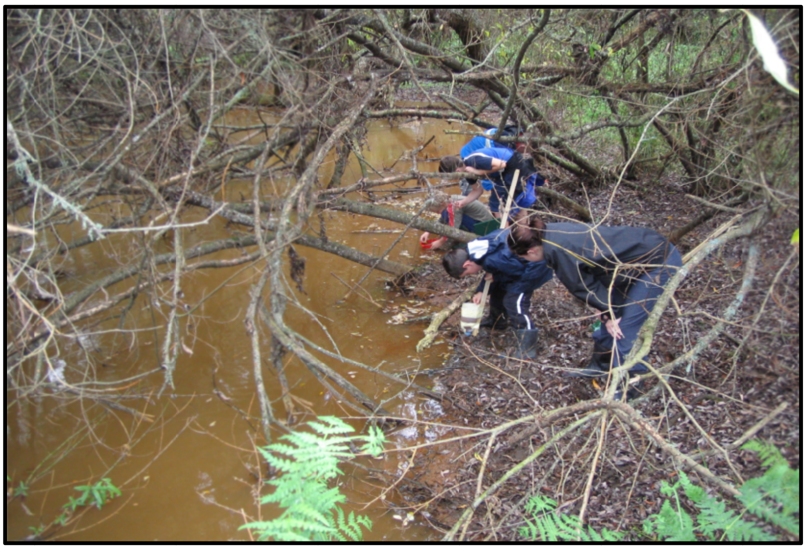

Figure 7.1. Students testing water quality in the degraded gully stream.

On receiving the results of this work, the students were surprised to discover that the nitrate levels in both streams were within a similar range. With the help of the city council officer, they decided that run-off from silage was not the only reason for damage to the gully stream. They concluded that a range of factors, largely concerned with management of the stream's banks and bed, was contributing to the damage. The implications for preventing further damage included ongoing maintenance of the stream to remove blockages, planting to provide stability to the banks and create areas of shade, and establishing designated and properly constructed crossings for horses and other animals to avoid compaction of the soil and reduction of its natural absorbency.

Designing and realisation For the students, finding the solution to the water quality problem was more complex than they had originally assumed. With the help of experts from the city council and the research centre, the students and their teacher agreed that the solution needed to focus on sharing the information they had gathered not only with those owners whose land bordered the stream but also with those who had waterways running through their properties that fed the stream. They agreed that the best way to achieve this would be to produce an informational pamphlet for distribution to these landowners. The pamphlet would allow the students to disseminate an important message on sustainable water management practices to those people whose actions were most likely to have an effect on the students' goal of improving the water quality of the stream. The teacher offered students support in designing the pamphlets, especially with respect to providing guidance with formatting, selecting appropriate images and ensuring that the information to be incorporated was accurate and likely to be accepted by the residents whose properties bordered the stream.

Identifying key attributes of the pamphlet During their work on a previous unit, the students had experimented with developing simple pamphlets. Under their teacher's guidance, they now drew on these skills to design and construct a pamphlet that was credible, informative and sufficiently motivating to prompt the receiver into action. The students collected a range of existing pamphlets in order to identify the features of a professionally designed pamphlet. One group of students also visited a local design company to gain further expert advice. This work led to discussions on the characteristics of the target recipients of the pamphlet and on its visual appeal, with the latter requiring consideration of font and picture size. Students also addressed accuracy of information, material selection, and structural details (e.g., number of panels, the position of folds). These elements formed the criteria guiding the students' pamphlet design and the assurance that the final product would meet its purpose. Students selected and checked information for accuracy, determined which images and text would have instant appeal to adult householders and considered how the guidance in the brochures would be received. The success of this work thus relied on students considering the values and attitudes of stakeholders and planning their action accordingly.

Modelling and developing a prototype The teacher had the students form design groups and asked two members from each group to produce a mock-up of their pamphlet so they could ascertain its capacity to impart information before beginning work on the first draft. Students printed several black-and-white models of their pamphlets, each time assessing and refining the content and text/graphic placement in order to achieve the best fit. Throughout, the teacher encouraged the students to keep their final goal in mind and to ensure that they continued to address the previously identified attributes.

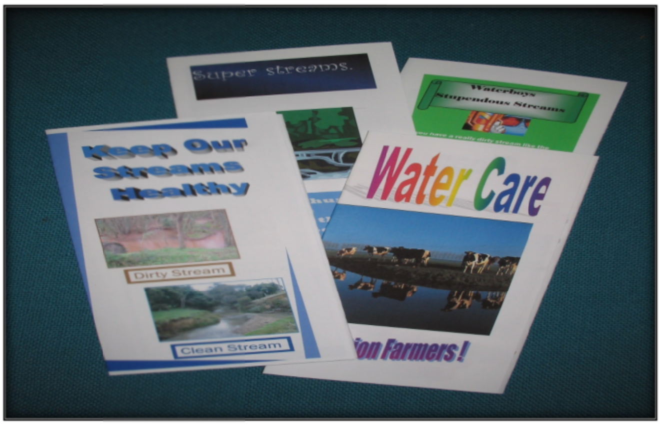

Figure 7.2. Completed pamphlets.

Evaluation On completing their modelling and editing work, the students gave their pamphlets to a representative from the research centre for critique and feedback. Several modifications later, the final versions were printed. Before delivering the pamphlets, the school composed a covering letter which explained the nature of the students' project and offered opportunities for feedback through a temporary portal on the school website. The delivered pamphlets and letter were received by residents with considerable interest and goodwill. While the long-term effectiveness of this action is uncertain, the students made extensive individual gains in their understanding of the processes involved in taking personal action to resolve environmental problems.

2. Designing bird-nesting boxes—sustainability and technology

In this example, both sustainability and technology education act as drivers, with the two learning areas complementing each other. Many primary schools have found that bird-nesting boxes form the basis of a topic well suited to this complementarity. The impetus for the topic (i.e., bird-nesting) usually derives from an interest in attracting native birds to the school grounds or in protecting those birds already there or found elsewhere in the local community.

One such example in New Zealand has been a focus on designing nesting boxes for penguins, in particular the world's smallest penguin, the little blue. This penguin can be found nesting in burrows in sand dunes all along New Zealand's coastline. These nesting sites have come under increasing pressure in recent years from the twin threats of coastal development and introduced predators such as cats and stoats. In response to these threats and consequent nesting failures, schools and community groups have been constructing nesting boxes within which the penguins can safely breed. In some instances, schools have collaborated with community groups to build and locate the nesting boxes. Building nesting boxes provides an authentic context for technology education. By allowing students to develop knowledge of the nesting requirements for the little blue, gain empathy for the bird, and learn how to take action for a more sustainable future, the activity meets objectives in both technology education and sustainability education.

As with the first example (stream degradation), it is important that students engaged in this activity take an inquiry learning approach so that they can formulate and find answers to questions that interest them. Teachers can facilitate this process by perhaps introducing the topic through a discussion centred on the problems associated with penguins nesting in the local area. Introductory work might include research about penguins and their place in the marine ecosystem, including their feeding and breeding behaviour. A field trip to a coastal site, possibly at dusk as the penguins come ashore, would help students gain a better understanding of the challenges the penguins face, and help develop empathy. This experience could lead to discussion of possible solutions to the difficulties the penguins experience throughout their breeding season, with the teacher guiding students towards a nesting-box solution.

If students accept this solution, a design phase should ideally follow, during which students consult stakeholders such as coastal landowners, develop a design brief and undertake modelling in order to ascertain the specifications for the nesting boxes. The aspects of function and production would need to be considered, as would decisions concerning choice of materials. These decisions would need to acknowledge sustainability and end-of-life waste issues for the materials, as well as their suitability for the penguins. Key design elements, such as ensuring only the penguins can access the boxes and that the boxes fit aesthetically within the coastal environment, would also be important. A feasibility study designed to consider issues such as costs of materials, access to construction tools, and possibly labour may also be required.

During the realisation phase, keeping the students' learning opportunities in view is vital. Depending on the age of the children, it may be necessary to engage adults (parents, community members) to help construct the nesting boxes, as occurred in a collaboration between a Lions club and Kahutara School (Aorangi Restoration Trust, 2013). However, ensuring that the adults do not alter the design of the boxes without first discussing this matter with the children is of fundamental importance. If adults take over this task, the children's learning about design cannot be assured. Adults can also help with transporting and siting of nesting boxes, and parents can be encouraged to join their children by signing up for a roster to monitor use of the boxes. In addition to periodic monitoring of the numbers of birds coming ashore and assessing how well the technological design process has met the criteria for penguin breeding success, evaluative techniques can be used to ascertain overall project outcomes.

In this example, the production of nesting boxes that lead to successful penguin breeding is an important outcome but is not the main focus. Rather, the key objective is student understanding of technological thinking and practice and sustainability thinking and behaviour, such that the students can transfer their learning to other contexts.

3. A technological problem incorporating sustainability

In this alternative approach to linking technology education and EfS, the chosen context could be one that is independent of environmental connections. To express this thought another way, the authenticity of the context remains an important consideration but the context may not be overtly environmental. For example, a common issue in junior classrooms is that of children bringing small, precious items to school such as toys and marbles that can be easily lost or misplaced, a situation that the children generally find very upsetting. A technological solution to the problem could be to have them design and construct a personal container to hold their special possessions. In addition to helping the children understand the place of design drawing and concept sketching, or the skills of construction, such as measuring, cutting and joining, this type of unit can encompass issues of sustainability.

Reference to the list of possible activities that focus students' technological practice on concepts of sustainability suggests examples that offer the basis of teacher planning. Thus, for example, students could learn about sustainability through the technological practice associated with developing containers for their precious items by:

- Investigating existing containers that will meet their needs and then identifying the sustainability characteristics of those containers and how these might be incorporated or improved upon in their own designs;
- Developing a design brief (set of criteria) for their own individual container that specifies its technical requirements as well as their personal preferences of materials and style, justifying these in terms of the social setting of their classroom (the intended place of use) and the environmental implications of their choice of materials;
- Modelling (including drawing and working models) and testing proposed container designs with regard to sustainability and also functional and aesthetic attributes;
- Matching the characteristics of available resources (tools, techniques, students' skill levels) to the construction requirements of their chosen container, which they have designed to be environmentally sustainable; and
- Evaluating the fitness for purpose of their container against their stated functional, aesthetic and sustainability specifications (as noted in their design brief).

This activity should enable students to understand that materials are resources used in technology and that these resources must be managed for sustainability, with that management including supply and disposal. Questions about the materials (e.g., wood, cardboard, plastic, clay, metal, etc.) the container could be made from would consider, in addition to those regarding ease of manufacture, issues of sustainability. The source of the material and how it became available for them to use, whether it is renewable or non-renewable, how much energy is used in making it, what material will be used to join or fabricate it and what effects all of this might have on the environment become important. As students consider these questions, they will also be learning to identify the impacts, both positive and negative, of new technologies on society and the environment. For example, when deciding which materials to choose for their container, they can identify what wastes will be produced when the container is made of any or all of these materials and the issues of what happens to this waste. Depending on the age of the children, an additional level of consideration could be the life expectancy of the container. The question of what will happen to the container once the children no longer want it can be posed. Can it be recycled or reused somewhere else? What is the product's expected life cycle?

It is important to note from this example that a number of the suggested activities present a logical fit with the specified context (a container for precious things) and the intended technological practice. Another point to note is that no one technology example can include all of the suggested activities, or that there is a linear order in which they should be addressed. The list simply gives examples of the types of activities that assist teachers connect EfS with technology education in a holistic sense.

Many similar opportunities to teach EfS within primary technology education are evident within our communities. Such opportunities should all, however, focus on producing something and lead to indirect or direct action in promoting sustainability messages.

REFERENCES

Aorangi Restoration Trust. (2013). *Lions Club and Kahutara School nestbox building*. Martinborough, New Zealand: Author. Retrieved from http://www.aorangitrust.org.nz/#!galleries/ceod

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2014a). *The Australian Curriculum v. 3.0: Technology*. Sydney, NSW, Australia: Author. Retrieved from http://www.australiancurriculum.edu.au/curriculum/learning_areas/technologies

Australian Curriculum, Assessment and Reporting Authority (ACARA). (2014b). *The Australian Curriculum v. 3.0: Sustainability*. Sydney, NSW, Australia: Author. Retrieved from http://www.australiancurriculum.edu.au/crosscurriculumpriorities/sustainability

Eames, C., Law, B., Barker, M., Iles, H., McKenzie, J., Patterson, R., Williams, P., & Wilson-Hill, F. (2006). *Investigating teachers' pedagogical approaches in environmental education that promote students' action competence: Final report.* Wellington, New Zealand: Teaching & Learning Research Initiative. Available online at http://www.tlri.org.nz/sites/default/files/projects/9224_finalreport.pdf

Johnsey, R. (1995). The design process: Does it exist? A critical review of published models for the design process in England and Wales. *International Journal of Technology and Design Education*, *5*, 199–217.

Kline, S. (1985). What is technology? *Bulletin of Science, Technology and Society*, *4*(3), 215–218.

New Zealand Ministry of Education. (2007). *The New Zealand Curriculum*. Wellington, New Zealand: Learning Media.

Pacey, A. (1983). *The culture of technology*. Oxford, UK: Basil Blackwell.

Schön, D. A. *The reflective practitioner: How professionals think in action.* New York, NY: Basic Books.

Chris Eames, John Lockley & Louise Milne
University of Waikato
Hamilton
New Zealand
email: c.eames@waikato.ac.nz