Technology Curriculum Support

A package of documents and papers developed by The Ministry of Education to support schools and teachers with the implementation of the technology curriculum in *The New Zealand Curriculum* (2007).

These papers are also published on Techlink, at www.techlink.org.nz/curriculum-support. This website will be kept up-to-date with the latest information and advice.

October 2007

This document and the Curriculum Support pages on the Techlink website was fully updated in April 2009.

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INTRODUCTION

The Ministry of Education has developed this package to support schools and teachers with the implementation of the technology curriculum in *The New Zealand Curriculum* (2007). The papers included in this package have been developed during 2007 to explain and exemplify the underpinning ideas within the technology curriculum in *The New Zealand Curriculum* (2007) and reflect a significant body of research and classroom practice.

The Ministry of Education would like to thank all those involved in the work leading up to the publication of this package. This includes the researchers involved, School Support Services Advisers, pre-service lecturers and the numerous teachers and school curriculum leaders who have provided guidance and ongoing feedback on the materials to date.

The Ministry of Education also welcomes ongoing feedback on the usefulness of this package, and guidance as to any additional material schools and teachers would find useful.

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MINISTRY OF EDUCATION OVERVIEW

Technology is described in *The New Zealand Curriculum* (2007) as intervention by design: the use of practical and intellectual resources to develop products and systems (technological outcomes) that expand human possibilities by addressing needs and realising opportunities.

Technology was introduced as a new and exciting area for student learning in 1995. This was a critical addition to the New Zealand curriculum, allowing students to keep pace with and understand social and technological change. Since then, the need for learning in this curriculum area has become even greater as our population has become increasingly diverse, technologies have become more sophisticated, the demands of the workplace have become more complex and New Zealand continues to need innovatively focused social, including economic, transformation.

Twenty-first century New Zealand needs students who are lifelong learners, confident and creative, connected and actively involved. To be successful citizens of the present and the future, they need interactive experiences in keeping with the technological communities of practice which are currently informing and developing our future. As young New Zealanders, they also need to know about their technological past and that of other societies and cultures. This allows them to develop an awareness of the impacts and influences of technological developments on environments and societies, and vice versa.

New Zealand's future relies on encouraging young New Zealanders to pursue careers with a technological focus. Technology education not only gives all students a level of technological literacy, but also provides senior secondary students with an educational foundation for technology related careers.

The technology curriculum in *The New Zealand Curriculum* (2007) is a dynamic and future focused framework for teaching and learning in technology. It gives students challenging and exciting opportunities to build their skills and knowledge as they develop a range of outcomes through technological practice. They bring together practical and intellectual resources in creative and informed ways to engage with the many technological challenges of today's world and of those in the possible future.

Technology education in New Zealand has a strong research foundation and the technology curriculum in *The New Zealand Curriculum* (2007) is internationally recognised as 'leading the way' when it comes to clearly describing the knowledge, skills and practices required for students to develop a comprehensive technological literacy. It allows teachers great flexibility, breadth and depth to develop learning opportunities that meet the needs and potential of their school communities and students. Opportunities can be aligned with teachers own skills and knowledge, and with the expertise of outside experts and mentors who act as catalysts for deeper learning and engagement of students.

The Ministry of Education supports a vision for technology education to provide 'seamless quality learning opportunities in technology for all New Zealand students as part of their compulsory schooling, and to further support technology programmes for students in years 11-13'.

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MINISTRY OF EDUCATION GUIDANCE

INTRODUCTION

This paper provides guidance from the Ministry of Education for school managers, Boards of Trustees, and curriculum leaders in relation to technology education. It outlines how the learning area of technology fits within *The New Zealand Curriculum* (2007).

It provides overall guidance for teaching and learning, including some specific guidelines for schools to consider during the implementation phase of the technology curriculum in *The New Zealand Curriculum* (2007) during years 2008 and 2009, and for 2010 and beyond. It also provides specific guidance and suggestions for schools offering programmes for students in years 1-6, years 7-8, and years 9-13.

OVERALL GUIDANCE

Technology is one of the eight learning areas included in *The New Zealand Curriculum* (2007). State and State Integrated schools are required to provide all students in years 1-10 with effectively taught programmes of learning in technology as part of a balanced school curriculum. The development of all learning programmes in technology should seek to align with the principles, vision, values and key competencies of *The New Zealand Curriculum* (2007). Decision making about knowledge, skills and competencies in all learning programmes in technology, should be based on the achievement objectives of the technology curriculum in *The New Zealand Curriculum* (2007).

The National Educational Goals (NEGs) and the National Administration Guidelines (NAGs), support the importance of technology for a balanced school curriculum. For example, the development of technological literacy is key to the development of the knowledge and skills needed by New Zealanders to compete successfully in the modern ever-changing world (refer to NEG 3).

School programmes in technology should also provide access for students to a nationally and internationally recognised qualifications system to encourage a high level of participation in post-school education in New Zealand (refer to NEG 8). Technology is now included in the canon of subjects for university entrance. Senior secondary programmes should therefore be developed, where possible, to provide appropriate pathways for students with the potential to further their technology education in the tertiary sector.

Quality teaching and learning in technology classroom curriculum should also seek to be in keeping with *The New Zealand Curriculum* (2007) including its curriculum design and pedagogical guidelines, and the NEGs and NAGs. In particular, planned learning experiences should allow for excellence to be achieved in technology through the establishment of clear learning objectives, monitoring of student performance against those objectives, and the development of learning opportunities to meet individual needs (refer to NEG 6, NAG 1).

A range of assessment practices should also be employed to gather information that is sufficiently comprehensive to enable the progress of students in technology to be evaluated and reported; to students, their parents and subsequent teachers (refer to NEG 2, 6, 7, 9 and 10, and NAG 1, 2 and 6).

IMPLEMENTATION OF THE TECHNOLOGY CURRICULUM

The Ministry of Education goals for technology education are: to develop seamless quality technology education for all New Zealand students from early childhood, and through years 1-13, as part of students general education; to raise the quality and effectiveness of teaching and learning in technology; and to promote a focus on the technology curriculum introductory learning area statement and achievement objectives, to provide consistent and coherent messages for teaching and learning in technology.

The technology curriculum in *The New Zealand Curriculum* (2007) consists of three strands (Technological Practice, the Nature of Technology and Technological Knowledge) and eight achievement objectives, to support the development of student technological literacy. All three strands of the technology curriculum in *The New Zealand Curriculum* (2007) work together to set the overall direction for learning in technology.

There is no longer a requirement for schools to provide learning experiences that cover four to six of the seven technological areas that were defined in *Technology in the New Zealand Curriculum* (1995). Instead, schools will be required to develop coherent learning programmes that reflect a broad range of contexts that draw from and cut across a variety of areas that come from communities of technological practice. Three types of transformations are associated with technology. These are the transformation of energy, information and materials.

To further increase student engagement and gain access to mentoring support networks, schools may also like to incorporate many of the technology related awards and competitions available into their technology programmes. Examples of these include Realise the Dream, CREST, Bright Sparks, the Transpower Neighbourhood Engineers Award, Young Designer Award.

The support material in this package has been provided to aid the development of understandings of the revised technology curriculum and help teachers and curriculum leaders as they implement the technology curriculum in *The New Zealand Curriculum* (2007). At this stage, additional resource material is available to support teachers in developing programmes and pedagogical strategies focused on the Technological Practice strand. Further research will be undertaken over the next three years to provide further resources for teachers focused on the two additional strands: Nature of Technology and Technological Knowledge. These resources will be available from 2010.

RECOMMENDATIONS FOR TEACHERS

When developing your implementation plans over the next three years, it is recommended that you consider the following:

In 2008–2009:

- Focusing teaching and learning on the Technological Practice strand.
- Only assessing and reporting student achievement in terms of the three Technological Practice achievement objectives.
- Exploring the Nature of Technology and Technological Knowledge strands to provide depth and breadth to students' technological practice. Using the five achievement objectives provided under these strands primarily as discussion tools.
- Beginning to explore the development of programmes that include all three strands.

From 2010:

- Incorporating all three strands into technology programmes.
- Focusing teaching and learning on all three strands.
- Assessing and reporting on student achievement using all eight achievement objectives.

To support the vision for seamless quality technology education, it is essential that technology teachers in early childhood centres and primary, intermediate and secondary schools have a shared understanding of technology education and what progression in technology learning looks like.

Working from the technology curriculum in *The New Zealand Curriculum* (2007), student achievement can be enhanced by effective assessment strategies guided by the achievement objectives. Data providing evidence of individual student achievement can then be recorded and provided to subsequent teachers to ensure 'next step learning' is communicated across different learning sites. This will support the dismantling of hurdles that exist at transition points for student learning in technology and will ultimately enhance student achievement in technology at senior secondary school and improve performance in technology standards for NCEA.

Years 1-6: Recommendations for consideration by Teachers:

- Ensure links are made to entry and destination programmes and develop reporting mechanisms to support seamless learning for students;
- Draw from their existing pedagogical strengths to ensure they provide technology learning experiences that focus on progressing student learning in technology;
- Develop their own specific knowledge and skills to support a broad range of contexts;
- Work with their local community to access available resources and expertise;
- Plan to use technology learning experiences to provide authentic contexts that allow for the development of key competencies and for supporting values education;
- Plan to use technology learning experiences to enhance student general literacy and numeracy; and
- Plan to use technology contexts that encourage links to be made with other learning areas.

Years 7-8: Recommendations for consideration by Teachers:

- Ensure links are made to entry and destination programmes and develop reporting mechanisms to support seamless learning for students;
- Draw from and expand their existing knowledge and skills to ensure they provide quality learning experiences for students in keeping with the new achievement objectives and allow for a broad range of contexts;
- Develop their pedagogical strategies to ensure effective use is made of specialist equipment, resources and facilities to support progression based learning for students in technology;
- Increase links between specialist technology and generalist classroom teachers to enhance programme planning and encourage links to other learning areas; and
- Make clear links for their students to technology related careers.

Years 9-13: Recommendations for consideration by Teachers:

- Ensure links are made to entry programmes and use reported data from these programmes to support seamless learning for students;
- Draw from and expand their existing knowledge and skills to ensure they provide quality learning experiences for students in keeping with the new achievement objectives and allow for a broad range of contexts;
- Develop their pedagogical strategies to ensure effective use is made of specialist equipment, resources and facilities to support progression based learning for students in technology;
- Work alongside other technology teachers to ensure coherency between learning experiences and coverage of a broad range of contexts as part of year 9 and 10 compulsory technology programmes;
- Work alongside teachers from other learning areas and/or subjects to ensure increased depth of student learning in technology is appropriately supported in year 11, 12 and 13 technology options;
- Make clear links for students to technology related careers and support students in their future education and/or career pathway planning; and
- Increasingly use mentors from communities of technological practice and encourage students to work with real clients as appropriate.

For further explanation of the ideas presented in this paper, please refer to the other papers contained in the technology curriculum support package.

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EXPLANATION OF TERMS

Levels of Curriculum

National Curriculum

The national curriculum for technology is the document provided by the Ministry of Education that sets out the direction for learning in technology. It includes the Technology Introductory Learning Area Statement and Achievement Objectives that progress from level 1-8 of *The New Zealand Curriculum* framework.

School Curriculum

The school curriculum for technology will be developed by all staff involved in the leadership and delivery of technology in the school. The school technology curriculum will be recorded by way of technology programmes that guide all staff teaching within it. Technology programmes will be in line with the expectations within the national technology curriculum, but will also take into account the needs and desires of the school community, the strengths of the teaching staff, and the interests and ability of the students.

Classroom Curriculum

The classroom curriculum for technology will be developed by classroom teachers to guide their teaching. The classroom curriculum will be recorded by way of learning experiences. Learning experiences developed will be in line with the school technology programme, but will also take into account the specific interests and abilities of the teacher/s and students within the classroom. The learning experiences may be structured into units where individual lessons are planned to manage the overall learning experience. Assessment (formative and summative), and reporting procedures, will be an integral part of the learning experiences.

INTRODUCTORY LEARNING AREA STATEMENT

The Technology Introductory Learning Area Statement has been developed to communicate the essence of technology as both a discipline and an essential learning area in the compulsory school sector. It therefore defines the concept of technology underpinning this learning area and provides a rationale for why it is important to study technology. The statement also outlines how the learning area has been structured into strands to help teachers develop technology programmes.

TECHNOLOGY CURRICULUM STRANDS

Technology has three strands –Technological Practice, the Nature of Technology, and Technological Knowledge. These strands provide a structure for the key ideas and practices that form the basis of technological literacy . These key ideas and practices have been categorised within each strand as separate but interrelated components.

Components of Technological Practice Strand

Understanding and undertaking technological practice is an important aspect of student learning in technology education in New Zealand. In order to support student learning associated with undertaking their own practice, three interconnected components have been identified. Research findings suggest that if teachers and students can focus on smaller components within technological practice, they are better able to identify learning needs and therefore respond more specifically to enhance formative interactions in the classroom.

The three components of practice, identified from classroom research, and verified in technologist communities, are: Brief Development, Planning for Practice, and Outcome Development and Evaluation. Brief Development focuses on the defining practices of technological development. Planning for Practice focuses on the organising practices. Outcome Development and Evaluation focuses on the trialling and production practices.

While each of these components is described separately, they interact in a highly iterative fashion to support and enhance overall technological practice. It is expected that while some learning experiences in technology education may focus on one or two components specifically, over a technology education programme all components should be comprehensively covered. Links between the components should be stressed in order for students to develop a sound understanding of, and capability in, undertaking technological practice.

Components of the Nature of Technology Strand

Understanding the Nature of Technology has been recognized as important in the development of a broader and more critical technological literacy. In order to support student learning associated with the philosophy of technology, two interconnected components have been identified. These are: the Characteristics of Technology and the Characteristics of Technological Outcomes. Characteristics of Technology focuses on developing a philosophical understanding of technology as a form of human activity. Characteristics of Technological Outcomes focuses on developing a philosophical understanding of the resulting outcomes of technological developments as they exist in the made world.

While these components are described separately, they interact in a highly iterative fashion to support a critical understanding of the nature of technology as a discipline. It is expected that while some learning experiences in technology education may focus on one or other of the components specifically, over a technology education programme both components should be comprehensively covered. Links between the components should be stressed in order for students to develop a sound understanding of the nature of technology.

Components of Technological Knowledge Strand

Developing Technological Knowledge has been recognized as important in the development of a broader and deeper technological literacy. In order to support student learning of technological knowledge, three interconnected components have been identified. These are: Technological Modelling, Technological Products and Technological Systems. Technological Modelling focuses on developing the big ideas underpinning functional and prototype modelling. Technological Products focuses on developing the big ideas underpinning materials use and development. Technological Systems focuses on developing the big ideas underpinning systems use and development.

While each of these components is described separately, they interact in a highly iterative fashion to support and enhance the development of technological knowledge. It is expected that while some learning experiences in technology education may focus on one or two components specifically, over a technology education programme all components should be comprehensively covered. Links between the components should be stressed in order for students to develop a sound understanding of the big ideas involved in technological knowledge.

TECHNOLOGICAL OUTCOMES

Technological outcomes are developed through technological practice for a specific purpose and are defined as material products and/or systems that are fully realised in situ. Technological practice also results in other outcomes that are referred to as intermediate outcomes. These intermediate outcomes are very important in technology and technology education, as they are valuable for developing ideas, exploring, testing and communicating aspects of technological outcomes before they are fully realised in situ. These include such things as feasibility studies, conceptual designs, models, prototypes etc.

See the Explanatory Papers Outcome Development and Evaluation, page 28; Characteristics of Technological Outcomes, page 36; and Characteristics of Technology, page 43.

ACHIEVEMENT OBJECTIVES

The achievement objectives are the outcomes for student learning that have been determined to be key for all students across New Zealand. In technology the achievement objectives have been derived from each component within the strands. They provide a generic description of what student achievement should reflect at level 1 through to level 8.

The achievement objectives provide a picture of progression of learning within each component. Achievement objectives represent large ‘chunks’ of learning. It is expected that a student’s individual progress through the levels of achievement will vary and that achievement is related to the student’s ability and experience rather than their chronological age. Achievement objectives require interpretation by teachers into the school curriculum (technology programme), and will require further translation into smaller goals for use in the planning and delivery of learning experiences. These smaller goals are referred to as specific learning intentions.

SPECIFIC LEARNING INTENTIONS

Curriculum driven specific learning intentions are derived from the achievement objectives. They reflect the intended technology learning that students will achieve as they participate in learning experiences.

Teachers should also develop specific learning intentions from the additional knowledge and skills required by the context of the learning experience. These are referred to as context driven specific learning intentions and will reflect key knowledge and skills that students will need to develop. These learning outcomes may be technological in nature (for example, graphical knowledge and skills, knowledge of materials, skill in material manipulation, knowledge of existing technological products and systems), or may be derived from other disciplines (for example, science, mathematics, the arts, social sciences, language, psychology etc).

Specific learning intentions should provide opportunity for all students to progress their learning in technology. Therefore, when developing specific learning intentions, teachers will need to draw from their knowledge of where the students’ current level of achievement is in relation to the intended learning, and what the next steps in their learning will be.

The technology Indicators of Progression have been developed to help teachers develop and use specific learning intentions that are in keeping with the achievement objectives.

TECHNOLOGY INDICATORS OF PROGRESSION

Indicators of progression have been developed in technology to help teachers mediate the achievement objectives into specific learning intentions. The indicators can be used to plan learning experiences, aid in diagnostic assessment, and support formative interactions within the classroom to help scaffold student learning. They can also support summative assessment for reporting purposes. The indicators are ‘indicative’ of the level expected by the achievement objective. They do not provide a checklist.

CONTEXT

'Context' in technology education has been used to refer to the overall focus of a technological development or of a technological learning experience within technology education. In order to ensure that the contexts chosen provide for a range of diverse learning opportunities, programmes should include contexts in both senses as explained above. These contexts should cover a range of transformations associated with technology. That is, the transformation of energy, information and/or materials for the purpose of manipulation, storage, transport and/or control.

When talking about the **context of a technological development**, the term refers to the wider physical and social environment within which the development occurs. For example:

- The context of Zambesi's work was that of *rebranding an airline*, with a focus on the manipulation of information
- The context of wind generation is *sustainable energy generation*, with a focus on the storage and control of energy
- The context of a packaged scallop product is *marketable food products*, with a focus on the manipulation, transport and storage of material and information – Techlink case study

When talking about the **context of a technological learning experience** the term refers to all the aspects that must be thought about to situate the learning. For example:

- The context in Meeting Seating was *outdoor seating within a school environment*, with a focus on the manipulation of materials – see *Connected Series 2005 Volume 2*
- The context in ICT Programming was *programme development in ICT*, with a focus on the control and storage of information
- The context in Hairs your Gift was *hair care*, with a focus on the manipulation and storage of materials

ISSUE

An issue in technology refers to a specific subset of the context that will allow students to identify a need or opportunity. For example:

- the issue in Meeting Seating was *designing seating that enhances discussion* – see *Connected Series 2005 Volume 2*
- the issue in ICT Programming was *developing educational programmes*
- the issue in Hairs your Gift was *developing hair products*

NEED OR OPPORTUNITY

A **need** in technology refers to an identified requirement of a person, group or environment. A need is identified from an issue, and sits within a context. Technological practice can be undertaken in an attempt to meet an identified need. For example, the need in Meeting Seating was *to develop a seat appropriate for a school garden where students could meet for discussions* – see *Connected Series 2005 Volume 2.*

An **opportunity** in technology refers to an identified possibility for a person, group or environment. An opportunity is identified from an issue, and sits within a context. Technological practice can be undertaken in an attempt to realise an identified opportunity. For example, the opportunity in Hairs your Gift was *to create a gift for a selected recipient.*

ATTRIBUTES AND SPECIFICATIONS

Attributes are descriptive aspects of the physical and functional nature of a technological outcome. **Specifications** define the requirements of the physical and functional nature of the outcome in a way that is measurable.

For example, an attribute may refer to the outcome being small enough to be comfortably held, whereas the specification would give the precise measurement in terms of length, width and depth.

FITNESS FOR PURPOSE IN ITS BROADEST SENSE

The concept of ‘fitness for purpose’ is commonly used to judge the ability of an outcome to serve its purpose in ‘doing the job’ within the intended location, where the job to be done is clearly defined by the brief. When ‘fitness for purpose’ is described as being ‘in its broadest sense’, the concept is extended to include the determination of the ‘fitness’ of the practices involved in the development of the outcome, (including such things as the sustainability of resources used, treatment of people involved in manufacture, ethical nature of testing practices, cultural appropriateness of trialling procedures, determination of lifecycle and ultimate disposal etc), as well as the ‘fitness’ of the outcome itself.

Extending the concept in this way is an attempt to locate both the concept of ‘fitness for purpose’ and its application within a philosophical understanding of the nature of technology whereby the performance of any outcome is but one of the factors that justifies a positive ‘fitness for purpose’ judgment.

STAKEHOLDERS

Stakeholders are any individuals or groups who have a vested interest in the technological development or technological outcome.

Key stakeholders are those people that are directly influential or will be directly impacted on by the technological practice itself and/or its resulting outcomes (including the technological outcome and any other by-products).

Wider community stakeholders are those people that are less directly influential for or impacted on by the practice or outcome. They can, nonetheless, be identified as having some level of influence, often through others, and/or they may be affected by the project or its outcome in the future.

A NEW TECHNOLOGICAL LITERACY

ABSTRACT

The aim of technology education in New Zealand is to develop students' technological literacy. This was the aim of the *Technology in the New Zealand Curriculum* (1995) and remains the aim of the revised technology curriculum in *The New Zealand Curriculum* (2007). This paper explains the shifts that have occurred between the 1995 and 2007 curriculum in technology. It describes the three new strands and outlines how they contribute to an overall technological literacy. The paper also introduces a series of explanatory papers that have been developed to explain the strands and their components in more depth.

TECHNOLOGICAL LITERACY IN *Technology in the New Zealand Curriculum* (1995)

The aim of the *Technology in the New Zealand Curriculum* (1995) was to support the development of technological literacy as based on the three strands:

- Technological Knowledge and Understanding
- Technological Capability
- Technology and Society

These three strands needed to be brought together in all technology programmes to ensure students were provided with opportunities to undertake technological practice. Therefore, technological practice was seen as the vehicle through which students could develop their technological literacy. Technological areas were provided in the 1995 document as a means of providing teachers with a diverse range of contexts to draw from in the development of technology programmes, and to encourage that students develop literacy from a broad range of learning contexts.

Undertaking technological practice has been shown to provide students with the opportunity to collaborate with others and make a difference to their own lives and developments in their immediate community. This has resulted in high levels of student engagement and allowed students to take increasing ownership of their learning and feel empowered to make decisions regarding the nature of their outcomes.

However, after more than ten years of implementing the 1995 curriculum in schools from years 1-13, it has been noted that the nature of the technological literacy resulting from students undertaking technological practice alone, was often limited in breadth and depth. It was also often lacking the level of critical analysis required for more informed decision making in students' own practice and, in particular, making choices of a more general nature with regards to technology per se.

These findings led to a realisation that technological practice on its own was not enough. Research was then undertaken to identify what might be missing and address these gaps in the revised technology curriculum in *The New Zealand Curriculum* (2007)[1].

TECHNOLOGICAL LITERACY IN *THE NEW ZEALAND CURRICULUM* (2007)

The research findings and subsequent curriculum development work resulted in technology education being restructured around three new strands:

- Technological Practice
- Nature of Technology
- Technological Knowledge

Classroom practice and research also raised issues around the inclusion of named technological areas. For example, the emphasis on technological areas often resulted in them being interpreted as discrete 'subjects', whereas learning in technology generally goes across a number of technological areas. More valuable contexts can be developed when these area are seen as more integrated. For this reason, the emphasis on technological areas has now been reduced and the requirement to cover four to six of the technological areas defined in the 1995 technology curriculum has been removed. This has been replaced by a more holistic framework to encourage learning programmes based on a broad range of contexts that draw from and cut across a variety of what may be termed technological areas. These areas reflect the communities of technological practice that exist within the technology sector.

1 For more details about this research please see papers by Compton and France 2007 available at www.iteaconnect.org/Conference/PATT/PATT18/fullprog-21a[1].pdf and Compton and France in Curriculum Matters 2007.

A broad range of contexts should ensure coverage of the three types of transformations associated with technology. These are the transformation of energy, the transformation of information, and the transformation of materials. These transformations can in turn be categorised into four purposes – to manipulate, store, transport or control. It is also expected contexts chosen will allow students to experience and/or explore a range of historical and contemporary examples of technology to further encourage diversity within learning programmes.

This more holistic framework allows teachers to draw from a mix of contexts and develop learning programmes for students, to work towards the achievement objectives from all three strands, in a way that best suits the school resources, teacher knowledge and skill, and the interests of the students.

Each strand contributes to the 'whole' of technological literacy as explained below.

The Technological Practice strand enables students to undertake their own technological practice within a particular setting and to reflect on the technological practice of others. Within this strand students will develop their capability in terms of levelled achievement objectives derived from three key components of technological practice – Planning for Practice, Brief Development and Outcome Development and Evaluation.

Learning experiences focused on this strand will allow students to gain a sense of empowerment as they undertake their own technological practice to find solutions to identified needs and/or realise opportunities. This strand also provides opportunities to embed the philosophical ideas from the Nature of Technology and Technological Knowledge in order to better inform their practice. As such, the Technological Practice strand focuses student learning in technology around 'know how'.

The Nature of Technology strand provides students with an ability to develop a critical understanding of technology as an intervening force in the world, and that technological developments are inevitably influenced by historical, social and cultural events. Within this strand students will develop their philosophical view of technology in terms of levelled achievement objectives derived from two key components of the Nature of Technology - Characteristics of Technology and Characteristics of Technological Outcomes.

Learning experiences focused on this strand will provide opportunities for students to undertake informed debate about contentious issues and increase their understanding of the complex moral and ethical aspects that surround technology and technological developments. They will also provide an opportunity to examine the fitness for purpose of technological outcomes in the past and to make informed predictions about future technological directions at a societal and personal level. Such philosophical understandings are essential to the development of a broad and critical literacy for New Zealand students. As such, the Nature of Technology strand focuses student learning in technology around 'know why'.

The Technological Knowledge strand provides students with a basis for the development of key generic concepts underpinning technological development and resulting technological outcomes. These concepts allow students to understand evidence that is required to defend not only the feasibility of a technological outcome, but also its desirability in a wider societal sense. Within this strand students will be able to develop technological understandings in terms of levelled achievement objectives derived from three key components of technological knowledge – Technological Modelling, Technological Products and Technological Systems.

Learning experiences focused on this strand will provide opportunities for students to explore functional modelling in order to understand simulated representations of reality as compared to the reality itself. This will allow them to fully appreciate both the power and limitations of functional modelling. Understanding the role and importance of functional modelling should reduce the propensity for students to take a 'build and fix' approach in their own technological practice. Exploring prototyping will provide students with a better sense of why prototyping is important, as well as how it can be undertaken to enhance any technological outcomes they may develop in their own technological practice. Knowledge of materials underpinning technological products, and the componentry and connections within technological systems, will enable students to infuse their technological practice with a higher level of technological understanding and support more informed material and/or componentry selection and manipulation in their decision making. As such, the Technological Knowledge strand focuses student learning in technology around 'know that'.

The three knowledge types, 'know how', 'know why' and 'know that', combine to provide students with all knowledge types seen as important in developing a sophisticated technological literacy.

EXPLANATORY PAPERS

The explanatory papers have been developed to support teacher understandings of the components of the three strands of the revised technology curriculum.
They provide explanations of the knowledge and/or practices underpinning each of the eight components from which the technology achievement objectives have been derived.

The Technological Practice explanatory papers provide illustrative examples of each of the three components, from a range of technological practices outside of education. They also provide illustrative examples of what each of the achievement objectives might look like at different levels within New Zealand based technology learning experiences, and provide a link to the pedagogical practices that have supported students in achieving them.

The explanatory papers for the Nature of Technology and Technological Knowledge are still under development. At this stage they only provide suggestions for possible learning experiences that might support student achievement at different levels. As illustrative examples become available they will be added to these papers.

EXPLANATORY PAPER

The Technological Practice Strand: Brief Development

ABSTRACT

The purpose of this explanatory paper is to clarify and define what a brief is and how it is developed as part of technological practice. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology and technology education.

COMPONENT DESCRIPTOR

Brief development is a dynamic process that reflects the complex interactions within ongoing technological practice. A brief is developed to clearly describe a desired outcome that would meet a need or realise an opportunity, and takes into account the physical and social environment. It is comprised of a conceptual statement that communicates what is to be done and why it should be done.

It also includes specifications that define the requirements of a technological outcome in terms of its physical and functional nature. The specifications provide guidance for ongoing evaluation during the development of an outcome, as well as serving as an evaluative tool against which the final outcome can be justified as fit for purpose. Brief Development can be thought of as the defining practices of technological practice.

KEY IDEAS

A brief in technology is defined as a succinct guiding document that is comprised of a conceptual statement that communicates, via any appropriate means (eg, through oral, written, graphical means), the focus and justified purpose of the technological practice to be undertaken to develop a technological outcome. That is, an explanation for what is to be done and why it should be done. This statement is based on findings from the exploration, and analysis of the context and issue from which the need or opportunity driving the project has been identified.

A brief also includes specifications that define the requirements of a technological outcome in terms of such things as appearance and performance. This is referred to as the technological outcome's physical and functional nature. Specifications are an explicit set of requirements that need to be satisfied for the outcome to be judged as 'fit for purpose' and can be described as normative standards. That is, they are measurable standards established by, and agreed to, by people to communicate precisely what a technological outcome ought to be and/or what it ought to be able to do. Identifying attributes is a common precursor to specification development. Attributes are not standardised measures, but rather broad descriptors that can be described as relative rather than standardised. That is, they may mean different things to different people.

A brief may also include specifications for the practice that must be adhered to when developing a technological outcome. When these are included the brief can be said to guide the development and allow for an evaluation of fitness for purpose in its broadest sense.

In an acknowledgement of intermediate outcomes of technological practice, (those outcomes that have not been developed through to a fully realised technological outcome), a developing brief will reflect the stage of outcome that the project is aiming for. For example, if the outcome of technological practice is a scale model, the brief will contain guidance in terms of developing a model to scale, and the purpose of the model. The specifications for this brief will relate to the model and its need to communicate and/or test the potential of a developing design, to resolve the need or opportunity should it go on to be realised as a technological outcome.

The development of a brief is an iterative process that reflects the complex interactions within ongoing technological practice. A brief cannot be viewed as a one-off exercise completed at the beginning of any project.

Rather, it is developed, refined and/or modified in an ongoing manner throughout the project. This is based on initial research into the context, the developing knowledge and skills of the technologist and changing contextual circumstances, which includes critical feedback from stakeholders.

The identification of an authentic need or opportunity relies on a comprehensive exploration and critical analysis of a context, and any associated issues. It would be expected that such an exploration may result in the identification of a number of needs or opportunities. Selection of one of these will rely on establishing the appropriateness of the need/opportunity, as a justified purpose for undertaking technological development.

Any brief developed is specific to the selected need or opportunity, and should take into account the physical and social environment of both the final outcome and the practices that are undertaken in its development. The social environment includes a range of factors such as the ethical, cultural, political, and economic aspects that work together in complex ways. To develop full understanding of the physical and social environment, it is necessary to explore how historical events have impacted on the relationships between these aspects, and how possible events may be influenced in the future.

As the development work continues, the knowledge and skills of the technologist are increased, particularly through functional modelling. This allows new understandings to be used to reflect on the justification of the purpose, the prioritisation of factors underpinning the specifications, and the feasibility of the developing outcome.

The initial attributes and final specifications of a brief are the result of extensive research, including trialling and testing of design ideas. They reflect the prioritisation of factors that have arisen as part of key and wider community stakeholder consultation, and understandings of the physical and social environmental impacts and influences. The specifications provide guidance for ongoing evaluation during the development of an outcome, as well as serving as an evaluative tool against which the final outcome can be justified as fit for purpose, or not, including where fitness for purpose is conceptualized in its broadest sense.

As the brief is developed, stakeholder feedback is essential, and the media used to communicate the brief should be chosen to gain feedback in the most effective and efficient manner. While the brief is developed in an ongoing manner within any project, it should be finalised prior to the completion of any outcome, so as to serve as the evaluative tool against which the final outcome is judged.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

With the changing world of air travel, Air New Zealand decided to undertake a major rebranding exercise. A key part of this was the design of new uniforms. Air New Zealand went to leading New Zealand design company Zambesi, to undertake this project. Zambesi explored the issues the airline was facing and sought to develop a uniform range that would meet the needs of all major stakeholders. For an example of how the brief developed throughout this technological practice, see Zambesi style.

Sealord is an innovative New Zealand company always looking at opportunities to extend its product range. Faced with an opportunity, provided by a supply of quick frozen scallops, a team of technologists worked together to design a new product. The brief developed had to provide guidance and evaluation tools for both the scallop product itself, as well as its packaging. For an example of how a range of factors were brought together by this team to develop the brief see Sealord Group case study

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY EDUCATION

Learning experiences

The following learning experiences have been provided to support teachers as they develop their understandings of the Brief Development component of the Technological Practice strand. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been summarised from classrooms across New Zealand, and provide examples of student achievement across a range of levels. This stance reflects the majority of classrooms within which it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

During a discussion about a lunchtime 'toilet' incident, students in this class identified that there were problems with regards to the toilets. There was general agreement that the toilets were unpleasant to use, and from this the teacher and students decided they should do something about them. They worked with a number of experts from the local community to make changes that the whole school would benefit from. For details of this unit please see Nicer Loos.

Students achieving at level 1 could:

- describe the improved toilets they worked to develop
- identify attributes that a toilet environment for girls and boys in a school would need to have to be nicer to use

Students achieving at level 2 could:

- explain the new toilet environment in terms of colours and fittings, and how the toilets would need to be cared for to make sure they continued to be nicer to use than the old ones
- describe the attributes required for toilets to be more pleasant for girls and boys to use, in terms of creating the environment itself (colours, the selection of fittings), as well creating systems to ensure the maintenance of the toilets in the future (cleaning systems and education of users)
- describe specific attributes they identified for their part of the project in a way that allowed them, and their teacher, to evaluate their progress and final outcome

Senior Primary/Intermediate (Years 5-8)

Year 7 students identified a common personal need created by their attendance at the Technology Centre. As they attended another school for their technology programmes they had to bring food for lunch, and during the winter they liked this to be hot. In the past this hot food was mostly pies. Together the classes looked at other possibilities for quick meal-snack ideas that would be both appealing and nutritious. For details of this unit please see Hot Bread Snacks

Students achieving at level 2 could:

- explain what they had chosen to develop as a snack
- describe the attributes required for their snack in terms of taste, appearance, texture, time to cook, ease of making, and nutritional value, in ways that allowed them and their teacher to evaluate their progress and final outcome

Students achieving at level 3 could:

- describe what they had decided to develop in terms of what they wanted it to be like and what they wanted it to provide and explain how this particular type of snack reflected the need in terms of personal likes and health choices
- describe the key attributes required for their snack in terms of taste, appearance, texture, time to cook, ease of making, and nutritional value in ways that allowed them and their teacher to evaluate their progress and final outcome
- refine their conceptual statement and key attributes as they experimented with different ingredients and methods of making their snack, and personally evaluated their snacks for taste, appearance and texture

Students achieving at level 4 could:

- justify what they had decided to develop and why they had chosen this particular type of snack, in terms of personal likes and health choices, and feedback from others about appropriate health choices for their age and body type, and the resources (time, equipment, ingredients, level of skill) required to cook such a snack successfully
- establish key attributes for their particular snack as a starting point for development work
- refine their conceptual statement and key attributes as they undertook further research, experimented with different ingredients and methods of making their snack, and carried out testing of their snacks personally and with others in the class, to gain feedback on its taste, appearance and texture in line with key attributes
- describe the key attributes required for their snack in terms of taste, appearance, texture, time to cook, ease of making, and nutritional value in ways that allowed them, their teacher and others in the class to provide feedback on their progress and final outcome

Junior Secondary (Years 9-10)

A year 10 class was given the context of issues affecting the wider ICT community, from which they had to select an issue of particular concern. From this issue, the students undertook brief development to support the creation of an informative kiosk presentation for an identified target audience focused on the issue. In creating their presentation, students applied the concepts learnt in a previous unit and how to manipulate digital images using *Fireworks* to enhance their presentation. For details of this unit please see Junior ICT Programme.

Students achieving at level 3 could:

- describe the opportunity focused on
- describe what the nature of the information kiosk in terms of what they wanted it to be like and what they wanted it to do and explain how this reflected the concern identified.
- describe the key attributes required for a presentation to a target audience, in ways that allowed them and their teacher to evaluate their progress and final outcome
- refine their conceptual statement and key attributes as they developed greater knowledge of the issue, skills in manipulation digital images and their target audience

Students achieving at level 4 could:

- identify an opportunity and establish a conceptual statement outlining their presentation based on this
- justify the focus and nature of their presentation, based on understandings of the issue, its impact on the ICT community and the target audience
- establish key attributes for their presentation as a starting point for development work
- refine their conceptual statement and key attributes as they undertook further research into the issue, experimented with design, typography and image manipulation and trialled material in different forms to gain feedback from members of their target audience, about the impact of animations and other effects on the development of understandings of the focus issue
- describe the key attributes required for their presentation, in terms of aesthetics and performance, in ways that allowed them, their teacher and members of their target audience to provide feedback on their progress and the fitness for purpose of their final outcome

Students achieving at level 5 could:

- identify an opportunity and establish a conceptual statement based on this and an understanding of the intended audience.
- justify the focus and nature of their presentation, based on understandings of the issue, its impact on the ICT community and feedback gained from key stakeholders representative of their target audience
- develop specifications for their presentation from identified attributes ensuring that each specification allows for a standardised evaluation to be undertaken.

- refine their conceptual statement and specifications as they undertook further research into the issue and its impact on the wider ICT community, developed further skills and understandings of presentation design, typography and image manipulation and gained evidence from key stakeholders of how both the information and its presentation impacted (positively and/or negatively) on the development of understandings of the issue
- describe final specifications for their presentation in terms of aesthetics and performance that allowed them, their teacher and key members of their target audience to provide feedback on their progress and the fitness for purpose of their final outcome

Senior Secondary (Years 11-13)

A group of year 13 students was invited to work with a local picture framing business called Edges. Edges provided a common context for the students to explore in order to identify issues, and potential needs and/or opportunities within these. Issues identified included: security, advertising and promotion, and construction and display of products.

The students worked closely with the client to develop a brief to define and specify the requirements of an outcome that would address an identified need or opportunity for Edges. The students' final outcomes were in the form of the brief and conceptual ideas for potential outcomes that would meet the brief. For details of this unit please see Client based student practice

Students achieving at level 4 could:

- identify a need and establish a conceptual statement for a potential outcome based on this
- justify the focus and nature of potential outcomes, based on understandings of the need or opportunity and the impact of the selected issue on Edges as a business
- establish key attributes for potential outcomes, and how they could be best communicated, as a starting point for development work
- refine their conceptual statement and key attributes, as they undertook further research and explored techniques for developing and communicating conceptual ideas, and gained feedback from personnel working at Edges
- describe the key attributes required for potential outcomes that allowed them, their teacher and personnel working at Edges to provide feedback on their developing communication skills, and the potential fitness for purpose of the conceptual ideas presented

Students achieving at level 5 could:

- identify a need and establish a conceptual statement for a potential outcome based on this
- justify the focus and nature of potential outcomes, based on understandings of the need and discussions with key stakeholders associated with Edges
- develop specifications for their presentation from identified attributes ensuring that each specification allows for a standardised evaluation to be undertaken
- refine their conceptual statement and specifications as they undertook further research and experimented with a range of techniques for developing and communicating conceptual ideas, and gained feedback from key stakeholders associated with Edges
- describe final specifications for their potential outcome that allowed them, their teacher and key stakeholders associated with Edges to provide feedback on the effectiveness of their communicative drawings/displays to convey design ideas, and the potential fitness for purpose of the conceptual ideas presented

Students achieving at level 6 could:

- identify a need and establish a conceptual statement for a potential outcome based on this
- justify the focus and nature of potential outcomes, based on understandings of the need or opportunity, understandings of current and prospective customers, and discussions with key stakeholders
- develop specifications for their presentation from identified attributes ensuring that each specification allows for a standardised evaluation to be undertaken for both the potential outcome and its communication to a

range of audiences

- refine their conceptual statement and specifications as they undertook further research into the need or opportunity, the physical and social environment within which Edges functions, and experimented with a range of techniques for developing, communicating and trialling conceptual ideas with different stakeholders such as Edges' staff, customers (past, current and potential future), to gain critical feedback on both the ideas and the techniques used to communicate them
- justify specifications for a potential outcome in terms of key and wider community stakeholders.

Students achieving at level 7 could:

- explore the context to select an issue which allowed them to identify a need and establish a conceptual statement for a potential outcome based on this and an understanding of the issue
- justify the focus and nature of potential outcomes, based on understandings of the impact of the selected issue on Edges as a business, understandings of current and prospective customers, and discussions with key stakeholders
- develop specifications for their presentation from identified attributes to guide development work of a potential outcome to address the issue, and to ensure the potential outcome is effectively communicated to a range of audiences ensuring that each specification allows for a standardised evaluation to be undertaken
- refine their conceptual statement and specifications as they undertook further research into the issue as it relates to Edges, the physical and social environment within which Edges functions and experimented with a range of techniques for developing, communicating and trialling conceptual ideas with different stakeholders such as Edges' staff, customers (past, current and potential future), to gain critical feedback on both the ideas and the techniques used to communicate them
- justify specifications for a potential outcome in terms of key and wider community stakeholders, resources available, and environment considerations related to the potential outcomes intended location.

Students achieving at level 8 could:

- explore the context to select an issue which allowed them to identify a need and establish a conceptual statement for a potential outcome based on this and an understanding of the issue
- justify the focus and nature of potential outcomes, based on understandings of the impact of the selected issue on Edges as a business, other factors influencing and impacting on Edges from the physical and social environment, including understandings of current and prospective customers, and discussions with key stakeholders
- develop specifications for their presentation from identified attributes to guide development work of a potential outcome to address the issue, and to ensure the potential outcome is effectively communicated to a range of audiences ensuring that each specification allows for a standardised evaluation to be undertaken
- refine their conceptual statement and specifications as they undertook further research into the wider context and the issue as it relates to Edges, the physical and social environment within which Edges functions and experimented with a range of techniques for developing, communicating and trialling conceptual ideas with different stakeholders such as Edges' staff, customers (past, current and potential future), to gain critical feedback on both the ideas and the techniques used to communicate them
- justify specifications for a potential outcome, and for the development of conceptual ideas of possible outcomes, in terms of key and wider community stakeholders, resources available, environment considerations related to the potential outcomes development and intended location, and implications from the wider context.

EXPLANATORY PAPER

The Technological Practice Strand: Planning for Practice

ABSTRACT

The purpose of this explanatory paper is to clarify and define the nature of effective planning that supports technological practice. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology and technology education.

COMPONENT DESCRIPTOR

Effective planning techniques are critical for informed and responsive technological practice. Planning tools must be fit for purpose if they are to ensure the successful development of outcomes. Planning allows understandings from past and current experiences, as well as those that may be reliably forecast, to be taken into account in a systematic and managed way. Efficient resource management and accessing of stakeholder feedback relies on forward planning. Planning for practice incorporates *ongoing* critical evaluation and *efficient* and *appropriate* documentation. Planning for Practice can be thought of as the organising practice of technological practice.

KEY IDEAS

Effective planning techniques ensure efficient resource management (including the management of materials, time, money and personnel) and as such are critical for informed and responsive technological practice. Planning for practice includes a recording aspect to support resource management, enable reflection on past decision making, and ensure vital documentation is maintained.

A range of planning tools can be used to make sure record keeping does not become arduous or irrelevant to enhancing the quality of the practice undertaken.These planning tools should be selected and/or developed on the basis that they are best suited to the nature of the practice being undertaken, and the communication strengths of the technologist. Record keeping may therefore include oral, graphical, written, and/or electronic modes of documentation as appropriate. Technological practice is enhanced when the documentation of planning strategies best meets the needs of all stakeholders, including the technologist themselves.

Planning tools include such things as: brainstorms, mind-maps, idea banks, reflective journals and/or scrapbooks, plans of action, Gantt charts, flow diagrams, graphical organisers, and structuring/diagramming techniques etc. In order to work most effectively and responsively, specific planning techniques need to be developed as part of technological practice to ensure that all factors key to success are taken into account throughout the developmental work.

Ongoing reflection and evaluation of past and current planning experiences, (both one’s own and those of others), can enhance the ability to make informed planning decisions. Planning should take into account the physical and social environment into which the outcome is to be situated, as well the environment in which the technological practice is occurring.

A significant aspect of supporting such planning is the analysis of the impacts and implications (ethical, environmental, political etc) of the practice, as well as those that result from the development of the outcome itself. Analysing both historical and contemporary contexts can help identify past planning strengths and weakness and inform future planning decisions.

Effective planning for practice should result in planning that is both flexible and robust. That is, It should be flexible enough to incorporate modifications as based on a critical evaluation of progress to date, and be able to respond to unforeseen eventualities (barriers or new opportunities), and/or changing factors. However, it should be robust enough to provide clear guidance of ‘where to next?’, ensure resource availability, and allow critical feedback to be gained in time for key decision points. Records should provide enough detail to enable them to be used to justify past decisions, or provide direction for new plans should the practice result in a dead end or should the development be queried by an external evaluator. This is particularly important to ensure ethical and/or legal protocols are followed in as required by social and/or legal conventions.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

Wellington City Council is always planning ways to enhance its city. The waterfront is a key feature of Wellington's landscape, and a focus on enhancing and expanding the Oriental Bay beachfront was decided to be a justifiable project for the Council to undertake. When undertaking technological practice to change the natural environment a number of key and wider community stakeholders must be part of the consultation process, and managing this, alongside the complex environmental issues that arise when undertaking such a project, requires effective planning to ensure critical feedback is gained at crucial decision making points and that resources are managed in appropriate and sustainable ways. For examples of the nature of planning underpinning this project see Oriental Bay Beach Development

Putting together a film is a complex management process as people are a key resource and as such require specialised resource management strategies. 'This is not a Love Story' is a Loose Unit film production by Keith Hill. With significant resource constraints to contend with – such as limited money, Keith had to also carry out strategic planning at every stage of the development, to ensure the project would continue and his ideas would be realised. For examples of some of the planning techniques used to work within severe constraints see This is not a Love Story

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY EDUCATION

The following learning experiences have been provided to support teachers as they develop their understanding of the Planning for Practice component of the Technological Practice strand. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been summarised from classrooms across New Zealand and provide examples of student achievement across a range of levels. This stance reflects the majority of classrooms, within which it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

A group of students had been learning about electricity as part of a science unit. They then decided to use this knowledge to make their own motorised toys to star in a puppet show for younger students at the school. For details of this unit please see the Ministry of Education's Connected Series 2005 Volume 1 – Super Toy Makers.

Students achieving at level 1 could:

- explain how they looked at a range of toys brought from home, to give them ideas about the features their toy could have and the type of material it could be made out of
- suggest how they could balance their toy by adding weight to the base of the fairy and how they could make a storage compartment for the battery
- suggest that the thick piece of cardboard could be used for the heavy base and the thinner cardboard could be used to hold the battery

Students achieving at level 2 could:

- identify the key stages required to complete an Angel toy with a spinning halo; these being the need to complete their design first, then make a working model of their toy to test that the halo spins properly, before making the proper body of the toy and applying the finishing decorations
- explain that old pieces of card were used to make a working model of the Angel's body and the spinning mechanism when they were test how well their design might work
- record key stages and resources needed in a flow diagram including an estimate of how much time it will take organise the materials they need, and make and test their toy, and that they would need new plain card, coloured pencils and ribbon to use in its final construction

Senior Primary/Intermediate (Years 5-8)

A group of students found that their school garden was producing more vegetables than could be used during particular growing seasons. They worked alongside a community expert to develop a pataka for storing the vegetables, so the gardening efforts would not go to waste. For details of this unit please see the Ministry of Education's *Connected Series 2005 Volume 3 – Our Pataka*.

Students achieving at level 2 could:

- identify the key stages required to ensure the construction of a storage hut within the timeframe and financial constraints and record these in a plan of action
- draw a design of their outcome and label the materials it could be made of

Students achieving at level 3 could:

- record a plan of action that showed key stages and how much time each stage would require, what knowledge was needed, and who could be approached to provide any additional expertise/skill needed to ensure the plan could be put into action
- review the initial plan of action and modify as needed to take account of changes to their timeline and environmental factors

Students achieving at level 4 could:

- develop a plan of action that included key stages, activities that needed to be undertaken and the resources required for these to be successful. Plan also included details of experts that would need to be accessed at each stage and how they could be contacted, and identified review points to reflect on progress to date
- allocate time for meeting with stakeholders (teacher, others involved in garden, outside expert, principal, local council) to ensure ideas and materials selected were in keeping with stakeholder expectations
- undertake periodic reflection of progress and use this to update their timelines and resource needs as the project proceeded to ensure dates for building were confirmed well in advance and plans made to cater for the helpers on the day

Junior Secondary (Years 9-10)

A year 9 class developed a class time capsule, with personalized contributions being designed by each class member. The students worked to a given brief but were required to personalize this to guide their individual pieces. Planning was a key part of the process to ensure the practice undertaken was coordinated and completed in time for the capsule's closure. For details of this unit please see Time Capsule

Students achieving at level 3 could:

- identify the key stages in the development of the class capsule, and the implications of these for their own capsule
- identify the materials they would need for the name stand, the resin artefact and the individual time capsule, and where they expected to access these from
- draw diagrams detailing how the name stand, the resin artefact and the individual time capsule would be made and the materials needed for each
- review diagrams and modify, as a result of progress to date and resource availability.

Students achieving at level 4 could:

- develop initial plans for their own capsule showing how they fitted in with the class plans
- draw diagrams showing how the name stand, resin-captured flower and capsule would be constructed; annotate diagram with notes about possible materials and their costs, and identify times to use gain feedback from the teacher, technician and other students
- review diagrams, develop step-by-step instructions, and compile a list of materials selected and where and how they could be accessed.

Students achieving at level 5 could:

- discuss the planning decisions made during the development of the class capsule, and past planning they had been involved in to identify strengths and weaknesses of particular planning tools
- use a combination of action plans, Gantt charts and flow diagram to plan how they could access knowledge and skills required to construct each part of their project; and ensure they had enough time with people at the museum to ensure their perspectives could inform future planning decisions
- develop a Gantt chart to clearly align tasks to be done with their timeframes, and provide guidance for where to next
- draw detailed flow diagrams showing how the name stand, the resin-captured flower and the capsule would be constructed; annotate diagram with notes about possible materials and costing
- document planning decisions and outcomes in a digital scrapbook of design ideas, including previous plans, charts and diagrams annotated with reflective comments showing why decisions and any changes had been made.

Senior Secondary (Years 11-13)

A group of year 11 students was provided with an opportunity to develop software to meet a specific learning need. The students were asked to identify a user with a specific learning need and investigate that need over the coming weeks. The users identified by the students had a range of needs.

One student had a ten-year-old sister who was just starting to do algebra; he wanted to make the subject fun, because when he had done it he had found it intimidating. Another wanted to create a learning programme that would teach his sister about healthy eating. Several students worked with ESOL students in the school and one worked with the school learning support unit. During the unit the students needed to learn about programming principles, interface design, coding animations and interactivity. For details of this unit please see ICT Programming

Students achieving at level 4 could:

- develop possible sketches and storylines for their programme, and use these to develop a list of resources required to support their development
- plan future activities that would provide opportunity to develop the knowledge and skill they required to develop their programme ideas; time with their target user was planned to occur at many stages to trial design ideas and check the suitability of the programme being developed
- develop a storyboard to communicate key ideas to others for feedback
- revise storyboard to serve as guide for the development of the programme

Students achieving at level 5 could:

- reflect on previous planning decisions they had made, identifying things they did well and not so well in the past, in terms of organising their time and resources
- evaluate possible planning tools for use in this project and select a visual diary format, a planning framework, and a storyboarding template to support their practice
- establish and record their initial plans in a format that demonstrated they were making informed decisions about what was required of them, in terms of accessing information from their target user, guidance from their teacher and/or mentor, and their personal development of skills and knowledge in the area of programming
- draw sketches of possible ideas for games and suggest potential storylines, using these to gain feedback from the target user before reviewing ideas for the programme
- capture their progress to date in a visual diary, and explore the implications for what steps they needed to take next and the resources required to support this
- develop diagramming techniques to communicate current thinking for feedback and to provide guidance for the construction of the programme
- evaluate progress to date, by reflecting on plans, drawing and structuring diagrams, and recording reasons for decisions made in their visual diary

Students achieving at level 6 could:

- critically analyse their own and others' planning practices to establish personal organisational abilities, and explain how these could be enhanced through the use of well selected planning tools
- research and evaluate a range of planning tools, to select tools justified as suitable to the context of the project and their personal organisational ability
- draw detailed sketches of feasible ideas for games and develop potential storylines, using these to gain feedback from the target user before reviewing ideas for the programme
- employ the use of selected planning tools (a visual diary, updateable planning framework, and a range of diagramming templates) at different times, to best support their forward planning, and time and resource management; provide justifications for decision making in terms of the physical and social environment in which they were working and the specific requirements of the target user

Students achieving at level 7 could:

- critically analyse their own and others' experiences of self and team management, to identify a range of planning tools that could be successful in enhancing management practices
- identify personal strengths and weaknesses in relationship to the planning and management requirements of the brief, and develop planning tools that would specifically address these in the context of the project
- employ specifically developed planning tools (a visual diary, updateable planning framework, and a range of diagramming techniques) in an effective manner, to manage, document and justify decisions in terms of the physical and social environment in which they are working and the specific requirements of the target user

Students achieving at level 8 could:

- critically analyse their own and others' project management experiences in the field of ICT, to identify key factors essential to efficient project management
- identify personal strengths and weaknesses in relationship to project management in technology, and plan learning opportunities to develop and enhance these
- critically analyse a broad range of planning tools and select those that would best support their project management practices
- develop an initial plan that allowed for extensive exploration of what efficient planning and resource management would require in this environment
- employ the use of specifically selected planning tools to support the project management of their work in an efficient and critically reflective manner, ensuring decisions about information presented, means of presentation, resources used and the management of time and resources were informed and critically evaluated in an ongoing manner, in keeping with contemporary understandings and project management best practice in the field of ICT.

EXPLANATORY PAPER

The Technological Practice Strand:
Outcome Development and Evaluation

ABSTRACT

The purpose of this explanatory paper is to clarify and define the way in which outcomes are conceptualised, developed and refined as part of technological practice. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology and technology education.

COMPONENT DESCRIPTOR

The development of a *technological outcome (product or system)* involves the creative generation of design ideas leading to the testing and refinement of these into a conceptual design for a potential outcome, and the production and evaluation of an outcome prior to it's acceptance for use in-situ. This is achieved through such things as research, experimentation, functional modelling, and prototyping.

Outcome development and evaluation relies on the use and/or development of constructive skills and knowledge - including those associated with communicating design concepts and working with materials. Analysis of evaluative data gained from functional modelling and prototyping, and the use of this to make informed and justifiable decisions for a potential and/or realised outcome is critical to ensure the final outcome when produced is fit for purpose as defined by the brief. Outcome Development and Evaluation can be thought of as the production and evaluation practices of technological practice.

KEY IDEAS

The successful result of technological practice is the realisation of a technological outcome (that is, a technological product or system) that is fit for purpose as described in the brief. While there are many situations where development work may end before this point, this component is focused on the production and evaluation practices involved in the creation of a conceptual design for a potential technological outcome, and the final production of that outcome.

This will involve the creative generation and testing of design ideas, the refinement of concepts to communicate an outcome that can be evaluated in terms of its potential to be fit for purpose, and the production and evaluation of an outcome to establish its fitness for purpose prior to it's acceptance for use in-situ. This is achieved through such things as:

- research - including accessing published research findings and carrying out one's own research through such things as the analysis of existing technological outcomes
- experimentation - particularly for the purpose of enhancing knowledge and skills surrounding the communication of design ideas, the working of materials, and safe and competent equipment usage
- functional modelling - to test design ideas prior to them being realised
- prototyping to provide evidence of the outcomes fitness for purpose or need for further development

Initial testing of design ideas through a range of functional models provides evaluative data to help refine a conceptual design. Evaluation of design ideas through functional modelling should be undertaken extensively, to identify if conceptual ideas communicate an outcome that is potentially fit for purpose and to ensure stakeholder opinion is a key part of this evaluative process.

Outcome development is enhanced through the effective presentation of conceptual ideas to others, including key stakeholders, using a range of graphical and other visual communication techniques. Stakeholder feedback needs to be accessed regularly and critically analysed to ensure that it informs the development work in an effective manner.

Exploration of the performance properties and/or aesthetic impact of possible materials, alongside their current and future accessibility, availability and disposability, all allow for informed material selection to support the resultant outcome as fit for purpose in the traditional sense as well as in its broadest sense. The establishment of context specific material knowledge and skills, and equipment usage, is essential for outcomes to be developed that are of a high quality.

Prototyping provides data from *in situ* trialling for the evaluation of a technological outcome's fitness for purpose. Accessing feedback from stakeholders is essential to all evaluations.

All evaluations should feed directly into planning for practice and will often provide the basis for justifications of changes to initial plans and resource projections. Such evaluative data is also used to inform the development and/or refinement of the brief where it is identified as being necessary.

To support the production of an outcome that can be deemed fit for purpose in its broadest sense:

- functional modelling should seek to explore the outcome's suitability with reference to both the outcome itself *and* the practices used in its development,
- prototyping should attempt to evaluate the outcome in keeping with the wider context within which the brief resides and/or the physical and social contemporary and possible future environmental influences and impacts.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

Te Ara is the new official encyclopaedia of New Zealand. The Government's Ministry of Culture and Heritage (MCH) decided to publish the encyclopaedia online – the first time any country has created an official national encyclopaedia in this way.

In order to ensure the online environment met the needs of key stakeholders , current and potential future users of the site, exhaustive testing and analysis of feedback was needed at key stages of the development. For examples of some of the different functional models to aid this, see the Techlink case study Engineering Te Ara

In motor racing, ultimate advantage is gained through understanding the interaction between the technology of a vehicle and the environmental conditions within which it must perform. Once the key design features of a vehicle are decided, prototype testing is often the only way to refine the outcome to optimize performance. Learning from past innovations to create contemporary products, prototype testing and ongoing modifications are key features of Graeme Addis's plans to win the New Zealand Sports Sedan Championship. For examples of how he developed and tested his outcome see the Techlink case study Winged Victory

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY EDUCATION

Learning experiences

The following learning experiences have been provided to support teachers as they develop their understandings of the Outcome Development and Evaluation component of the Technological Practice strand. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been summarised from classrooms across New Zealand and provide examples of student achievement across a range of levels. This stance reflects the majority of classrooms, within which it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

A group of students worked alongside a practicing engineer and local Kaumatua to design and develop a concrete Taniwha, to serve as a seat that would provide a meeting space and support discussions for the envirogroup and others in the school. It was situated outside in the garden, and a range of design ideas was trialled to strike a balance between functional and aesthetic attributes. For details of this unit please see the Ministry of Education's Connected Series 2005 Volume 2 – Meeting Seating.

Students achieving at level 1 could:

- draw design ideas for a seat, and develop models out of clay to represent what a selected idea may look like
- carry out assigned roles in developing the seat
- evaluate the Taniwha seat, in terms of how it looks in the garden setting and how comfortable it is to sit on

Students achieving at level 2 could:

- draw design ideas and create a model of the selected design that communicated the 'look' of a potential outcome; develop a mock-up to test material use and construction techniques
- identify the strengths and weaknesses of design ideas and be involved in discussions to select an appropriate design
- evaluate the Taniwha seat in terms of how it met the needs of the envirogroup

Senior Primary/Intermediate (Years 5-8)

After being involved in a soap making unit, the students in this class began to ask questions about why soap is not recommended for use on hair, and why shampoos are so expensive compared to soap. They also wondered why conditioners are necessary. This sparked the idea for a unit based around making hair care gifts.

The students carried out extensive investigations of hair, and the chemistry of hair care products, before making a hair gift pack for a selected recipient. Each gift pack included a hair wrap and a 'button' for fastening it. For details of this unit please see Ministry of Education's Applications Series 2005 – *Lips, Lipids and Locks* and Hairs your Gift

Students achieving at level 2 could:

- develop logo designs for gift pack for use on the button and labels;
- evaluate logo designs and product ideas as suitable or not for recipient, and select those appropriate for further development
- develop a gift pack containing products in keeping with the recipients needs
- evaluate the gift pack in terms of how it addressed the attributes identified for their recipient

Students achieving at level 3 could:

- develop logo designs for gift pack that reflected the selected recipient's interests and/or personality; test their logo designs with peers to determine their suitability for use on the button and labels; explore and test different recipes for shampoo and wax to determine product range suitable to meet recipient needs
- evaluate logo designs and product ideas to determine suitability for recipient and select those appropriate for further development;
- undertake testing of shampoo (acidity and tensile strength) and hair wax (drop and rub), and use results to modify products as based on the needs of the identified recipient
- develop a gift pack containing products that addressed the attributes identified for their recipient
- evaluate the gift pack against key attributes identified in the brief to determine how well it would serve as a gift for the recipient

Students achieving at level 4 could:

- develop logo designs for gift pack that took into account the resources available, (material and manufacturing process of the button, size and material of labels); communicate design ideas to recipient to gain feedback; explore and test different recipes for shampoo and wax and research ingredients; compile a summary of findings for recipient to gather feedback on suitability, in terms of hair type and personal preferences concerning fragrance and ingredients
- evaluate logo designs and product ideas in terms of their ability to meet the attributes identified from recipient feedback and the constraints identified from research into resources available;
- undertake testing of shampoo (acidity and tensile strength) and hair wax (drop and rub), and use results to modify products based on ensuring key attributes were prioritised to best meet recipient needs
- develop prototype samples of products for recipient testing, using their feedback to refine products

- develop a gift pack containing products that incorporated all key attributes identified
- gather recipient feedback to provide evidence of how well it addressed the key attributes for use in an evaluation of the gift pack's fitness for purpose

Junior Secondary (Years 9-10)

In an attempt to consolidate earlier learning in technology, this teacher decided to focus her year 10 students on developing batters, as a way of developing a better understanding of food formulation.

The students began by trying out basic recipes, such as pikelets, to gain experiences to work from. They were asked then asked to work with people outside the classroom, to identify a client for their 'batters in a bottle' development work. There was a strong focus on sensory evaluation and storage testing, to help students to evaluate their outcomes to create high quality food products suitable for their selected client. For details of this unit please see Batters in a Bottle

Students achieving at level 3 could:

- develop designs for labels that reflect the selected client's colour preferences; explore the suitability of range of containers; explore and test different recipes for a range of potential products, and identify storage issues associated with the ingredients for each
- evaluate designs and product ideas to determine suitability for the client and select one for further development;
- undertake sensory testing with client to refine recipe
- develop a package of bottled ingredients, including labels for containers that address the client's colour, taste and 'ease of making' preferences
- evaluate the package against key attributes identified in the brief

Students achieving at level 4 could:

- develop designs for labels, and select a range of containers and product outcomes that reflect the selected client's colour, taste, nutritional requirements and requirements for making preferences, (i.e. ease of use, time to make);
- develop concept diagrams to test design ideas with the client to gain feedback on what attributes are key from their perspective
- explore and test different recipes for a range of potential products and use the outcomes as functional models to gain further feedback from client on taste preferences (sensory testing using a hedonic scale) and nutritional concerns based on the ingredients used (discussion of recipes);
- test ingredients to identify any storage issues and explore how these may be influenced by container choice
- evaluate labels, containers and product ideas, and select a package design appropriate for further development, refine package design to ensure it incorporates key attributes
- develop a prototype of bottled ingredients for client testing; refine product in keeping with client feedback on key attributes associated with the look and user friendliness of labelling and instructions and the quality of outcome produced
- develop a package of bottled ingredients, including labels for containers, that incorporate the key attributes as determined by the client's preferences, and address the constraints imposed by storage requirements
- gather client feedback to provide evidence of how well it addressed the key attributes for use in an evaluation of the package's fitness for purpose

Students achieving at level 5 could:

- experiment with a range of 'ready to make' food packages and analyse how labelling and packaging requirements enable the product to be successful – or not; reflect on past experiences of food preparation and use this analysis and reflection to develop a feasibility guide, to inform the generation of initial ideas for developing a 'batters in a bottle' food package

- develop designs for labels, and select a range of containers and product outcomes justified in terms of the requirements of the brief, (based on client preferences and specifications associated with storage, packaging and user friendliness);
- develop appropriate functional models (including concept diagrams, discussion prompts, photographs of container types, recipes, and photos of products); use the models to illustrate the range of options available and test initial design ideas as to how they may form a package; use models to gain critical feedback from the client on the specifications they consider essential.
- experiment with a range of labels, recipes and storage options, and seek input from additional sources, (research findings, other people who may eat the food product such as family members, friends etc), to determine suitability of resources in terms of the specifications
- refine package ideas, incorporating justified label designs, containers, recipes and ingredients, and undertake further functional modelling with the client to gain critical feedback to select one for further development; modelling included sensory testing of food product, functionality testing of containers, judgments on quality of label including clarity of instructions
- develop a prototype of bottled ingredients for client trialling in the environment for which the package is being developed; refine product in keeping with client feedback related to the specifications of the brief and any additional comments from others who viewed and/or used the package, or ate the food product
- use feedback from key stakeholders, including the client and teacher, to provide evidence to support an evaluation of the fitness for purpose of the final 'Batters in a Bottle' package

Senior Secondary (Years 11-13)

A year 12 class worked with a local client to develop an innovative lighting product for an inner city café/restaurant and club called Sandwiches. The students were provided with initial learning experiences around lighting, to increase their skills and understandings before embarking on designing and refining an appropriate lighting product for their client. This was an important aspect of the programme as the outcomes to be developed needed to be of a high quality and comply with all relevant safety codes. For details of this unit please see Bright Ideas

Students achieving at level 4 could:

- develop design ideas for potential lighting products reflective of the key aesthetic attributes established from Sandwiches 'Retro Kiwiana' style; develop a functional model (for example, using sketches, annotated diagrams, material samples, colour suggestions) to test design ideas with the client to gain feedback
- explore and test different materials for a range of potential lighting products ,taking into account key attributes of cost effectiveness and safety; create mock-ups to gain further feedback from client on preferences; explore possible means of production for different design ideas and evaluate these in terms of suitability for batch production
- evaluate design ideas, and select a design appropriate for further development; experiment with materials and design features to ensure they incorporate key attributes and will allow for the development of a feasible outcome
- develop a prototype lighting product; gain product safety certification from registered electrician prior to trialling *in situ*, for client feedback; refine in keeping with client feedback on key attributes associated with the look and function of the lighting product
- present a final lighting product that incorporated the key attributes determined from the opportunity provided by the client's preferences and constraints imposed by budget, production and safety requirements
- gather client feedback to provide evidence of how well it addressed their needs/desires and use this in an evaluation of the lighting system's fitness for purpose

Students achieving at level 5 could:

- research and explore a range of lighting products for public venues including those already used in Sandwiches; reflect on experiences from previous tea lantern development; use this analysis and reflection to inform the generation of a range of initial ideas that fully explore the opportunity provided

- evaluate the design ideas to select those that are justified as appropriate in terms of the requirements of the brief (based on Sandwiches style, client preferences and specifications associated with safety and batch production); develop appropriate functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles) to illustrate the range of options available and test initial design ideas to determine their feasibility for the environment of Sandwiches; use models to gain critical feedback from the client and mentors on the specifications they consider essential
- experiment with a range of materials and design features, seeking guidance from additional sources (research findings, mentors, friends etc) to determine suitability of resources, in terms of the specifications related to safety, durability, construction processes, and associated costs
- refine design ideas incorporating justified features and materials and undertake further functional modelling with the client and mentors, to gain critical feedback to select one for further development
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client and mentor feedback; refine, in keeping with client and mentor feedback related to the specifications of the brief, and any additional comments that could enhance the system without compromising any specifications
- present a final lighting product that meets the specifications of the brief, as determined from the opportunity provided by the client's preferences and constraints imposed by budget, production and safety requirements
- use feedback from key stakeholders, including the client, teacher and mentor, to provide evidence to support an evaluation of the fitness for purpose in terms of the brief of the final lighting product

Students achieving at level 6 could:

- critically analyse a range of contemporary and historical lighting products for public venues, including those used in Sandwiches currently and in the past; critically reflect on experiences from previous technological practice – including tea lantern development; use this analysis and reflection to inform the generation of a range of initial ideas that explore the potential of the opportunity provided
- evaluate the design ideas to select those that are justified as appropriate in terms of the requirements of the brief (based Sandwiches style, client preferences and specifications associated with safety and batch production), and from the physical and social environment in which the lighting product is to be placed; develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, models to illustrate potential materials and their effect) to illustrate the range of options available and test initial design ideas of how they may work in the environment of Sandwiches; use models to gain critical feedback from the client, mentors and customers on the specifications they consider essential and desirable.
- experiment with a range of materials and design features, seeking guidance from additional sources (research findings, mentors, friends etc) to justify suitable resources in terms of the specifications related to safety, construction processes, and associated costs, as well as wider considerations of physical (resource availability) and social (symbolic associations of the design) considerations
- refine design ideas incorporating justified features and materials and undertake further functional modelling with the client and other stakeholders (including customers), to gain critical feedback to select one for further development
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client, mentor and customer feedback; refine, in keeping with client and mentor feedback related to the specifications of the brief, and any additional comments from key stakeholders and customers that could enhance the product without compromising any specifications
- present a final lighting product that met the specifications of the brief and was appropriate to physical and social environment of Sandwiches
- use feedback from a range of stakeholders, including the client, teacher and mentor and customers, to provide evidence to support an evaluation of the lighting product's fitness for purpose, in terms of the brief and the physical and social environment of Sandwiches

Students achieving at level 7 could:

- explore a range of contemporary and historical lighting products, including those used in Sandwiches currently and in the past, with particular emphasis on critically analysing their fitness for purpose; reflect on experiences from previous technological practice – including tea lantern development, critically analysing these in terms of how fit for purpose they were; use this analysis and reflection to inform the generation of a range of innovative ideas that explore the potential of the opportunity provided
- evaluate the design ideas to select those justified as appropriate, in terms of the requirements of the brief (based on Sandwiches style, client preferences and specifications associated with safety and batch production) and from the physical and social environment in which the lighting system is to be placed, and the wider context of lighting public venues. Develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, models to illustrate potential materials and how they can be modified to change effect) to illustrate the range of options available and test initial design ideas of how they may work in the environment of Sandwiches. Use models to gain critical feedback from the client, mentors, a range of customers and other stakeholders identified (musicians that regularly play at Sandwiches, potential future customers, neighbouring shop owners etc) on the specifications they consider essential and desirable.
- explore a range of resources and the implications of material selection for disposal, and critically investigate design features, including an exploration of the implications for product maintenance, seeking guidance from additional sources (research findings, mentors, friends etc) to determine the suitability of resources. Undertake evaluative testing procedures in line with accepted codes of practice to ensure they would meet the specifications related to safety, production processes, and associated costs, as well as wider considerations of physical (resource availability sustainability/disposal) and social (symbolic associations of the light product's aesthetic) considerations
- explore the implications of the changing use of the venue (during the day, early evening, late night) and refine design ideas accordingly, incorporating justified features and materials, and undertake further functional modelling with the client and other stakeholders to gain critical feedback to select one for further development.
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client, mentor and customer feedback. Refine in keeping with client and mentor feedback related to the specifications of the brief and any additional comments from key stakeholders and customers that could enhance the system without compromising any specifications.
- present a final lighting product that met the specifications of the brief and was appropriate to physical and social environment of Sandwiches
- evaluate the final lighting product's fitness for purpose against the brief, using key and wider community stakeholder feedback to justify its suitability to address the issue of lighting public venues

Students achieving at level 8 could:

- explore a range of contemporary and historical lighting products, including those used in Sandwiches currently and in the past, with particular emphasis on critically analysing the product's fitness for purpose in its broadest sense. Identify wider issues associated with the context of lighting in public venues. Reflect on experiences from previous technological practice – including tea lantern development, critically analysing these in terms of how fit for purpose they were. Use this analysis and reflection to inform the generation of a range of innovative ideas that fully exploit the potential of the opportunity provided.
- evaluate the design ideas to select those justified as appropriate in terms of the requirements of the brief (based on Sandwiches style, client preferences and specifications associated with safety and batch production), and from the physical and social environment in which the lighting system would be placed. Develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, models to illustrate potential materials and how they can be modified and finished to create a range of effects) to justify the options available, as allowing for a lighting product that would be fit for purpose in its broadest sense. Use models to gain critical feedback from the client, mentors, customers and other stakeholders identified (musicians that regularly play at Sandwiches, potential future customers, neighbouring shop owners etc) on the specifications they considered essential and desirable.
- explore a range of resources, and the implications of material selection for ultimate disposal; critically investigate design features, including an exploration of the implications for ongoing product maintenance, seeking guidance from additional sources (research findings, mentors, friends etc) to determine the suitability of resources. Undertake evaluative testing procedures in line with accepted codes of practice) to ensure they will be appropriate for use in a lighting product that will be fit for purpose
- explore the implications of the changing use of the venue (during the day, early evening, late night), and refine design ideas accordingly, incorporating justified features and materials; undertake further functional modelling, with the client and other stakeholders, to gain critical feedback to select one for further development
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client, mentor and customer feedback; refine, in keeping with client and mentor feedback related to the specifications of the brief, and any additional comments from key stakeholders and customers that could enhance the system without compromising any specifications
- present a final lighting product that was fit for purpose
- critically evaluate the lighting product's fitness for purpose against the brief, issue and context, using key and wider community stakeholder feedback to justify its fitness for purpose

EXPLANATORY PAPER

The Nature of Technology Strand:
Characteristics of Technological Outcomes

ABSTRACT

The purpose of this explanatory paper is to clarify and define what a technological outcome is, and how it is characterised and described. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology. This paper also suggests possible learning experiences.

COMPONENT DESCRIPTOR

Technological outcomes are products and systems developed through technological practice for a specific purpose. A technological outcome is evaluated in terms of its fitness for purpose. Technological outcomes can be described by their physical and functional nature. A technological outcome can only be interpreted when the social and historical context of its development and use are known. The term proper function is used to describe the function that the technologist intended the technological outcome to have and/or its socially accepted common use. If a technological outcome does not carry out its 'proper' function successfully it is described as a malfunction. Alternative functions are successful functions that have been evolved by end-users. Technological outcomes work together with non-technological entities and systems in the development of socio-technological environments.

KEY IDEAS

Technological outcomes are defined as fully realised products and systems, created by people for an identified purpose through technological practice. Once the technological outcome is placed *in situ*, no further design input is required for the outcome to function. Being fully realised means technological outcomes are more than a concept or plan for something to be developed - they actually exist and function as designed in the made world. Function includes all aspects that underpin the fitness for purpose of the technological outcome – including aesthetic aspects. Taking this definition into account, technological outcomes can be distinguished from natural objects (such as trees and rocks etc), and works of art, and other outcomes of human activity (such as language, knowledge, social structures, organisational systems etc).

Within this definition, technological outcomes can be categorised into two types – technological products and technological systems. However, the relationship between technological products and systems can be complex. In many ways, it depends on the way you look at a technological outcome as to whether you would identify it as a technological product or a technological system For example, a cell phone could be described as a technological system, which is made up of interconnected components. Alternatively, a cell phone may be described as a technological product, where the internal components are no longer the focus of the description, being replaced by a focus on the materials.

A key feature of technological products and systems is that they are intimately connected to other entities (including natural objects and people) and systems (including political, social, cultural systems etc). That is, technological outcomes help to form socio-technological environments as the made world combines with the natural and social world. Socio-technological environments include such things as communication networks, hospitals, transport systems, waste disposal, recreational parks, factories, power plants etc. For example, the cellular communication environment incorporates a range of technological products and systems (cell phone, towers, data logging computers, transmitting circuits, receiver circuits and so on), alongside non technological systems (such as legal, political, financial, energy etc) and entities (such as people, geographical features,).

A technological outcome is characterised as having a 'dual nature' – that is: a physical nature, what it looks like and/or is comprised of; and a functional nature, what it can do. Understanding the relationship between the physical and functional natures of technological outcomes provides a good starting point for understanding the technological outcome as a whole.

Understanding this relationship is crucial when undertaking technological practice to develop a technological product or system for a specific function. This understanding allows technologists to recognise that several potential options exist for an outcome's physical and specific functional nature. For example, should you wish to design a technological outcome that would function as a drinking vessel; you may explore a range of shapes (coffee mug *versus* long stem wine glass) and/or materials (ceramic versus glass). What will determine the physical nature in the end, will be the decisions made as to what would provide the drinking vessel with the best fitness for purpose. This will be defined by such things as the liquid to be held, the needs/desires of the intended users, and the environment in which the vessel will end up being situated, alongside the materials, components and equipment available for it manufacture. Similarly, should you wish to design a technological outcome using particular materials or components, you may explore the performance possibilities this would provide in order to identify possible functions the outcome could be designed to achieve. Therefore, the functional nature requirements will set boundaries around the suitability of proposed physical nature options, and the physical nature options will set boundaries around what functional nature is feasible for a technological outcome at any time.

The relationship between the physical and functional nature of any technological outcome can provide a useful analytical tool for guiding decisions regarding the fitness for purpose of a technological outcome during its development. It also provides an effective analytical tool for interpreting existing technological outcomes as well as providing a basis for understanding past and contemporary influences on its development such as being able to establish what knowledge, skill, equipment and materials were available. Understanding the physical and functional nature of a technological outcome also provides insight into possible future implications, and subsequent adaptations or innovations for the outcome's development. The physical nature of a technological outcome can provide critical clues as to the possible function of a technological outcome when this is not known.

When undertaking the analysis of existing technological outcomes, design elements provide another useful analytical tool useful for interpreting outcomes and their design decisions. Design elements based on the form (or physical nature of outcomes) refers to such things as movement, pattern and rhythm, proportion, balance, harmony and contrast, and style. Elements related to the function (or functional nature of outcomes) refer to such things as strength and durability, safety and stability, efficiency, reliability, user-friendliness and ergonomic fit. These elements can be used to understand how form and function factors were prioritised in the design and development of outcomes in order for that outcome to be considered fit for purpose. Design elements also provide guidance for factors to be considered during the development of technological outcomes.

Technological outcomes can also be described and understood in relation to their intended and actual function. The term proper function is used to describe the function that the technologist intended the technological outcome to have and/or its socially accepted common use. The intended function is what drove the development of the physical nature as described above, and what allowed the technological outcome to be evaluated as fit for purpose.

The concept of alternative function is also important when understanding technological outcomes. Alternative functions evolve from the successful use of the technological outcome in a way that was not originally intended by the technologist. Not only do users regularly employ technological outcomes for alternative functions, they may modify the physical nature in order to optimise its performance in terms of this new function. They may also put pressure on technologists to redesign the original technological outcome to meet the additional functional needs they have identified. This demonstrates one way in which end-users, technological outcomes and technologists interact with each other. When an alternative function comes to be the socially accepted normal function of the outcome, this becomes the 'new' proper function of the outcome.

Malfunction is a descriptive term for a technological outcome that does not carry out its proper function successfully. This is referred to as single event failure, and is usually easy to distinguish from any gradual reduction in function caused by general wear-and-tear effects on a technological outcome over time. Malfunction is also very different to what can be described as designed failure, where a product, or component of a system, is intentionally designed to stop working after a certain number of uses. The ethics of designing the life-time of a technological outcome must take account of complex factors such as market forces, maintaining jobs, consideration of future material developments, changing fashions, social norms, and public opinion. Exploration of examples of mal-function, gradual reduction in functioning from ongoing use, or 'designed failure' of technological outcomes, provides an interesting focus for understanding the complex interface between design, materials, end-users, established instructions and parameters of use, and the environments in which technological outcomes are situated.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

The malfunctioning of the O-rings in the Challenger space shuttle in 1986 provides a dramatic context to explore issues around the physical and functional nature of technological outcomes, and the way in which technological products make up a connected technological system. Understanding how products interact within a wider system, when designed to meet specific environmental parameters is crucial to successful function. In this case, while the O-rings were fit for purpose within specific environmental parameters, they malfunctioned when these were exceeded. The impact this accident had on the general public, scientists and technologists (at a personal career level and collective community level), NASA, and the American Government are easily accessible for exploration and would provide a rich source to encourage debate.

Sites such as the FAS Space Policy Project and the Space shuttle Challenger Disaster – a NASA tragedy are just two of many informative sources available.

The role of end-users in developing alternative functions and stimulating innovative redesigning is well captured in many New Zealand examples of technological outcomes. Finding new functions for existing materials, and/or developing new materials to enhance performance, are also strong features of successful technological industries in New Zealand. A range of examples (such as wind turbines, film technologies, car batteries and electric fence technology) can be used as a focus to explore the dual nature of technological outcomes. Sources such as IPENZ's e-nz magazine, numerous internet sites, and current items in news media can all be used to provide New Zealand based resources with varying depths of information.

POSSIBLE LEARNING EXPERIENCES

The learning experiences suggested below have been provided to support teachers as they develop their understandings of the Characteristics of Technological Outcomes component of the Nature of Technology strand, and how this could be reflected in student achievement at various levels. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been written in such a way as to support student learning across a range of levels. This stance reflects the majority of classrooms where it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

Small groups of students could be provided with a range of familiar objects (for example, concrete block, rock, pen, wheatbix, apple, plant, potato, potato chips, stick, walking stick etc) and asked to select which of these they consider to be technological outcomes – giving reasons for their selections. Some of the objects could be the same for each group to see if different groups categorise the same object differently.

Students discuss their reasons for selecting objects as being technological outcomes as a class, and the teacher draws out a shared definition of a technological outcome from these discussions. Students could be asked to select a technological outcome and describe this to the class while the rest of the students close their eyes. The remaining students then try to guess what the outcome is. The teacher models questions that get the students thinking about describing *both* the physical and functional nature of the outcome.

The teacher could then provide students with two sets of technological outcomes. One set could be technological outcomes that have been developed for a similar purpose and environment but from different historical eras (for example, chalk, quill, pencil, pen and handheld computer tablet). The other set could include technological outcomes that have been developed for a similar purpose and time, but for different environments (for example, make-up brush, toothbrush, hairbrush, nail brush, hearth broom and yard broom). Ask students to describe the physical and functional nature of each of the technological outcomes and make links to how and why the outcomes within each set differ.

Students achieving at level 1 could be expected to:

- identify technological outcomes as different to other objects because they been made by people
- describe a technological outcome in terms of what it looks like
- describe a technological outcome in terms of what it does.

Students achieving at level 2 could be expected to:

- identify technological outcomes and explain that they differ to other objects because of the way people have designed and made them for a particular purpose, and to function in a specific way
- describe the physical nature of a technological outcome and explain how this allows the outcome to function in a certain way.

Senior Primary/Intermediate (Years 5-8)

Students could explore two related examples of technological products and technological systems, (for example a billy and an electric jug, and a non-sprung wooden clothes peg and a plastic spring clothes peg). Students could identify and explain why the examples could be called products or systems. Students describe the way in which the physical attributes of their technological outcome allows it to carry out the function it has been designed for, and suggest how fit for purpose each outcome appears to be. Students could discuss how changing the environmental condition or the age of the users might impact on how successfully the outcome could be used.

The teacher could provide the students with a partially developed brief that includes a conceptual statement and the performance specifications for a technological outcome. Depending on the prior knowledge and experience of the students, these may be related to the earlier examples, (for example, a peg for keeping food fresh once opened) or completely unrelated. In pairs, students explore a range of design ideas and evaluate these against the requirements provided in the brief as to how the technological outcome should function. Students could also discuss other functions that a modified version of the design could be used for by different people in different situations. A whole class discussion could focus on differences and similarities in the design ideas and link these to the relationship between the physical and functional nature of technological outcomes.

Students achieving at level 2 could be expected to:

- categorise technological outcomes as products or systems and explain why they have been described as such
- describe the physical nature of a technological product and explain how this allows the outcome to function in a certain way
- describe the physical nature of a technological system and explain how this allows the outcome to function in a certain way.

Students achieving at level 3 could be expected to:

- develop designs of a range of technological outcome that could provide a given function and explain their physical nature
- evaluate designs to select which they consider has the potential to provide the best fitness for purpose.

Students achieving at level 4 could be expected to:

- identify the proper function of selected technological outcomes and suggest possible alternative uses
- explain what might happen to the outcome, the user and/or the environment if selected technological outcomes were used to do things they were not designed for.

Junior secondary (Years 9-10)

Students could explore an historical event to explore why a technological outcome malfunctioned. For example, the Challenger disaster could be explored to develop student understandings about how proper function relies on the outcome being used in the context it was designed for, and changing this context can result in outcome malfunction.

Students could then explore the technological outcome they are currently developing (for example, a stool) in terms of its ability to function in a range of contexts (for example, used on different types of surfaces – wooden floors, carpet, concrete, grass etc) and potential ways of being used (for example, being stood on, swung on, supporting multiple people etc).

Students could discuss ways in which they could maximise the outcome's reliability and/or efficiency across multiple contexts. Particular attention should be paid to the implications of decision making that establishes acceptable functional parameters, and what evidence and reasoning students need in order to justify decisions with regards to the physical and functional nature of their technological outcome.

Students achieving at level 3 could be expected to:

- describe the potential fitness for purpose of the technological outcome they are developing and explain how its physical and functional nature both enable and limit its fitness for purpose in a variety of contexts
- explain how changes to the physical nature of their outcome could enhance its fitness for purpose

Students achieving at level 4 could be expected to:

- describe the proper function of the selected technological outcome
- explain why the selected technological malfunctioned and how this impacted on key stakeholders and the general public
- suggest changes that could be made to their own technological outcome to reduce the chance of it malfunctioning

Students achieving at level 5 could be expected to:

- explain the concept of malfunction and use the selected technological outcome to illustrate the difference between malfunction and failure due to wear and tear
- discuss how the malfunction of the selected technological outcome impacted on subsequent decisions for related technological developments and operational guidelines
- explain how explorations of their own outcome in various situations allowed them to gain a deeper understanding of how they could modify their design, to reduce user misuse and/or inappropriate environmental location

Senior Secondary (Years 11-13)

Students select an incident where a socially significant technological outcome has malfunctioned, (for example, the Cave Creek platform collapse) and examine the reasons provided for the failure. Students explore, in particular, what physical and functional aspects appeared to be prioritised and how this was justified at the time of development and after the malfunction.

Implications of the event are explored in terms of subsequent technological outcome development, and the development of or modification to codes of practice that occurred to minimise future risks. Lessons learnt from all events investigated in the class are summarised and linked to how technological outcomes and technological knowledge is enhanced through exploring the reasons for the failure.

Students identify an existing technological outcome in their local environment and analyse it in terms of its wider socio-cultural and historical context. Suggestions for how this outcome could be modified to enhance it in some way could be explored and a feasibility study carried out to form the basis of a proposal for future developments. This could provide the basis for the student to undertake their own technological practice in the future.

Students achieving at level 4 could be expected to:

- describe the proper function of the technological outcome that failed
- explain how the failure of a technological outcome occurred, and how this related to the relationship between its physical and functional nature
- identify the proper function of a selected technological outcome and suggest how it could be redesigned to improve it in some way.

Students achieving at level 5 could be expected to:

- explain the concept of malfunction and use the selected technological outcome to illustrate the difference between malfunction and failure due to wear and tear and/or designed failure
- explain why a technological outcome malfunctioned, and how this impacted on the development of related technological developments
- explain how the risk of a selected technological outcome malfunctioning could be reduced.

Students achieving at level 6 could be expected to:

- discuss how the technological outcome that failed was part of a socio-technological environment and the implication of this for the risk of malfunction
- describe technological outcomes within the socio-technological environment that could be described as both a technological product and a technological system
- describe the socio-technological environment that surrounds the selected technological outcome and identify the impacts and implications of the environment on its successful functioning in the future.

Students achieving at level 7 could be expected to:

- explain how decisions about the physical and functional nature of a technological outcome that failed reflects the prioritization of certain factors over others
- analyse the selected technological outcome in terms of how design elements have been prioritised
- establish an argument for the retention of redesign of the selected technological outcome.

Students achieving at level 8 could be expected to:

- critique the development of a technological outcome that failed, in terms of decisions made about its fitness for purpose prior to and post its failure *in situ*
- provide a feasibility study for the future development of a selected technological outcome that could be improved to increase its fitness for purpose in the broadest sense; the argument should reflect a sound understanding of historical, cultural, social and geographical influences and impacts.

EXPLANATORY PAPER

The Nature of Technology Strand: Characteristics of Technology

ABSTRACT

The purpose of this explanatory paper is to clarify and define the discipline of technology, how it is characterised and described. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology. This paper also suggests possible learning experiences.

COMPONENT DESCRIPTOR

Technology is defined as purposeful intervention-by-design. It is a human activity, known as technological practice that results in technological outcomes that have impact in the world. Technological outcomes can enhance the capability of people and expand human possibilities. Technological outcomes change the made world, and may result in both positive and negative impacts on the social and natural world. Technology uses and produces technological knowledge. Technological knowledge is aligned to function and validation of this knowledge occurs within technological communities when it is shown to support the successful development of a technological outcome. Technology is historically positioned and inseparable from social and cultural influences and impacts. Contemporary Technological Practices increasingly rely on collaboration between people within the technology community and with people across other disciplines.

KEY IDEAS

Technology is a unique form of human activity. This component of the Nature of Technology strand sits within an overarching view that sees technology as a group of socially embedded activities, termed technological practice, that are driven by human will, in response to need, desire and/or opportunity. Key to this practice is its purposeful and productive nature. This means that outcomes are arrived at through an intentional process of design, decision making and manufacturing, rather than through processes of the natural world or things occurring by chance. Key aspects of technological practice include the brief development practices, planning and resource management practices, and the construction and/or processing and evaluation practices of producing an outcomes.

Needs, desires, and the identification of possible opportunities provide the initial impetus for technological practice to be undertaken to develop fit for purpose technological outcomes. Technological outcomes include technological products and systems developed to extend human sensory perception and/or physical ability. In this way they serve as a means of extending the 'natural' functioning of the human body. For example, microscopes and telescopes allow for the extension of our sense of sight, while horse driven wagons, cars, planes and spacecraft allow for the extension of our ability to transport ourselves. Not all technological practice results in completed technological outcomes – that is, fully realised and situated technological products or systems. Other outcomes of technological practice include such things as: a brief describing an outcome, a feasibility argument, design ideas for parts of an outcome, conceptual designs of an outcome, functional models, or prototypes that have yet to be trialled *in situ*. While not technological outcomes as such, they are valid outcomes for practising technologists and for students when undertaking their own technological practice.

Viewing technology as a socially embedded human activity allows for the development of understandings of technology that recognise and value that what is designed is always positioned within a particular time, physical and social location. Therefore, the social world of culture, politics and dominant ideologies of the time, as well as natural world, combine to influence the nature of technological developments. Technology in turn has a profound and complex influence on the social and natural world through its creation of the made world.

Technology, understood as inseparable from society and the environment, allows space for ways of looking at the world differently, to produce innovative solutions and create technologies that may well alter our perceptions of what it is to be human. For example, the interface between humans and artificial intelligence and robotics challenges our ideas of the boundaries between people and machines in ways far greater than earlier uses of technology that supported more 'traditional' ways of being human, such as the development and use of artificial limbs or pacemakers.

Such a view of technology brings together two alternative perspectives (technological determinism and social shaping of technology) that have often been discussed. The technological determinist perspective sees technology as determining social change, while the social shaping' perspective sees society as determining technological development. Bringing these perspectives together allows for the recognition of both these perspectives in that technology and society are intertwined in complex and often difficult-to-determine ways. This view is referred to as a socio-technological perspective.

Creative and critical thinking are important to technologists for developing and exploring initial design concepts, refining and selecting those that are feasible, and in the way in which they realise these concepts in a material sense as technological outcomes. This combination of informed creativity and critical reflection encourages technologists to push boundaries, learn from the past, and project into future possibilities. Technology is underpinned by reasoned decision making. This reasoning relies on both functional and practical reasoning. Functional reasoning focuses on knowing how and why things work. Practical reasoning focuses on knowing what is justifiable in social and ethical terms and is based on what 'should' or 'ought' to be done. This can be described as normative in nature. That is, things that deal with what has value, what is 'good' and 'bad', and what is considered 'right' and 'wrong'. All normative aspects reflect social and cultural morals and ethics of particular groups of people within specific environments and eras.

Practical reasoning therefore provides the normative element of technology. Without this element, or if functional reasoning is overly emphasised, technology may be perceived, and indeed practiced, in a restrictive and technical way.

While technological practice is based upon the 'best' knowledge available to technologists and reasoned decision making, there are always unknown and unexpected consequences when technological practice is undertaken and technological outcomes implemented. This is particularly so when technological products and/or systems are transferred to settings that they were not specifically designed for. Examples of this can be found where technological outcomes developed for the 'first world' were inappropriately transplanted into 'third world' countries as 'aid'. For example, solar ovens were used as containers because using fire as an energy source was the socially accepted norm.

Recognition that technological practices, and their resulting outcomes, often have different value across people, places and times, is important in understanding technology and its power and limitations. While technology can be thought of as seeking to enhance human capability, in reality not all technological outcomes are beneficial or useful to *all* people. In fact, some technological outcomes are developed to purposefully disadvantage some people, as in the case of war technologies. Establishing the worth of any technological development therefore relies on a critical analysis that takes into account historical precedents and a multiplicity of social, cultural and political perspectives.

Technology is interdisciplinary in nature, but it is also a discipline in its own right. Technological practice draws on technological knowledge and skills, as well as a breadth of knowledge and skills from other disciplines as required by the specific context being explored (for example, science, mathematics, art, psychology, ethics etc). An important part of understanding technology therefore, is to understand what makes technological knowledge different to knowledge from other disciplines, so that they can be used in mutually supportive and enhancing ways.

Contemporary understandings suggest that all knowledge is socially constructed, as a result of people's interactions with each other and the world in which they live. Different disciplines therefore, can be thought of as validating specific knowledge as it has developed from shared understandings of a particular group of experts within that discipline.

This is no different for technological knowledge. However, what is different is the basis upon which people judge technological knowledge to be worthy of inclusion within such shared understandings. The basis upon which experts validate or measure the worthiness, or not, of new ideas put forward is known as the epistemic basis. In technology, this basis is focused on whether the knowledge provides for the successful *functioning* of a technological outcome. This is different to scientific knowledge; the epistemic basis of scientific knowledge is focused on its ability to provide the most successful e*xplanation* for phenomenon in the world. This difference reflects the difference in the purpose of the two disciplines. That is, the purpose of technology is to intervene in the world, whereas the purpose of science is to explain the world.

Technological knowledge can be used as rules or regulations. For this to occur technological knowledge becomes codified but only after technological experts consider they have adequate evidence to validate it as such. Codified technological knowledge refers to such things as codes of practice, codes of ethics, intellectual property codes, codes of standards, material tolerances etc. Codified knowledge serves to remind technologists of their responsibilities and provide them with access to established knowledge and procedures that have been shown to support successful technological development in the past. In this way codified knowledge can be used to provide constructional, ethical and/or legal compliance constraints on contemporary technological developments.

The increasingly interdisciplinary nature of contemporary technology requires that technologists engage in more integrated forms of technological development, where collaborative activity between people and across disciplines is critical for success. Recognising the differences between knowledge across disciplines, and establishing the value of each within particular contexts is important in interdisciplinary work. Interdisciplinary collaboration in technology provides exciting opportunities to ‘work at the boundaries’ of established fields. However this may cause situations where no codified technological knowledge exists to guide practice, or existing codes are no longer adequate. This may lead to tensions between people and the potential for an increase in unknown and unintended consequences. Collaboration therefore often requires technologists to engage in constructive debate, carry out informed prioritisation based on extensive functional modelling and multiple perspectives, and employ sophisticated strategies for decision making within their practice.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

The explanation of why history unfolded so differently on different continents, and the resulting fortunes of different cultural groups because of this, is an excellent example of the socio-technological perspective explained above. Briefly, the interaction of geography and biogeography and the technological developments that were made possible due to this, has been argued convincingly as the basis for significant ethnic differences, rather than any genetic predispositions. Jarad Diamond’s popular book *Guns, germs and steel: a short history of everybody for the last 13,000 years*, details this argument, and centralises food production technologies as a critical feature in the history of the world.

New Zealand is Different: Chemical milestones in New Zealand’s history provides a series of historical examples of the inter-relationship between technology and society. In particular it describes some of the chemistry and technology that has contributed to the development of New Zealand’s current economic, research and development base. This book also forms the basis for a website called An History of Technological Innovation in New Zealand, which can be found at www.techhistory.co.nz. Examples provided include such things as the story of aerial topdressing in New Zealand. This provides an illustrative example of how technology is embedded in society and the resulting benefits and losses associated with this. Aerial topdressing is presented here as an innovation that literally ‘took off’ due to the need to make grassland more economically viable and the availability of surplus tiger moths and pilots after the war. While this was undoubtedly a success for increasing land productivity that resulted in a significant rise in the standard of living in New Zealand, the destruction of hundreds of square miles of forest (with little use being made of the timber in most cases), and subsequent overgrazing leading to extensive soil erosion and runoff into lakes and waterways. Overall this technological innovation then could also be viewed as an ecological disaster.

POSSIBLE LEARNING EXPERIENCES

The learning experiences suggested below have been provided to support teachers as they develop their understandings of the Characteristics of Technology component of the Nature of Technology strand and how this could be reflected in student achievement at various levels. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been written in such a way as to support student learning across a range of levels. This stance reflects the majority of classrooms where it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

Students are asked to look around them and discuss what they see in terms of them belonging to the made world, the natural world or the social world. Select a range of technological outcomes (things that belong to the made world) and ask students to discuss what they think the purpose of each technological outcome is and why they think it was developed. Encourage them to think about what life may have been like before it was developed and how it has changed things for different groups of people – children, adults, teachers etc, as appropriate to the example. Students could work in groups and select a particular example and see if they can work out how and why it might have been developed. They could think about the types of things the technologist would have needed to know to make the selected example appropriate for particular users and environments. Ongoing discussions encourage students to reflect on their own technological practice (past and present if appropriate) and make links between what technologists do and what students can and should be doing.

Students achieving at level 1 could be expected to:

- identify things around them that belong to the made world
- identify the types of things a technologist would have had to take into account when developing a technological outcome

Students achieving at level 2 could be expected to:

- identify the year their selected technological outcome was made and discuss what factors might have impacted on its development at this time
- identify how their outcome changed how people do things and discuss any positive and/or negative it has had on society and/or the environment
- make suggestions as to how the technological outcome may change in the future and explain why they think these suggestions are feasible.

Senior Primary/Intermediate (Years 5-8)

Students could work in 'expert groups' to undertake an exploration of a selected technological development that is related (in some way) to the current or future context within which they will undertake their own technological practice. If the teacher planned to have students involved in developing a skin care product for example, different groups might look at developments associated with: a specific product from the past, a specific product currently available, essential oil extraction, Maori practices associated with skin care, evaluation procedures, packaging protocols etc.

Each group would explore how historical contexts and environmental locations have impacted on the selected development, and provide specific examples of the influence of particular people, groups or social conventions. They could also explore how the technological development had impacted on individuals, society and the environment. Students identify the knowledge that was necessary for different stages of the development and explain how such knowledge influenced decision making at key points.

The students explain to the teacher why the technological development they have selected might be useful in developing a better understanding of the context within which their own technological practice will be undertaken. Prior to the group beginning to work in depth teachers provide guidance on how realistic/appropriate the selected development is, based on things like the availability of resources (information and/or people), and its relevance to future work. Each group develops a means of presenting their results of to the whole class for critique. Class discussions are held to identify points of commonality and difference, and to begin to identify the different types of knowledge that underpin technology.

Students achieving at level 2 could be expected to:

- identify social and environmental factors that influenced their selected technological development
- identify both positive and negative impacts that the development has had on a variety of people in the past and today
- make suggestions as to how their technological development might impact on how people do things in the future.

Students achieving at level 3 could be expected to:

- explain how social and/or environmental factors have changed/are changing and the possible influences this might have on their selected technological development, and discuss what this might mean for future developments, including the student's own future technological practice
- identify the technological knowledge underpinning their selected development
- explain how different technological developments have impacted on society and/or the environment.

Students achieving at level 4 could be expected to:

- explain how different examples of technological developments have expanded human possibilities
- discuss the short and long term impacts of selected developments on individuals, society and the environment, and discuss how many of these impacts were known or anticipated before they happened
- identify examples of creative and critical thinking within their selected development and discuss how this influenced the development
- identify the knowledge and skills that have supported different selected developments.

Junior secondary (Years 9-10)

Students could explore a contemporary technology-related controversial context (for example, genetic engineering, stem cell research, global warming, alternative energy sources, environmentally-friendly building design etc) and identify issues that have arisen from this context. As part of this they could interview a range of people to establish their views, and explore in depth the influences on and impacts of people's perceptions and attitudes on related technological developments. Current codes of practice related to the wider context (both national and international), could be identified and their development and purpose explained and analysed In terms of how they may Influence future developments both positively and negatively

Students achieving at level 3 could be expected to:

- explain how a selected technological issue is seen today by different groups of people and how this may have changed from past perspectives
- identify the factors that come together to influence the formation of people's views about a selected issue
- identify the codes of practice relevant to their issue
- identify the different types of knowledge people value, and how this depends on their knowledge of and attitudes towards a selected issue.

Students achieving at level 4 could be expected to:

- explain how a selected technological issue has impacted both positively and negatively on individuals, society and the physical environment
- discuss the short and long term possible impacts of potential new technological developments within the context of a selected issue, focusing on individuals, society and the physical environment
- identify the knowledge used to support different perspectives within a selected issue.

Students achieving at level 5 could be expected to:

- describe a personal position regarding the acceptance of a particular technological development related to the selected technological issue and explain this in terms of their own experiences and developing views

- explain why the codes of practice relevant to their issue were developed and the impact these have had on related technological developments to date and the possible influence on future developments.

Senior Secondary (Years 11-13)

Students identify a technologist and carry out a series of interviews with them about their work, in order to develop an informative case study about their technological practice. The technologist selected should allow students insight into the interdisciplinary nature of technological developments and the collaboration practices of technologists. The nature of the interviews (face to face, email, phone etc) needs to be appropriate for the technologist, and could be supplemented with additional explorations (for example, analysis of product information, websites, marketing materials, related articles etc). Students ask questions that will identify the details of a technological outcome the technologist is working on or has completed in the past.

It is important that the student allows the technologist to identify a technological outcome they are comfortable discussing. Issues associated with intellectual property and market sensibility could be explored by the student in relation to this. Students also work with the technologist to establish the technological knowledge and other knowledge and skills they require, the personal and professional attributes they have, and the way in which they work with others. Extensive investigation of the decision making processes employed by the technologist could be undertaken, and their levels of creative and critical thinking explored in the context of the identified example.

After completing their individual case study, students could set up a series of formal debates, focusing on such things as 'technologists should be held accountable for any technological disasters'. In taking part in the debate students pool the understandings gained from comparing and contrasting individual case studies, to develop collaboratively based affirmative or negative arguments. Arguments should recognise the complexity of technology as a collaborative field that requires complex decision making based on different perspectives, creative and critical thinking, and practical and functional reasoning. Arguments should also provide insights into student understanding of such things as the role of codified technological knowledge and personal influences that drive technological developments.

Students achieving at level 4 could be expected to:

- explain how a technologist seeks to enhance human possibilities and discuss that this Is often viewed differently depending on the acceptability of possible short and long term impacts on society and/or the environment
- discuss the role of creative and critical thinking in the decision making of a technologist
- identify the knowledge and skills used in the technologist's practice and how this impacts on their decision making.

Students achieving at level 5 could be expected to:

- explain how the past experiences, attitudes and knowledge of the technologist impacts on how they undertake their work
- identify codified technological knowledge important to the technologist and explain how it impacts on their practice
- explain how and why the identified technological knowledge became codified.

Students achieving at level 6 could be expected to:

- discuss the interdisciplinary nature of the knowledge and skills used in the technologist's practice
- identify examples of collaboration the technologist is involved in and explain how this impacts on their work
- explain an example of when codified knowledge has been challenged due to new knowledge, capability or changing social pressures
- discuss the advantages and disadvantages of technologists working in collaborative teams, and what techniques technologists use to manage such team work and any intellectual property issues that may arise.

Students achieving at level 7 could be expected to:

- explain how ongoing contestation and competing priorities impact on decision making processes undertaken by technologists, and discuss examples of how decisions reflect technologist's own backgrounds, their colleagues' backgrounds, established codes and the influential contemporary factors from wider physical and social environment of the
- discuss the influences of rapidly developing technological knowledge and capability and changing social expectations on technologists' practice
- explain how technologists employ creative and critical thinking to support innovative practice and discuss the role of technologists when challenging existing social boundaries.

Students achieving at level 8 could be expected to:

- illustrate and explain the complexity of technological practice that must be undertaken to manage on-going contestation and competing variables (from technologists, stakeholders, general public, and wider social and physical environments) to ensure resulting interventions in the world are justifiable
- explain why technological developments result in unknown and/or unanticipated consequences, and how technologists manage the risks associated with this
- argue for or against the requirement for technologists to collectively embrace a level of social responsibility.

EXPLANATORY PAPER

The Technological Knowledge Strand: Technological Modelling

ABSTRACT

The purpose of this explanatory paper is to define technological modelling and clarify the role and nature of functional modelling and prototyping. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology. This paper also suggests possible learning experiences.

COMPONENT DESCRIPTOR

Technological modelling refers to modelling practices used to enhance technological developments and includes functional modelling and prototyping. *Functional modelling* allows for the ongoing testing of design concepts for yet-to-be-realised technological outcomes. *Prototyping* allows for the evaluation of the fitness for purpose of the technological outcome itself.

Through technological modelling, evidence is gathered to justify decision making within technological practice. Such modelling is crucial for the exploration of influences on the development, and for the informed prediction of the possible and probable consequences of the proposed outcome. Technological modelling is underpinned by both *functional and practical reasoning*. Functional reasoning focuses on ‘how to make it happen’ and ‘how it is happening’. Practical reasoning focuses on ‘should we make it happen?’ and ‘should it be happening?’

Decisions as a result of technological modelling may include the: termination of the development in the short or long term, continuation of the development as planned, changing/refining the design concept and/or the nature of the technological outcome before proceeding, or to proceed as planned and/or accept the prototype as fit for purpose.

KEY IDEAS

A model is a representation of reality. In technology, functional modelling is used to represent how things might be if a technological development was to continue, in order to establish if development should proceed and prototyping is used to evaluate the outcome once realised. Technological modelling is critical in the process of identifying the outcome’s potential and probable impact in the world, as it moves from conceptual idea through to being fully realised and implemented *in situ*. It also supports exploration of influences that may impact on technological outcome and its development.

Technological modelling is a key tool for technological development across all technological domains. However, the specific knowledge and skill base underpinning the implementation of technological models and the interpretation of data gained is particular to domains.

The media used, and types of procedures undertaken in technological modelling, vary depending on the stage of development, preferences, requirements, and the capability of the technologist[2.] The audience from which input and targeted feedback is sought will also influence the type of media and model used. For example, at the early stage of development, functional modelling may simply involve the technologist thinking through their design ideas and/or discussing these with other technologists, to test their suitability. As the development moves on, this may progress to drawings on paper or within computer programmes, to more formal written and/or diagrammatic explanations appropriate for a wider range of audiences. Three-dimensional mockups using easily manipulated material such as clay, cardboard, styrodur, and CAD software, are often used to enable design ideas to be

2 As discussed in CoT, contemporary technological development often involves more than one person. In the figure and discussion therefore, ‘technologist’ is used in an attempt to simplify the practices being described. In reality the ‘technologist’ may be a group of people and the make-up of this group may change as the development proceeds and different skills and knowledge are required.

evaluated in terms of appearance and function. Progressively, the materials used become more closely aligned to the actual materials that will be used in the final outcome, with the final prototype using these exclusively.

Technological modelling can be categorised into two related types – functional modelling and prototyping. The difference in type is linked to what is being modelled, the purpose of the modelling and the stage in the development that it is taking place.

Functional modelling is often referred to by different names across different technological domains. For example, functional modelling may be referred to as test or predictive modelling in biotechnology, animatics in film making, a toile in garment making, and mockups or mocks in architecture and structural engineering. In all these cases, what is being modelled, or represented, is the yet-to-be realised technological outcome for the purpose of testing design concepts with regards to the physical and functional nature of the outcome required by the brief. Design concepts include design ideas for parts of an outcome as well as a complete conceptual design for the outcome as a whole.

Functional modelling therefore, provides a tool to support informed projections into probable future impacts; allowing for the exploration and evaluation of design concepts, from a range of perspectives, from which to make justifiable decisions regarding future development. These decisions need to take into account such things as known specifications, material and technique suitability, as well as historical and socio-cultural factors. If these are not taken into account, the likelihood of unintended negative consequences resulting from a technological outcome increases.

The earlier in the development that functional modelling occurs, the stronger the focus is on 'go/no-go' decisions. If a 'go' decision is made, the result may be to revise the design concept or move on to the next stage in development of the original design concept. Functional modelling should therefore occur extensively in the early stages of technological practice, when establishing whether the design concept being developed has worth (in its widest social sense) and when 'what if?' questions need to be asked and explored. Early stages of functional modelling often employ 'guestimation', based on similar technological outcomes and developments and/or drawing from other 'known' situations or past problems/issues.

Functional modelling provides opportunity to reduce the waste of resources that can often occur if technologists rush too quickly to the realisation phase, relying on a more 'build and fix' approach to technological development. Because of this, functional modelling can be seen as a key tool for encouraging and enabling more environmentally sensitive and potentially sustainable developments. The better the functional modelling, the greater the confidence a technologist can have that the fully realised technological outcome will be fit for purpose, and will result in fewer unknown and/or undesirable impacts on the world. While it may not result in the removal of all unknown or undesirable impacts, functional modelling can work to significantly reduce these through informing decision making around risk identification and management. However, all functional models are limited due to their representational nature. That is, what is being tested is only a simulation or a part of what the actual outcome will be.

Prototyping is the modelling of the realised but yet to be implemented technological outcome. The purpose of prototyping is to evaluate the fitness for purpose of a technological outcome against the brief.

At the point of realisation, the outcome has an increased 'impact in the world', due to the fact it now exists in a functioning material form and can implemented in its intended location. However, prototyping seeks to gather further evidence to inform subsequent decisions focusing on establishing it's acceptability for implementation or the need for further development. Evaluation of its fitness for purpose is measured against the specifications established in the brief. Because the technological outcome now exists in a material form, prototyping allows for a greater level of exploration of unintended consequences/impacts on people and the physical and social environment in which it will be situated.

As with functional modelling, decisions from prototyping can result in a 'no-go' decision or in a significant change, meaning a need to revise the design concept. Decisions to halt or significantly change development at this point suggest earlier work may not have been undertaken in sufficient depth. This has implications for the technologist, as the costs (such as time, labour, materials and money) involved in developing a prototype are high, and would be unsustainable should such decisions occur regularly at this stage of the development process.

Alternatively a decision to undertake further development may be made after prototyping, resulting in less dramatic modifications, or refinement of the outcome to enhance its performance and/or suitability. Prototyping may also result in the decision to implement as is. Prototyping thereby provides the means to evaluate a technological outcome, in order that its fitness for purpose can be optimised, or to provide justification for the outcome to be fully implemented as fit for purpose.

Prototyping can also be used for the purpose of testing 'scale-up' opportunities, and can provide key information regarding decisions around ongoing or multi-unit production and marketing for commercial purposes, as appropriate.

Specific methods of prototyping are validated by different communities and this must be taken account of if the outcome's worth is to be accepted by key stakeholders and the wider community. This is not to say new methods cannot be developed. However, any new method would need to show itself to have equal or greater benefits than previously accepted practices.

Figure 1 provides a summary of functional modelling and prototyping, as types of technological modelling within technological development.

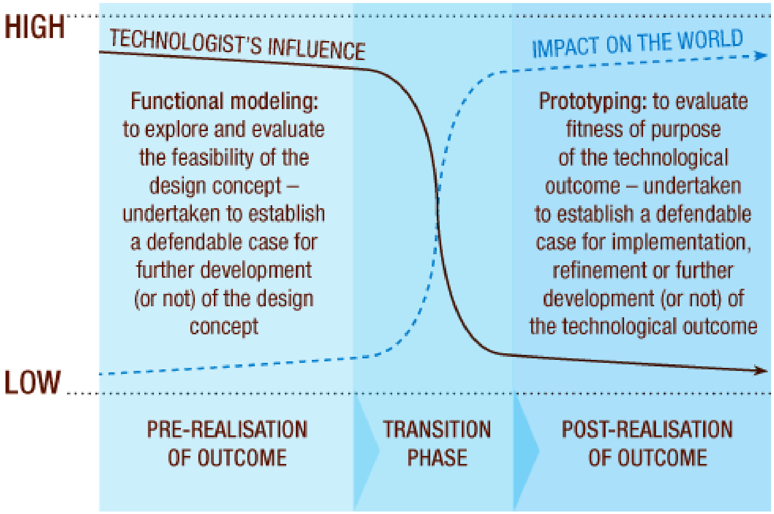


Figure 1: Technological Modelling in Technological Development

Figure 1 illustrates that a technologist's influence on the impact their work will have in the world decreases as the development work proceeds. Initially the technologist has high levels of control over how the design will progress (or not) and be developed. As the design becomes more developed and widely communicated, the influence of the technologist begins to *decline*. At the transition phase, where the design idea is first realised as a technological outcome in its material form, the technologist's influence declines. In contrast, the impact of the potential outcome *increases* as development proceeds towards its realisation, with a significant increase occurring at the transition phase.

The 'impact in the world' includes both beneficial and harmful impacts, such as environmental, social, economic, and political benefits or costs. The transition phase should be viewed as a critical decision point in any development, for once realisation of an outcome has occurred, there is 'no going back'. As a result of prototyping however, any future development work can of course be subsequently halted, or directions changed.

Technological modelling is used to inform decisions regarding risk management through identifying and assessing possible risk factors associated with the development of a technological outcome. Assessing risk involves establishing the probability of identified risks occurring and the severity of the impact should it occur. Managing risk involves making decisions to avoid, mitigate, transfer or retain the risk.

Technological modelling employs two types of reasoning - *functional and practical reasoning*, to ensure that a holistic evaluation of a technological outcome's potential and actual 'impact in the world' is made, reflective of a balanced normative and technical understanding of fitness for purpose. *Functional reasoning* provides a basis for exploring the functional potential of the design concept. That is, 'how to make it happen' in the functional modelling phase, and the reasoning behind 'how it is happening' in prototyping. *Practical reasoning* provides a basis for exploring social aspects (moral and ethical) surrounding the design concept and outcome testing. That is, the reasoning around decisions as to 'should it happen?' in functional modelling and 'should it be happening?' in prototyping. In this way, practical reasoning provides a framework, or rational structure, to justify what 'ought' to happen – providing the crucial 'normative' element of technology.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY[3]

The current issue around irrigation in the South Island of New Zealand – in particular the Mackenzie Basin, provides a contemporary context to gain insight into how technologists are working to resolve issues; using both functional and practical reasoning to balance a range of stakeholder priorities and attempt to find a best fit solution.

This example also provides insights into how a diverse group of professionals are working alongside the Government and general public to ensure all needs, including long term environmental needs, are fully understood and justifiably prioritized for any future development decisions. For an introduction to this issue – see the May/June 2006 edition of e.nz.

Exploring vehicle prototypes provides an opportunity to examine a range of historical examples, showing the way prototype cars and bikes have been used to gain crucial market feedback and ensure design flaws are identified and corrected prior to the shift into mass marketing. Examples can be found where the prototype was too far outside of acceptable 'norms' or performance expectations to support ongoing development (eg, the early generation hybrid cars).

Other examples show how a prototype can shift people's perceptions and stimulate other technologists to cross historical boundaries (eg, the New Zealand designed Aquada). Analysis of the prototyping of vehicles can highlight the complexities associated with gaining robust end-user feedback, and the economic and personal costs associated with poor decision making leading up to the development of a prototype that fails. Henry Petroski's book - *To Engineer is Human: The role of failure in successful design* provides descriptive accounts of the impacts of failure on technological development.

POSSIBLE LEARNING EXPERIENCES

The learning experiences suggested below have been provided to support teachers as they develop their understandings of the Technological Modelling component of the Technological Knowledge strand, and how this could be reflected in student achievement at various levels. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been written in such a way as to support student learning across a range of levels. This stance reflects the majority of classrooms, where it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

Students could explore imaginative play, toys, television and/or computer games to help them distinguish between simulated situations and reality. Teacher guided class discussion could focus on developing an understanding of how reality is different to simulations and the implications of this. For example, when playing with a doll, children simulate the care of a baby – however, the implications of dropping the doll are quite different to dropping a baby.

Students could be introduced to the term model and encouraged to discuss what they think a model is, and how it might be useful in technological developments. Students are then provided with opportunity to play with different modelling materials (such as LEGO, plasticine, Meccano, Connex, cardboard, concept maps, computer modelling

3 These are provided for the purpose of increasing teacher background understandings of this component – however they may also be relevant for senior students.

packages etc), and to explore how different materials may allow greater testing of how something might work. For example, static LEGO could be compared with technic LEGO, computer simulations could be explored with 3D models etc. Students could then discuss their ideal playground and undertake functional modelling, to decide as a group what ideas could be feasible for an actual playground for their school.

Students achieving at level 1 could be expected to:

- explain that models are not the same as the real thing, and describe some examples of models and why they have been developed
- identify that functional models can help you to sort through ideas to see what would be good to do in the future.

Students achieving at level 2 could be expected to:

- explain that models can be useful to help you think about things before they happen, but can also make you think something is possible that isn't – or vice-versa
- explain how they used descriptions and drawings to test their design ideas for a playground.

Senior Primary/Intermediate (Years 5-8)

Students could be provided with information about a range of models, including both functional models and prototypes, which have been used in the past development of specific technological outcomes.

Examples could be chosen from areas of interest to the students and might include such things as musical instruments, sporting equipment, cars, bikes, food products, clothing etc. In groups, the students could identify what the purpose of each model might be and what particular characteristics of each model allowed it to fulfil its purpose. As a class, the students could discuss what things they would have to know if they were developing these models. Students identify the limitations of the model in terms of what it cannot provide information about.

Students are then encouraged to reflect on their current technological practice and undertake technological modelling of some form, to guide them in the next stage of their development. As part of this, they need to clearly identify the purpose of the modelling. That is, are they testing their design idea? (functional modelling) or the outcome itself (prototyping)? They also could be asked to explain why they choose the medium used, and how and from whom they would get feedback to inform their decision making. Students use their model and evaluate its effectiveness against its stated purpose.

Students achieving at level 2 could be expected to:

- explain the difference between functional models and prototypes
- explain how models can be used to get input and feedback from people to inform the development of a technological outcome
- discuss the information gained from their technological modelling (either functional modelling or prototyping) and what they decided to do.

Students achieving at level 3 could be expected to:

- identify different types of functional models and explain why particular materials were used in different examples
- identify different examples of prototyping and explain how the evidence gained allowed people to evaluate the outcome's fitness for purpose
- explain the choice of modelling they undertook and how this informed their decision making.

Students achieving at level 4 could be expected to:

- explain a range of examples of functional models, and discuss how they allowed the technologists to predict what impact their design ideas for potential outcomes might have, should they be realised
- explain how examples of technological modelling in the past allowed technologists to determine both what could be done and what should be done
- justify the decisions they made in their own technological practice after gaining information from technological modelling.

Junior secondary (Years 9-10)

Students could select examples of successful (for example, Post Its, Aquada, telephones, printing press, antibiotics, Hamilton jet, vaccines, a past successful student outcome etc) and unsuccessful technological outcomes (for example, Thalidomide, Chenobyl and/or Three Mile Island nuclear power plants, Cave Creek, Hindenburg airship, Titanic, Columbia, Sliver Bridge, early generation hybrid cars, unsafe toy and/or food products, a past failed student outcome etc).

They could explore the extent to which functional modelling was used during development phases, and what factors (economic, social, political, technological knowledge etc) influenced the developments. Particular attention should be paid to understanding key decision points and the basis upon which these decisions were made. Resources such as Technological Accidents: Learning from Disaster at www.econ.canterbury.ac.nz/downloads/philofit.pdf could be discussed as a basis to support students in developing an understanding of the complexities involved in managing risk in technological developments.

Examples from the students' past and current technological practice could also be brought into discussions, to encourage them to identify appropriate times where functional modelling may have enhanced success. Students select a particular example of an unsuccessful technological outcome and make a case, based on a retrospective analysis and their developing understandings, for how things might have been done differently.

Students achieving at level 3 could be expected to:

- identify examples of successful and unsuccessful technological outcomes and explain the role that functional modelling played in each
- identify the factors that influence the extent to which functional modelling is used during the development of an outcome
- identify how functional modelling could have reduced risks associated with the development or implementation of a technological outcome.

Students achieving at level 4 could be expected to:

- identify decisions that focused on what could happen and those that focused on what should happen and explain how these impacted on the resulting technological outcome
- explain how prototyping has played a role in supporting the implementation of a technological outcome with both successful and unsuccessful results.

Students achieving at level 5 could be expected to:

- explain how evidence was gathered and used to the support of the development of successful and compare this with an example where the resulting technological outcome was unsuccessful
- discuss examples of how prototyping allowed maintenance requirements to be determined
- outline a case for how technological modelling could lessoned the chance of market failure or resulting disaster, in the case of a particular technological outcome.

Senior Secondary (Years 11-13)

Students could identify a local community issue, and work alongside key stakeholders to identify their different priorities and how they impact on their perceptions about what type of solution would be fit for purpose.

Examples of issues could include: establishment of a marina, restoration of a mining site, reclamation of a wetlands area, site of a new building sub-division, need for flood protection, need to stop sand dune erosion, redesign of an accident prone intersection etc.

From this basis students work to identify arguments for possible scenarios that employ both functional (what can be done) and practical (what ought to be done) reasoning, and use these to develop a series of functional models to test a range of design ideas and explore any real and/or perceived risks associated with them. Models developed could be justified in terms of purpose, medium and the validity of the evidence they will provide in order to make decisions of 'where to next?' Students could employ a range of models and gather evidence, to support their decision for a recommendation of a feasible conceptual design that would address some or all of the needs/opportunities provided by the issue and mitigate identified risks.

Students achieving at level 4 could be expected to:

- explain how functional modelling can be employed to make informed predictions as to how a potential outcome might be perceived by key stakeholders
- explain how different forms of functional modelling can be used to identify conflicts between key stakeholder priorities, and suggest how these can be explored for areas of commonality
- present a design concept of a possible outcome, that is explained in terms of a balance between what could be done and what should be done.

Students achieving at level 5 could be expected to:

- explain why different functional models provided different types of evidence
- explain the reasoning that led them to decide on a particular conceptual design as feasible
- present and justify a design concept for a technological outcome that would address the needs/desires of key stakeholders.

Students achieving at level 6 could be expected to:

- explain the difference between functional and practical reasoning and discuss how both types of reasoning informed their decision making
- explain how functional models used enhanced and/or limited their ability to explore and identify the risks
- present and justify a design concept for a technological outcome that would address the needs/desires of key stakeholders, and take account of predictions from the wider social and physical environment.

Students achieving at level 7 could be expected to:

- justify the need to gather a range of evidence through different types of functional modelling, in order to make decisions about both what could and should be done in relationship to a particular issue
- employ functional modelling to identify and assess possible risks in relation to a range of design ideas developed to address a selected issue, and present an argument for how these risks could be managed
- present and justify a design concept for a technological outcome that would most effectively address the needs/desires of key stakeholders and take account of predictions from the wider social and physical environment; provide a range of evidence as part of their justification.

Students achieving at level 8 could be expected to:

- using illustrative examples from the issue explored, explain the critical role of functional modelling in making informed predications and defensible decisions, regarding an outcome's suitability to address a range of factors inherent in the issue
- explain and justify the use of different media and procedures in functional modelling to ascertain the risks associated with different potential outcomes, based on a critical understanding of the issue, related historical development practices and past outcomes, and the specific perspectives of individual stakeholders and the community as a whole, and identified requirements of the social and physical environment in the short and long term.

EXPLANATORY PAPER

The Technological Knowledge Strand: Technological Products

ABSTRACT

The purpose of this explanatory paper is to explain material understandings as they relate to a technological product, clarify why and how materials are selected and how they allow technological products to work the way they do. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology. This paper also suggests possible learning experiences.

COMPONENT DESCRIPTOR

Technological products are material in nature and exist in the world as a result of human design. Understanding the relationship between the composition of materials and their related performance properties is essential for understanding and developing technological products. Technological knowledge within this component includes the means of evaluating materials to determine appropriate use to enhance the fitness for purpose of technological products. It includes understandings of how materials can be modified and material innovation. Understanding the impact of material selection and development on the design, development, maintenance and disposal of technological products is also included.

KEY IDEAS

Technological outcomes may be referred to technological products and/or technological systems (see Characteristics of Technological Outcomes for an explanation cases where the same outcome could be referred to as both a product and system). However, in this component, the focus is on understanding the physical nature of a technological outcome as viewed as a product, and therefore it is *material* understandings that are key to this component.

Technological products are defined as material objects that result from technological practice, and as such have been designed by people to exist in order to fulfil an intended function. The key concepts underpinning the technological product component are those that relate to the identification, description, use and development of materials with reference to how materials allow a product to be fit for the purpose it was designed.

The specific knowledge base underpinning these concepts will vary depending on the specific materials used in any particular product. That is, the material understandings needed to develop and understand food products differ to those required to develop and understand garments or furniture. However all materials have inherent qualities that can be described as structural (conductive, ductile etc) or sensory (colour, texture etc) in nature and together these provide a material with its overall performance properties. The inherent qualities are determined by the composition of the material. The composition of materials relates to such things as the type and arrangements of particles that make up the material.

Materials can be formed, manipulated and/or transformed to enhance the fitness for purpose of a technological product. ‘Forming’ refers to how materials are shaped (cut, moulded, bent etc) to the ‘form’ required for use in the product. Manipulating and transforming refers to how materials are joined, combined and/or finished in ways that change their performance properties.

Material selection is based on matching the desired performance criteria of a technological product with the performance properties of the materials available to ensure the material selected will be adequate for use in the product. Material evaluation plays a critical role in material selection making decisions that can be justified in terms of the material not only being adequate, but be the *optimal* material for use when all factors are considered. In order to effectively evaluate a material’s suitability, specific knowledge of material composition is critical, as are understandings of what techniques and/or procedures are accepted within particular communities of practice.

Material innovation refers to making available new performance properties through either transformation of materials to formulate a new material or through the use of existing materials in a new way. The contemporary field of material innovation is crossing many traditional disciplines and showing increasingly diverse and exciting possibilities for material performance properties, and therefore the types of functions that a technological product may have. The development of 'smart' materials in a range of areas allows for the exploration of the relationship between material performance properties and what types of products can be designed. The defining characteristic of a 'smart' material is its ability to change or adapt in response to an external prompt which may be technological in nature or from human input. The external trigger causes a transformation resulting in a change to the properties of the material itself. Examples of products developed from smart materials include functional foods, heat regulating clothing, light responsive sunglasses, artificial muscles, self cleaning textiles, self adjusting optical lenses, colour changing shirts etc. An example of smart material development can be seen at www.techlink.org.nz/Case-studies/Technological-practice/Materials/smart-fibres

Understanding the impact of material selection, evaluation and innovation on a technological product's design, development, maintenance and disposal is an important focus within this component. This will help develop robust technological understandings of sustainability as it relates to justifiable resource management, designed-for life cycle, and disposal issues as key factors for consideration in product design decisions. For example, the products associated with iTunes, and the ways music can now be downloaded digitally, has resulted in a significant shift in resource issues surrounding compact disc and digital technology, particularly in terms of packaging and marketing requirements. The potential function of new products associated with the storage and transmission of music rests upon the properties of the new materials that have been developed.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY[4]

Nanotechnology is an exciting new field that promises to 'turn yesterday's science fiction into today's reality'. There is a wealth of information available about nanotechnology, including some interesting arguments for and against it currently being debated at all levels of society. From 'grey goo' horror stories to utopian visions, nanotechnology provides insight into all of the generic concepts associated with this component. The relationship between material performance properties and product possibilities is central to this field. The Centre for Responsible Nanotechnology provides a useful starting website resource at http://crnano.org. Key concepts underpinning nanotechnology can be found at www.zyvex.com/nano, and for more general news articles see www.nanotech-now.com.

Professor Wei Gao and his group, in the Faculty of Engineering's Department of Chemical and Materials Engineering at the University of Auckland, have developed a technique to make a very fine film of zinc oxide adhere to substrates of glass, silicon and metal. These act as conductors or semi-conductors and emit light. This ongoing research and development is leading towards a new generation of opto-electronic materials for use in devices such as screen display, solar cells and lasers which display information using electrical signals and light emission.

This new material provides an interesting case study as work is still being undertaken to better control the sought-after functional properties. If successful, zinc oxide is set to revolutionise the opto-electronics industry in much the same way as silicon revolutionised the ICT industry.

POSSIBLE LEARNING EXPERIENCES

The learning experiences suggested below have been provided to support teachers, as they develop their understandings of the Technological Products component of the Technological Knowledge strand and how this could be reflected in student achievement at various levels. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been written in such a way as to support student learning across a range of levels. This stance reflects the majority of classrooms where it is

4 These are provided for the purpose of increasing teacher background understandings of this component – however they may also be relevant for senior students.

expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

In small groups students could explore a range of technological products developed for similar functions and identify what is different about them and why this might be. For example, one group could explore a range of different brushes (toothbrushes, wire brushes, paint brushes etc) and establish why different materials were used for the handles and bristles to carry out different specific purposes.

Other groups could explore a range of drinking vessels (ceramic cups, takeaway cups, wine glasses etc), cooking utensils (wooden spatula, metal pasta spoon, plastic fish-slice etc), skin creams (moisturisers, lip balms, sun-creams etc), cutting tools (scissors, knives, axes etc), balls (tennis, cricket, soccer, ping-pong, squash etc) and learn about the materials used and the performance properties they provide that allow them the product be fit for its designed purpose.

Students achieving at level 1 could be expected to:

- identify the materials used in a range of products that serve a similar purpose
- suggest why identified materials might have been selected for use in particular products

Students achieving at level 2 could be expected to:

- describe the performance properties of identified materials
- discuss examples to identify the relationship between materials selected and what products can do

Senior Primary/Intermediate (Years 5-8)

Exploring products from two technology domains could provide students with an opportunity to identify generic understandings about material use in technology. For example, students could select a range of biotechnological products (such as: compost, yoghurt, ginger beer, antibiotics, insulin, vaccines, cheese, hybrid plants etc), and explain the way performance properties of the materials allow them to function as intended.

When exploring the use of materials involving living organisms, students could develop understandings of issues associated with ethics, product stability and/or safety. They could discuss the challenges involved in using such materials for a particular function, and how risk is managed through extensive and often stringent codes of practice and functional modelling, prior to development work.

Students could then examine other products such as clothes, furniture, sport equipment etc and explore these as described above. The links between materials used in contemporary technological products and those used in the past, and the change in the type and nature of functions able to be carried out, could also be explored. This could be supported by student involvement in ongoing class discussions about the wide range of materials that are used in technology, and how these have developed over time to provide people with new options of what might be possible and how things might be done. As part of the class discussion, students could reflect on past products they have developed and critique the suitability of the materials they used, taking into account the impact of resource availability, costs and time constraints as well as how fit for purpose the resultant product was for the intended function. They could identify how their future work may attempt to address issues around working with materials and dealing with waste as based on developing understandings.

Students achieving at level 2 could be expected to:

- describe the performance properties of identified materials in biotechnological products
- explain how the properties of the materials identified relate to how the product works

Students achieving at level 3 could be expected to:

- explain how the materials used in a selected biotechnological product allow it to function as designed
- identify materials used in other technological products and explain why they have particular performance properties
- discuss materials used in biotechnological and other products and identify similarities and differences

Students achieving at level 4 could be expected to:

- explain how the fitness for purpose of a biotechnological product was enhanced through the joining of different materials
- explain how the fitness for purpose of another technological product was enhanced through the way the materials were shaped
- explain how the fitness for purpose of a technological product was enhanced by the use of a finishing technique on a particular material

Junior secondary (Years 9-10)

Students could listen to music and, by listening only to the sounds, attempt to identify the instruments used. They could explain why they have identified instruments, in relationship to what materials they think would have been capable of making specific sounds. They could undertake further research to establish what instruments were in fact used in the music listened to, and make links with how these have been brought together to create particular musical genres (for example, rock, blues, jazz, and classical etc).

Students could then select one of these instruments, or any other they may be interested in, and determine the materials used in its construction and how this may have changed over time. Investigation into how similar sounds may have been produced in other cultures could also be undertaken, and links made to traditional techniques of playing and instrument manufacture as based on available materials. The performance properties of the instrument could be explored, in terms of how they allow the musical instrument to function in the way it does. Particular attention can be paid to the way in which the materials used were shaped and how this allows the user to play it in certain ways.

Students can present their findings to the class and discuss the new knowledge that was required for the development of each instrument to its current form. Potential future developments of musical instruments in general could be explored, and links made between materials and issues such as the impact of the skill level of the user, safe handling, maintenance and restoration of instruments, resource sustainability, and the disposal and/or collection of instruments when no longer fit for purpose.

Students achieving at level 3 could be expected to:

- explain how the selection of particular materials enables an instrument to be crafted and played in certain ways
- explain how different materials used in different cultures and times to create instruments allowed for the production of particular types of sounds

Students achieving at level 4 could be expected to:

- explain how a musical instrument was enhanced through the joining of different materials
- explain how the fitness for purpose of another musical instrument was enhanced through the way the materials were shaped
- explain how the cleaning and ongoing care of a musical instrument has been enhanced by the use of a finishing technique

Students achieving at level 5 could be expected to:

- discuss how materials used in a range of musical instruments were selected as suitable for use as related to their composition
- explain how materials change under different conditions, and how this impacts on their selection for use to meet the performance requirements of a musical instrument

Senior Secondary (Years 11-13)

Students could explore the different types of lighting products available on the market today, and identify the properties of the materials used in their development. These could be compared and contrasted with lighting products from the past and/or those used in different cultures, to determine how different materials have impacted on the performance of lighting products and their fitness for purpose across a range of purposes and environmental conditions.

They could then select a particular lighting product of direct relevance to their own technological practice, and explore the knowledge and techniques required for development, and the notion of its designed life cycle. The product could be critiqued in terms of wider social and environmental considerations regarding the availability, production, modification, usage and disposal of the materials used in the products. The students could then use these understandings to inform their own conceptual design and development of a lighting product for an identified client.

Students achieving at level 4 could be expected to:

- describe how the forming of new materials allowed lighting products to be developed for different purposes
- explain how the materials used in a particular lighting product were modified to ensure the product functions in a safe and reliable way

Students achieving at level 5 could be expected to:

- explain why particular materials were selected for use as related to the desired performance criteria of lighting products developed for differing purposes and environmental locations
- discuss examples to show how the composition of a material impacts on selection decisions

Students achieving at level 6 could be expected to:

- explain the composition of the materials used in a lighting product, and how these have allowed the material to be shaped, joined and finished in ways that increase safe use and ongoing maintenance
- explain how existing materials have been modified to increase their suitability for lighting products in particular contexts and/or for specialised functions

Students achieving at level 7 could be expected to:

- explain the concepts and processes involved in the evaluation of suitable materials for a range of reliable and safe lighting products
- explain how these concepts and processes influenced the initial design ideas and life cycle decisions, ongoing development, maintenance guidelines and disposal of lighting products
- critique the selection of materials for a range of lighting products, on the grounds of material sustainability, user-friendliness and disposal

Students achieving at level 8 could be expected to:

- explain how new materials have impacted on the possible design and performance of lighting products
- explain the concepts and processes involved in a material innovation that provided opportunity for an increase in the type and nature of lighting functions
- discuss how these concepts and processes influenced the development of new lighting products in terms of expanding the initial design ideas, influencing life cycle decisions, enhancing ongoing development and evaluation, ensuring effective maintenance and acknowledging issues associated with the ultimate disposal of products

EXPLANATORY PAPER

The Technological Knowledge Strand: Technological Systems

ABSTRACT

The purpose of this explanatory paper is to explain understandings of componentry and processes as they relate to a technological system, clarify why and how components are selected and connected and how they allow technological systems to work the way they do. It presents the component descriptor, the key ideas underpinning it, and illustrative examples of these from technology. This paper also suggests possible learning experiences.

COMPONENT DESCRIPTOR

Technological systems are a set of interconnected components that serve to transform, store, transport or control materials, energy and/or information. These systems exist in the world as the result of human design and function without further human design input. Understanding how these parts work together is as important as understanding the nature of each individual part.

Technological system knowledge includes an understanding of input, output, transformation processes, and control, and an understanding the notion of the 'black box' particularly in terms of sub-system design. Understanding redundancy and reliability within system design and performance, and an understanding of the operational parameters of systems are also included. Specialised languages provide important representation and communication tools and are therefore included to support developing ideas of system design, development, maintenance and troubleshooting.

KEY IDEAS

Technological outcomes may be referred to technological products and/or technological systems (see Characteristics of Technological Outcomes for an explanation cases where the same outcome could be referred to as both a product and system). However, in this component, the focus is on understanding the physical nature of a technological outcome as viewed as a system, and therefore it is componentry and process understandings that are key to this component.

Technological systems are defined as a set of interconnected components designed by people to fulfil an intended function without further human design input. This means that while a technological system may include input from people to allow the system to function, this input does not alter the system design, and therefore, intended function. For example, while a person driving a car may apply the brakes (human input to activate the system), the functioning of the brake system (as a technological system) is not reliant on this person's design input.

People may be involved in making judgments around intended functions through selecting a particular setting for a manufacturing production system – however, once selected, the designed function continues as intended. The judgment therefore again exists as an input to the technological system. Similarly, quality control decisions around outputs can also be inputs to the technological system, providing impetus for a changing of operational parameters. Over time, system feedback may lead to a need for the system's re-design.

The knowledge base underpinning these generic concepts will vary, depending on the specific nature of the technological system being explored and/or developed. For example, the understandings required to develop biotechnological systems differ significantly to those required to develop electronic control systems. However, the key concepts underpinning technological systems are those generic concepts that relate to how the inputs are transformed to outputs and what is involved in the control of this. Inputs to technological systems include such things as raw materials, information and energy.

Outputs from technological systems include the intended outcome of the system. For example, the output of a manufacturing system for Easter eggs is transformed material – that is, the egg itself. The output of a telephone communication system is transformed and transported information – that is, a voice in another location. The output of a wind-based energy generation system is transformed and stored energy – that is, electricity. However, most technological systems also produce other outputs such as waste products – including pollution. These may be known or unknown at the time of development.

Transformation processes are those processes that occur within a system, to ensure the inputs are transformed into the outputs in a controlled and intended way, without need for additional human design input. Simple technological systems are defined in this context as systems that have been designed to change inputs to outputs through a single transformation. Other systems may involve one or more subsystems. The property of a subsystem refers to the role it provides in the technological system as a whole and can be established by examining the way in which the inputs change to outputs during that part of the system. Where subsystems exist, effective interfaces are critical for the successful function of the system as a whole.

Control mechanisms within a system are designed to enhance the efficiency of the technological system by maximising the desired outputs and minimising the undesirable outputs. Adjustments to the transformation processes can be a part of a system's design, whereby feedback from any part of the system allows for ongoing responsiveness to input requirements and/or output success, thereby allowing the system to be self regulatory.

Self-regulatory systems are different to intelligent systems. Intelligent systems are those that have been designed to adapt to environmental inputs in ways that change the nature of the system components and/or transformation processes in known and unknown ways to produce hopefully desirable but unspecified outputs.

An exploration of generic concepts, such as redundancy and reliability within a technological system's design and performance, is important in supporting the development of understandings about a system's operational parameters. *Operational parameters* refer to the boundaries and/or conditions within which the system has been designed to function. These concepts are important to understand when establishing the fitness for purpose of technological systems. Ethics play a significant part in the decisions around reliability and redundancy, as improvements in both these areas within a system inevitably comes with associated costs.

The concept of *redundancy* within a technological context refers to the inclusion of more time, information and/or resources than would strictly be needed for the successful functioning of the technological system. Redundancy may be built into a technological system, as a contingency plan to allow room for detecting or tolerating faults before the success of the system is compromised. This concept can be thought of as 'allowing a bit extra' or taking a 'belt and braces' approach to design, and can be understood at varying levels of complexity. While the inclusion of redundancy options in a system may provide additional capability, often in terms of increasing safety margins, redundancy can also result in 'over engineering' a system by including components that provide no added functional advantage to the system. This form of redundancy is something system designers strive to eliminate, as it often impacts on a system's ability to function within agreed specifications, (for example, specifications around the cost of production).

An example of simple redundancy measures can be seen in the use of component parts with tolerances higher than those required to make the system fit for purpose. Within complex system design, a broad understanding of redundancy is required to ensure all variables (produced by multiple levels of interconnectedness) are included in decision making.

The concept of *reliability* within this context relates to the probability that a system (or sub-system) will perform a required function under stated conditions for a stated period of time. Reliability is therefore a part of that system's overall design and that of its constituent parts. Tolerances for reliability are determined by the specifics of each development and the nature of the output. For example, if the system is designed to result in an output that enhances human safety, reliability tolerances will be more stringent. Reliability as a concept underpins understandings associated with all three types of situations where a technological system no longer functions successfully. These three types being: malfunctioning, a gradual reduction in function caused by ongoing use, or designed failure.

The concept of '*black box'* is important in describing technological systems. A black box can be thought of as representing a part of a technological system that is reduced to inputs, outputs, and a hidden transformation process or series of processes. There are advantages and disadvantages in adopting a black box approach when working with and understanding technological systems.

An advantage is that it can provide an opportunity for complex systems to be explored and understood in a holistic sense. It also allows for system maintenance to be undertaken without in depth knowledge, through the replacement of isolated parts of a system with little to no disruption to rest of the system. Ease of such replacement would be an inherent part of the system design and would need to take into account such things as the costs associated with the disposal of a part when repair of the part could have sufficed.

A significant disadvantage of black boxing is that the detail is rendered invisible, and therefore not available to be understood. This may pose problems in future system modification and/or development. It may also result in a loss of empowerment for the end-user, particularly should any malfunction occur or when troubleshooting or repair work is required.

Technological systems are often represented in symbolic ways to communicate their constituent parts. While there are some generic symbols associated with systems, for example arrows to denote direction, specialised languages also exist and are central to the development and communication of technological systems. Design concepts of systems can therefore be represented using a variety communication tools (eg, computer software, flow diagrams, web diagrams, 3D models etc) in order to explore and understand relationships between parts of a single system and/or between different systems. Different technology communities often supplement or modify generic symbols as part of more specialised diagrams/representations.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY[5]

Mass production manufacturing systems are an example of technological systems that have had a significant impact in the world. Such technological systems transformed the one-off (and therefore craft based) nature of product development and served to change the way labour was managed and perceived in the post-industrial age.

There are four types of manufacturing systems: custom manufacturing, intermittent and batch manufacturing, continuous manufacturing and flexible manufacturing; all have advantages and disadvantages. Exploring examples of increasingly self-regulatory technological systems allows for insights into the increased sophistication of internal feedback, as key parts of a system use data from its own functioning to control and modify its transformation processes.

Black boxing has become a feature of much contemporary design and technological development. It is employed more frequently, because of the complex nature of many sophisticated technological systems, to the point where many complete sub-systems are developed as black boxes. These often become disposable units when a system malfunctions.

The modern car provides an excellent example of a technology that was initially based on highly visible mechanical systems that many lay people could understand and confidently repair. In the past this was a requirement for early cars as they often broke down and garages (and mechanics) were few and far between, and New Zealand roads were often isolated and demanding. Drivers therefore carried tools and spare parts as a matter of course. In contrast to this, a modern car is more reliable, drivers do not expect it to breakdown, and, if it did, would rarely entertain the notion they could undertake their own repairs. As modern cars become more electronically controlled and managed by a centralized computer system, opening the bonnet exposes a series of carefully integrated black boxes, with the mechanical systems becoming less accessible.

Servicing, troubleshooting and addressing malfunctions therefore, have become highly specialised activities that the majority of lay people would deem outside their capability. In fact, many automotive mechanics would also argue that current levels of black boxing are such that their role has reduced from any form of mechanical intervention, to one of computer assisted diagnostic work with the purpose of finding and replacing parts; little knowledge being needed of what might be happening within the part at fault.

5 These are provided for the purpose of increasing teacher background understandings of this component – however they may also be relevant for senior students.

POSSIBLE LEARNING EXPERIENCES

The learning experiences suggested below have been provided to support teachers as they develop their understandings of the Technological Systems component of Technological Knowledge, and how this could be reflected in student achievement at various levels. There is no expectation that these would form the basis of any specific unit of work in technology. The learning experiences have been written in such a way as to support student learning across a range of levels. This stance reflects the majority of classrooms where it is expected that students will demonstrate a range of levels of achievement.

Junior Primary (NE-Year 4)

Students could explore a range of familiar technological systems (such as: an electric jug, a windup toy, yoghurt maker, television, computer, fish tank, popcorn maker, washing machine, torch, pacemaker etc) and identify the components of the system and what it has been designed to do. Teachers could lead a discussion about technological systems and explore what they have in common with, and how they differ from, natural systems (for example, the digestive system) and social systems (for example, the lunch ordering system at school).

The teacher and students could select an example from the familiar systems above and together discuss what the inputs, outputs and transformation processes are. They could also explore how the system ensures that the transformation occurs in a controlled fashion. In pairs, the students could select their own example and identify its inputs and outputs, controls and transformation processes. Allowing students to use the systems would aid these explorations, as would being able to pull some apart where appropriate.

As part of class discussions, students could suggest definitions for a technological system, to enable them to distinguish technological systems from non-technological systems and begin to explore why the same technological outcome may be referred to as a technological system or a technological product.

Students achieving at level 1 could be expected to:

- identify the components of a systems and how they connect to each other
- identify the inputs and outputs of a system

Students achieving at level 2 could be expected to:

- explain the change that has happened to an input for the output to be produced in a simple system
- describe the role each component has in the transformation of the input to output in a simple system

Senior Primary/Intermediate (Years 5-8)

Students could identify a number of simple technological systems from different contexts, and represent the parts of the systems using appropriate language tools (including graphical symbols) for the type of system focused on. The systems explored could be categorised by the students as being primarily focused on transforming energy, information or materials. Students could then explore a more complex technological system that consists of one or more black boxed components, (for example, a security system, manufacturing system, car wash, fermentation system etc) and discuss the advantages and disadvantages of not knowing what is happening inside the ‘box’.

In order to gain a better understanding of the concept of black boxes and technological systems, students could be involved in making a bread product. As part of their technological practice they are provided with the opportunity to experience a variety of ways of making bread. That is, they could make bread in a traditional way; accessing their own ingredients and carrying out the steps by hand, whereby their design input is necessary for the transformation to occur. In this case, the bread making *is not* a technological system. They could then make bread with a bread-maker but accessing all their own ingredients. In this case, the bread maker *is* a technological system – but its system nature can be viewed as a black box, as its transformation processes are hidden. Finally the students could make bread with a bread-maker using a ‘ready bread mix’. In this case, the bread maker (a technological system) and the mix (an input into this system) can both be thought of as black boxes. The students could also view a video showing a commercial bread factory and identify technological systems employed in this context.

They could explore the nature of the outputs in all these scenarios and determine the ratio of wanted (bread product) versus unwanted (waste/energy depletion/pollution etc) outputs in each case. Ongoing class discussions could be held around the quality and reliability of the end product, and how easy it was for the student to modify the product to allow for different tastes etc., within each method used. Students could complete a PMI (plus/minus/interesting) analysis of making bread in a variety of ways.

Students achieving at level 2 could be expected to:

- describe the process and type of transformation that occurs within the bread-maker and how it is controlled
- describe a black box within a system

Students achieving at level 3 could be expected to:

- describe a range of simple technological systems (including a system involved in bread making) using appropriate language tools
- explain what a black box is, and give examples of how a black box can be both helpful and unhelpful

Students achieving at level 4 could be expected to:

- identify an example of a control mechanism within a technological system and explain how it influences the transformation process
- explain how different inputs are managed in a technological system to ensure they are transformed efficiently into outputs

Junior secondary (Years 9-10)

Students could investigate the computer network within their school to identify and explore subsystems that make up the whole system. Students could explore the way that the system has been designed so that failure in a particular subsystem is managed, to guard against overall system failure and/or damage. This may be by way of alternative paths or shutdown options.

Extensive investigation could be undertaken to uncover the workings of a black box within the identified system. Issues associated with ongoing support and maintenance could be explored and suggestions made for the different levels of expertise required to develop, use, maintain and repair their school computer systems.

Students achieving at level 3 could be expected to:

- describe their school computer network using appropriate symbols and language to represent its components and connections
- identify examples of black boxes within the network and suggest how these may be viewed differently by members of the school community

Students achieving at level 4 could be expected to:

- identify control mechanisms within the network and explain how they influence different transformations
- explain how control mechanisms enhance the systems fitness for purpose as a school network

Students achieving at level 5 could be expected to:

- identify all subsystems within the network and explain the role each has in the networks overall performance
- discuss how the interface between each subsystems allows the network to work together in ways that guard against system failure or damage should any subsystem malfunction

Senior Secondary (Years 11-13)

As part of student involvement in the development of an electronic game, they could focus on developing understandings associated with micro-controllers. Undertaking product analysis of a number of everyday appliances allows students to begin to explore the nature of the transformation processes occurring within what was previously the system 'black box' of the appliance's cover. Once these processes are understood, students can practice writing software that would allow for these processes to occur. Exploring a range of components (such as real time clocks, micro-controllers, pulse width modulation blocks, motors etc) and the interfaces between them allows students to build up their systems knowledge related to subsystems, redundancy and reliability that will support their design decisions for the development of their own game.

Students achieving at level 4 could be expected to:

- subsystems within an appliance and explain how they integrate with other sub-systems in a controlled manner
- explain how the fitness for purpose of a particular appliance was enhanced through the use of a micro-controller.

Students achieving at level 5 could be expected to:

- explain the specialised transformation processes occurring within components that serve as subsystems within an appliance
- discuss how electronic interfaces support the development and maintenance of systems.

Students achieving at level 6 could be expected to:

- explain how multiple sub-systems allow for the development of systems with additional features
- describe examples of how micro-controllers allow for self-regulation to occur within a system.

Students achieving at level 7 could be expected to:

- explain how reliability was enhanced through the design, development and maintenance of a particular technological system
- discuss examples of designed redundancy and explain why it was deemed necessary to enhance user safety.

Students achieving at level 8 could be expected to:

- explain the impact of energy efficiency and failsafe on the operational parameters of systems used in familiar appliances
- explain the operating parameters of an appliance and the implications of these for its design and ongoing maintenance requirements.

TECHNOLOGY INDICATORS OF PROGRESSION

The Indicators of Progression, as presented in the matrices below, provide support for teachers to interpret the Achievement Objectives for each strand of the technology curriculum within *The New Zealand Curriculum* (NZC) (2007). There are three matrices, each focused on one of the three strands of the technology curriculum, describing the eight levels of the NZC. Each matrix:

- restates the Achievement Objectives for each level
- provides guidance to teachers on what they could do to support student learning at each level
- provides suggestions indicative of what student achievement a particular level might look like.

The *teacher guidance* highlights the importance of the teacher's role in supporting student learning. It also acknowledges how the nature of teaching needs to change to ensure students are able to take more responsibility for their learning as they progress from levels 1-8 of the NZC. This has been emphasised by using the following terms to denote this shift in responsibilities from teacher to student.

- **Provide** is used when the teacher takes full responsibility for introducing and explicitly teaching new knowledge/skill or practices.
- **Guide** is used when the teacher assumes students will have some level of understanding/competency to draw from but continues to take the majority of the responsibility for developing these further.
- **Support** is used when the balance shifts towards the student taking more responsibility for their learning, drawing from their past learning to consolidate and extend their understandings. In this case the teacher plays a more supportive role through questioning and challenging students to support them in their learning.

The *teacher guidance* also uses the term **ensure** to denote when the teacher plays a monitoring role to check that conditions critical for learning are met. For example, in 'planning for practice' and 'outcome development and evaluation' the teacher must ensure an appropriate brief is available to guide student work.

The *indicators of achievement* do not define specific knowledge and skills, but rather focus on generic understandings and capabilities that students should demonstrate across a range of different contexts. It is expected that teachers should be able to contextualise the indicators by re-phrasing them into appropriate language for the unit being studied, and the students they are teaching. By doing this the indicators can be used as targeted assessment tools inside the classroom with students.

The *teacher guidance* and *indicators of progression* for the technological practice strand have been developed through classroom research and refined through subsequent trialling. These indicators are therefore ready to be used to guide formative and summative assessment practices, planning decisions and the development of effective and efficient reporting mechanisms for multiple audiences, including the students, their caregivers, and future teachers both within and across schools.

The *teacher guidance* and *indicators of progression* for the technological knowledge and the nature of technology strands are currently in draft form as they are still in their development stage. These indicators are therefore NOT ready to be used for summative assessment practices or reporting purposes. They are being made available for teachers to use as discussion tools to increase understandings of the two new strands; they also provide support for formative interactions between teachers and students when developing knowledge and skills inherent in the two new strands, for the purpose of enhancing student technological practice. These will be reviewed again prior to the requirement for teachers to report on these two strands.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION — LEVEL ONE

Teachers should establish if students hold any misconceptions or partial understandings that would inhibit students meeting the level one achievement objectives for the technological practice, and plan learning experiences to challenge and/or progress these as guided by the level one Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Describe the outcome they are developing and identify the attributes it should have, taking account of the need or opportunity and the resources available.	**ACHIEVEMENT OBJECTIVE** Students will: Outline a general plan to support the development of an outcome, identifying appropriate steps and resources.	**ACHIEVEMENT OBJECTIVE** Students will: Investigate a context to communicate potential outcomes. Evaluate these against attributes; select and develop an outcome in keeping with the identified attributes.
TEACHER GUIDANCE To support students to undertake brief development at level one teachers could: • provide the need or opportunity and develop the conceptual statement in negotiation with the students • provide a range of attributes for discussion • guide students to identify the attributes an appropriate outcome should have.	**TEACHER GUIDANCE** To support students to undertake planning for practice at level one teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • provide students with a detailed plan of what they will be doing during their technological practice. This could be presented and explained as a design process the teacher has developed, with key stages that need to happen clearly identified within it • provide a range of appropriate resources for students to select from.	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level one teachers could: • ensure that there is a brief with attributes against which a developed outcome can be evaluated • establish an environment that encourages and supports student innovation when generating design ideas • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and using manipulative media such as plasticine, wire, card etc • provide opportunities to develop skills required to produce their outcome.
INDICATORS OF ACHIEVEMENT Students can: • communicate the outcome to be produced • identify attributes for an outcome.	**INDICATORS OF ACHIEVEMENT** Students can: • describe what they have done already • identify what they will do next • identify the resources they might use.	**INDICATORS OF ACHIEVEMENT** Students can: • describe potential outcomes, through drawing, models and/or verbally. • identify potential outcomes that are in keeping with the attributes, and selects one to produce • produce an outcome in keeping with identified attributes.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION — LEVEL TWO

Teachers should establish if students have developed robust level one competencies and are ready to begin working towards level two achievement objectives for the technological practice components, and plan learning experiences to progress these as guided by the level two Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Explain the outcome they are developing and describe the attributes it should have, taking account of the need or opportunity and the resources available.	**ACHIEVEMENT OBJECTIVE** Students will: Develop a plan that identifies the key stages and the resources available.	**ACHIEVEMENT OBJECTIVE** Students will: Investigate a context to develop potential outcomes. Evaluate these against identified attributes; select and develop an outcome. Evaluate the outcome in terms of the need/opportunity.
TEACHER GUIDANCE To support students to undertake brief development at level two teachers could: • provide the need or opportunity and develop the conceptual statement in negotiation with the students • guide students to discuss the implications of the need or opportunity and the conceptual statements and support them to establish a list of attributes an appropriate outcome could have • provide students with an overview of the resources available and guide them to take this into account when identifying the attributes for the outcome	**TEACHER GUIDANCE** To support students to undertake planning for practice at level two teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • provide students with an overview of the stages they will be working through during their technological practice. This could be presented and explained as a design process the teacher has developed, and it could be used to support students to identify what the key stages are • provide a range of appropriate resources and guide students to decide which of these they wish to use in their outcome.	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level two teachers could: • ensure that there is a brief with attributes against which a developed outcome can be evaluated • establish an environment that encourages and supports student innovation when generating design ideas • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and using manipulative media such as plasticine, wire, card etc • provide opportunities to develop skills required to produce their outcome • guide students to evaluate their outcome against the brief.
INDICATORS OF ACHIEVEMENT Students can: • explain the outcome to be produced • describe the attributes for an outcome that take account of the need or opportunity being addressed and the resources available.	**INDICATORS OF ACHIEVEMENT** Students can: • identify and record the key stages and resources required to produce their outcome • describe what they have done already and what resources have been used • explain what they are going to do next.	**INDICATORS OF ACHIEVEMENT** Students can: • describe potential outcomes, through drawing, models and/or verbally • evaluate potential outcomes in terms of identified attributes to select the outcome to produce • produce an outcome in keeping with the brief • evaluate the final outcome in terms of how successfully it addresses the brief.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION LEVEL THREE

Teachers should establish if students have developed robust level two competencies and are ready to begin working towards level three achievement objectives for the technological practice components, and plan learning experiences to progress these as guided by the level three Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Describe the nature of an intended outcome, explaining how it addresses the need or opportunity. Describe the key attributes that enable development and evaluation of an outcome.	**ACHIEVEMENT OBJECTIVE** Students will: Undertake planning to identify the key stages and resources required to develop an outcome. Revisit planning to include reviews of progress and identify implications for subsequent decision making.	**ACHIEVEMENT OBJECTIVE** Students will: Investigate a context to develop ideas for potential outcomes. Trial and evaluate these against key attributes to select and develop an outcome to address the need or opportunity. Evaluate this outcome against the key attributes and how it addresses the need or opportunity.
TEACHER GUIDANCE To support students to undertake brief development at level three teachers could: • provide the need or opportunity and develop the conceptual statement in negotiation with the students • guide students to describe the physical and functional nature of an outcome (eg, what it looks like and what it can do) taking into account the need or opportunity, conceptual statements and resources available • guide students to identify the key attributes an appropriate outcome should have. Key attributes reflect those that are deemed essential for the successful function of the outcome.	**TEACHER GUIDANCE** To support students to undertake planning for practice at level three teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • provide students with an overview of what they will need to do during their technological practice and guide students to develop their own design process • provide a range of resources for students to select from and guide students to select those that will be appropriate for their outcome • guide students to review their plans at key points and reflect on progress to make informed decisions regarding earlier plans and resources	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level three teachers could: • ensure that there is a brief with attributes against which a developed outcome can be evaluated • establish an environment that encourages and supports student innovation when generating design ideas • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and using manipulative media such as plasticine, wire, card etc • provide opportunity to develop knowledge and skills related to the materials/components they will use • support students to evaluate their outcome against the brief.
INDICATORS OF ACHIEVEMENT Students can: • describe the physical and functional nature of the outcome they are going to produce and explain how the outcome will have the ability to address the need or opportunity • describe attributes for the outcome and identify those which are key for the development and evaluation of an outcome.	**INDICATORS OF ACHIEVEMENT** Students can: • develop a plan that identifies key stages, and resources required to produce their outcome • review progress through the keys stages and resources used to date and use this to inform future planning decisions.	**INDICATORS OF ACHIEVEMENT** Students can: • describe design ideas (either through drawing, models and/or verbally) for potential outcomes • evaluate design ideas in terms of key attributes to develop a conceptual design for the outcome • evaluate suitability of materials/components, based on their performance properties, to select those appropriate for use in the production of the outcome • produce an outcome that addresses the brief • evaluate the final outcome against the key attributes to determine how well it met the need or opportunity.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION LEVEL FOUR

Teachers should establish if students have developed robust level three competencies and are ready to begin working towards level four achievement objectives for the technological practice components, and plan learning experiences to progress these as guided by the level four Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Justify the nature of an intended outcome in relation to the need or opportunity. Describe the key attributes identified in stakeholder feedback, which will inform the development of an outcome and its evaluation.	**ACHIEVEMENT OBJECTIVE** Students will: Undertake planning that includes reviewing the effectiveness of past actions and resourcing, exploring implications for future actions and accessing of resources, and consideration of stakeholder feedback, to enable the development of an outcome.	**ACHIEVEMENT OBJECTIVE** Students will: Investigate a context to develop ideas for feasible outcomes. Undertake functional modelling that takes account of stakeholder feedback, in order to select and develop the outcome that best addresses the key attributes. Incorporating stakeholder feedback, evaluate the outcome's fitness for purpose in terms of how well it addresses the need or opportunity.
TEACHER GUIDANCE To support students to undertake brief development at level four teachers could: • provide an appropriate context and issue that allows students to access resources (including key stakeholders) • guide students to identify a need or opportunity and develop a conceptual statement • guide students to understand the physical and functional nature required of an outcome, and how the key attributes relate to this • guide students to consider the key stakeholders and the environment where the outcome will be located.	**TEACHER GUIDANCE** To support students to undertake planning for practice at level four teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • provide planning tools and support students to record key stages and resources needed, including when they will need to access stakeholder feedback. (Please note; records only need to capture what students plan to do and what they need to do it to guide their practice and allow them to review this periodically) • support students to review their plans at key points and reflect on progress to make informed decisions regarding earlier plans and resources • support students in organising their resources (including time, money, materials, equipment and access to stakeholders etc).	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level four teachers could: • ensure that there is a brief with attributes against which a developed outcome can be evaluated • establish an environment that encourages and supports student innovation when generating design ideas • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and increasing the range and complexity of functional modelling • provide a range of materials/components and the opportunity to develop the necessary knowledge and skills to test and use them • guide students to evaluate outcomes in situ against key attributes.
INDICATORS OF ACHIEVEMENT Students can: • identify a need or opportunity from the given context and issue • establish a conceptual statement that communicates the nature of the outcome and why such an outcome should be developed • establish the key attributes for an outcome informed by stakeholder considerations • communicate key attributes that allow an outcome to be evaluated as fit for purpose.	**INDICATORS OF ACHIEVEMENT** Students can: • establish a plan to manage resources and stakeholder interactions, setting out key stages, actions to be undertaken and progress review points • review progress according to the current plan, and revise planning as appropriate to ensure completion of outcome.	**INDICATORS OF ACHIEVEMENT** Students can: • describe design ideas (either through drawing, models and/or verbally) or potential outcomes • undertake functional modelling to develop design ideas into a conceptual design that addresses the key attributes • evaluate suitability of materials/components, based on their performance properties, to select those appropriate for use in the production of a feasible outcome • produce and trial a prototype of the outcome • evaluate the fitness for purpose of the final outcome against the key attributes.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION — LEVEL FIVE

Teachers should establish if students have developed robust level four competencies and are ready to begin working towards level five achievement objectives for the technological practice components, and plan learning experiences to these as guided by the level five Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Justify the nature of an intended outcome in relation to the need or opportunity. Describe specifications that reflect key stakeholder feedback and that will inform the development of an outcome and its evaluation.	**ACHIEVEMENT OBJECTIVE** Students will: Analyse their own and others' planning practices to inform the selection and use of planning tools. Use these to support and justify planning decisions (including those relating to the management of resources) that will see the development of an outcome through to completion.	**ACHIEVEMENT OBJECTIVE** Students will: Analyse their own and others' outcomes to inform the development of ideas for feasible outcomes. Undertake ongoing functional modelling and evaluation that takes account of key stakeholder feedback and trialling in the physical and social environments. Use the information gained to select and develop the outcome that best addresses the specifications. Evaluate the final outcome's fitness for purpose against the brief.
TEACHER GUIDANCE To support students to undertake brief development at level five teachers could: • provide an appropriate context and issue that allows students to access resources (including key stakeholders) • support students to identify a need or opportunity and develop a conceptual statement • support students understand the physical and functional nature required of an outcome • guide students to develop key attributes into specifications.	**TEACHER GUIDANCE** To support students to undertake planning for practice at level five teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • provide a range of planning tools and support students to analyse these to inform selection of the tools they will use to record[1] their planning (Please note; records only need to capture what students plan to do and what they need to do it to guide their practice and allow them to review this periodically) • support students to review past planning decisions in an ongoing manner and evaluate progress to inform their ongoing planning • support students to manage their resources (including time, materials, money, equipment and access to stakeholders etc).	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level five teachers could: • ensure that there is a brief with clear specifications against which a developed outcome can be evaluated • establish an environment that supports student innovation and encourages analysis of existing outcomes • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and increasing the range and complexity of functional modelling • provide a range of materials/components and the opportunity to develop the necessary knowledge and skills to test and use them • guide students to evaluate outcomes in situ against brief specifications.
INDICATORS OF ACHIEVEMENT Students can: • identify a need or opportunity from the given context and issue • establish a conceptual statement that justifies the nature of the outcome and why such an outcome should be developed • establish the specifications for an outcome based on the nature of the outcome required to address the need or opportunity, and informed by key stakeholder considerations • communicate specifications that allow an outcome to be evaluated as fit for purpose.	**INDICATORS OF ACHIEVEMENT** Students can: • select and use planning tools to identify and record key stages, actions to be undertaken, determine progress review points, and manage resources • use planning tools to record initial plans and ongoing revisions in ways which provide justification for planning decisions made.	**INDICATORS OF ACHIEVEMENT** Students can: • generate design ideas that are informed by research and analysis of existing outcomes • undertake functional modelling to develop design ideas into a conceptual design that addresses the specifications • evaluate suitability of materials/components, based on their performance properties, to select those appropriate for use in the production of a feasible outcome • produce and trial a prototype of the outcome • evaluate the fitness for purpose of the final outcome against the specifications.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION — LEVEL SIX

Teachers should establish if students have developed robust level five competencies and are ready to begin working towards level six achievement objectives for the technological practice components, and plan learning experiences to progress these as guided by the level six Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Justify the nature of an intended outcome in relation to the need or opportunity and justify specifications in terms of key stakeholder feedback and wider community considerations.	**ACHIEVEMENT OBJECTIVE** Students will: Critically analyse their own and others' past and current planning practices in order to make informed selection and effective use of planning tools. Use these to support and justify ongoing planning that will see the development of an outcome through to completion.	**ACHIEVEMENT OBJECTIVE** Students will: Critically analyse their own and others' outcomes to inform the development of ideas for feasible outcomes. Undertake ongoing experimentation and functional modelling, taking account of stakeholder feedback and trialling in the physical and social environments. Use the information gained to select, justify, and develop a final outcome. Evaluate this outcome's fitness for purpose against the brief and justify the evaluation using feedback from stakeholders.
TEACHER GUIDANCE To support students to undertake brief development at level six teachers could: • provide an appropriate context and issue that allows students to access resources (including key stakeholders) and guide them to take into account wider community considerations • ensure students identify a need or opportunity relevant to the given issue and context • ensure students understand the physical and functional nature required of an outcome • support students to develop specifications and justify them based on key and wider community stakeholder considerations.	**TEACHER GUIDANCE** To support students to undertake planning for practice at level six teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • support students to critically analyse a range of planning tools that have been used in past practice • ensure tools selected by students will provide appropriate support for their practice • support students to use selected tools to effectively manage resources (including time, materials, money, equipment and access to stakeholders etc) to enable the outcome produced to successfully meet the brief.	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level six teachers could: • ensure that there is a brief with clear specifications against which a developed outcome can be evaluated • establish an environment that supports student innovation and encourages critical analysis of existing outcomes • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and increasing the range and complexity of functional modelling • provide a range of materials/components and the opportunity to develop the necessary knowledge and skills to test and use them • support students to undertake prototyping to evaluate the outcome's fitness for purpose and identify any further development requirements • ensure students gain targeted stakeholder feedback.
INDICATORS OF ACHIEVEMENT Students can: • identify a need or opportunity from the given context and issue • establish a conceptual statement that justifies the nature of the outcome and why such an outcome should be developed • establish the specifications for an outcome as based on the nature of the outcome required to address the need or opportunity, consideration of the environment in which the outcome will be situated and resources available • communicate specifications that allow an outcome to be evaluated as fit for purpose. • justify the specifications in terms of key and wider community stakeholder considerations.	**INDICATORS OF ACHIEVEMENT** Students can: • select appropriate planning tools informed by the critical analysis of own and others' planning practices • use planning tools to plan for the effective management of resources to ensure completion of an outcome • use planning tools to record initial plans and ongoing revisions in ways which provide justification for planning decisions made.	**INDICATORS OF ACHIEVEMENT** Students can: • generate design ideas that are informed by research and the critical analysis of existing outcomes • undertake functional modelling to refine design ideas and enhance their ability to address the specifications • evaluate design ideas in terms of their ability to support the development of a conceptual design for a feasible outcome • evaluate the conceptual design against the specifications to determine the proposed outcomes potential fitness for purpose • evaluate suitability of materials/components, based on their performance properties, to select those appropriate for use in the production of a feasible outcome • produce and trial a prototype of the outcome to evaluate its fitness for purpose and identify any changes that would enhance the outcome • use stakeholder feedback to support and justify key design decisions and evaluations of fitness for purpose.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION LEVEL SEVEN

Teachers should establish if students have developed robust level six competencies and are ready to begin working towards level seven achievement objectives for the technological practice components, and plan learning experiences to progress these as guided by the level seven Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Justify the nature of an intended outcome in relation to the issue to be resolved and justify specifications in terms of key stakeholder feedback and wider community considerations.	**ACHIEVEMENT OBJECTIVE** Students will: Critically analyse their own and others' past and current planning and management practices in order to develop and employ project management practices that will ensure the effective development of an outcome to completion.	**ACHIEVEMENT OBJECTIVE** Students will: Critically analyse their own and others' outcomes and evaluative practices to inform the development of ideas for feasible outcomes. Undertake a critical evaluation that is informed by ongoing experimentation and functional modelling, stakeholder feedback, and trialling in the physical and social environments. Use the information gained to select, justify, and develop an outcome. Evaluate this outcome's fitness for purpose against the brief. Justify the evaluation using feedback from stakeholders and demonstrating a critical understanding of the issue.
TEACHER GUIDANCE To support students to undertake brief development at level seven teachers could: • provide a context that offers a range of issues for students to explore • support students to select an authentic issue within the context. An authentic issue is one which is connected to the context, and allows students to develop a brief for a need or opportunity that can be managed within the boundaries of their available resources. • ensure students identify a need or opportunity relevant to the issue • ensure students understand the physical and functional nature required of an outcome • support students to justify the nature of their outcome in terms of the issue it is addressing • support students to develop specifications and provide justifications for them drawing from stakeholder feedback, and wider community considerations such as the resources available to develop the outcome, ongoing maintenance of the outcome once implemented, sustainability of resources used to develop the outcome and the outcome itself, disposal of the developed outcome when past its use by date.	**TEACHER GUIDANCE** To support students to undertake planning for practice at level seven teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • support students to critically analyse a range of planning tools and project management practices that have been used in past technological practice • support students to use selected tools to effectively manage resources (including time, materials, money, equipment and access to stakeholders etc) to enable the outcome produced to successfully meet the brief.	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level seven teachers could: • ensure that there is a brief with clear specifications against which a developed outcome can be evaluated • establish an environment that supports student innovation and encourages critical analysis of existing outcomes • support students to critically analyse evaluative practices used within functional modelling • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and increasing the range and complexity of functional modelling • provide a range of materials/components and the opportunity to develop the necessary knowledge and skills to test and use them • support students to undertake prototyping to gain evidence that enables clear judgments regarding the outcome's fitness for purpose and determine the need for any changes to enhance the outcome • support students to gain targeted stakeholder feedback and understand the implications of the physical and social environment in which the outcome is to be located.
INDICATORS OF ACHIEVEMENT Students can: • explore the context to select an issue • identify a need or opportunity relevant to their selected issue • establish a conceptual statement that justifies the nature of the outcome and why such an outcome should be developed with reference to the issue it is addressing • establish the specifications for an outcome using stakeholder feedback, and based on the nature of the outcome required to address the need or opportunity, consideration of the environment in which the outcome will be situated, and resources available • communicate specifications that allow an outcome to be evaluated as fit for purpose • justify the specifications in terms of stakeholder feedback, and the nature of the outcome required to address the need or opportunity, consideration of the environment in which the outcome will be situated, and resources available.	**INDICATORS OF ACHIEVEMENT** Students can: • select appropriate planning tools and develops project management practices informed by the critical analysis of own and others' planning practices • use planning tools and project management practices to plan for the effective management of resources to ensure completion of an outcome • use planning tools to record initial plans and ongoing revisions in ways which provide justification for project management practices employed.	**INDICATORS OF ACHIEVEMENT** Students can: • generate design ideas that are informed by research and critical analysis of existing outcomes • develop design ideas for outcomes that are justified as feasible with evidence gained through functional modelling • critically analyse evaluative practices used when functional modelling to inform own functional modelling • undertake functional modelling to evaluate design ideas and develop and test a conceptual design to provide evidence of the proposed outcome's ability to be fit for purpose • evaluate suitability of materials/components, based on their performance properties, to select those appropriate for use in the production of a feasible outcome • undertake prototyping to gain specific evidence of an outcomes fitness for purpose and use this to justify any decisions to refine, modify and/or accept the outcome as final • use stakeholder feedback and an understanding of the physical and social requirements of where the outcome will be situated to support and justify key design decisions and evaluations of fitness for purpose.

COMPONENTS OF TECHNOLOGICAL PRACTICE: INDICATORS OF PROGRESSION — LEVEL EIGHT

Teachers should establish if students have developed robust level seven competencies and are ready to begin working towards level eight achievement objectives for the technological practice components, and plan learning experiences to progress these as guided by the level eight Indicators of Achievement below.

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Students will: Justify the nature of an intended outcome in relation to the context and the issue to be resolved. Justify specifications in terms of key stakeholder feedback and wider community considerations.	**ACHIEVEMENT OBJECTIVE** Students will: Critically analyse their own and others' past and current planning and management practices in order to develop and employ project management practices that will ensure the efficient development of an outcome to completion.	**ACHIEVEMENT OBJECTIVE** Students will: Critically analyse their own and others' outcomes and their determination of fitness for purpose in order to inform the development of ideas for feasible outcomes. Undertake a critical evaluation that is informed by ongoing experimentation and functional modelling, stakeholder feedback, trialling in the physical and social environments, and an understanding of the issue as it relates to the wider context. Use the information gained to select, justify, and develop an outcome. Evaluate this outcome's fitness for purpose against the brief. Justify the evaluation using feedback from stakeholders and demonstrating a critical understanding of the issue that takes account of all contextual dimensions.
TEACHER GUIDANCE To support students to undertake brief development at level eight teachers could: • support students to identify a context that offers a range of issues for them to explore • ensure students select an authentic issue within their selected context • ensure students identify a need or opportunity relevant to the issue and context • ensure students understand the physical and functional nature required of an outcome • support students to justify the nature of their outcome in terms of the issue and context • support students to develop and justify specifications that will allow the evaluation of the outcome and its development to be judged as fit for purpose in the broadest sense. Fitness for purpose in its broadest sense refers to the 'fitness' of the outcome itself as well as the practices used to develop the outcome (eg, such things as the sustainability of resources used, ethical nature of testing practices, cultural appropriateness of trialing procedures, determination of lifecycle and ultimate disposal).	**TEACHER GUIDANCE** To support students to undertake planning for practice at level eight teachers could: • ensure that there is a brief against which planning to develop an outcome can occur • ensure students critically analyse a range of planning tools and project management practices that have been used in past technological practice • support students to select planning tools and project management practices that will ensure the efficient development of an outcome to completion. Efficient management of resources ensures that the use of time, material and people is optimised during the development and production of an outcome that successfully meets the brief.	**TEACHER GUIDANCE** To support students to undertake outcome development and evaluation at level eight teachers could: • ensure that there is a brief with clear specifications against which a developed outcome can be evaluated • establish an environment that supports student innovation and encourages critical analysis of existing outcomes and knowledge of material innovations • support students to critically analyse the ways in which the fitness for purpose of existing outcomes have been determined, and how appropriate development practices were established • provide opportunities to develop drawing and modelling skills to communicate and explore design ideas. Emphasis should be on progressing 2D and 3D drawing skills and increasing the range and complexity of functional modelling • provide a range of materials/components and the opportunity to develop the necessary knowledge and skills to test and use them, and support students to establish which would be optimal for use when taking into account all contextual dimensions • support students to undertake prototyping to gain evidence that enables clear judgments regarding the outcome's fitness for purpose and determine the need for any changes to enhance the outcome • ensure students gain targeted stakeholder feedback and understand the implications of the physical and social environment in which the outcome is to be located.
INDICATORS OF ACHIEVEMENT Students can: • identify and evaluate a range of contexts to select an authentic issue • identify a need or opportunity relevant to their selected issue • establish a conceptual statement that justifies the nature of the outcome and why such an outcome should be developed with reference to the issue being addressed and the wider context • establish the specifications for an outcome and its development using stakeholder feedback and based on the nature of the outcome required to address the need or opportunity, consideration of the environment in which the outcome will be situated, and resources available • communicate specifications that allow an outcome to be evaluated as fit for purpose in the broadest sense. • justify the specifications as based on stakeholder feedback and the nature of the outcome required to address the need or opportunity, consideration of the environment in which the outcome will be situated, and resources available.	**INDICATORS OF ACHIEVEMENT** Students can: • select appropriate planning tools and develops project management practices informed by the critical analysis of own and others' planning practices • use planning tools and project management practices to plan for the efficient management of resources to ensure completion of an outcome • use planning tools to record initial plans and ongoing revisions in ways which provide justification for project management practices employed.	**INDICATORS OF ACHIEVEMENT** Students can: • generate design ideas that are informed by research and critical analysis of existing outcomes and knowledge of material innovations • develop design ideas for feasible outcomes that are justified with evidence gained through functional modelling that serves to gather evidence from multiple stakeholders and test designs ideas from a range of perspectives • undertake evaluation of design ideas informed by critical analysis of evaluative practices to support the development of a conceptual design for an outcome that optimises resources and takes into account maintenance and disposal implications • undertake functional modelling of the conceptual design to provide evidence that the proposed outcome has the potential to be fit for purpose • evaluate suitability of materials/components, based on their performance properties, to select those appropriate for use in the production of a feasible outcome that optimises resources and takes into account maintenance and disposal implications • undertake prototyping to gain specific evidence of an outcomes fitness for purpose and use this to justify any decisions to refine, modify and/ or accept the outcome as final • use stakeholder feedback and an understanding of the physical and social requirements of where the outcome will be situated to support and justify an evaluation of the outcome and development practices as fit for purpose.

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL ONE

Teachers should establish if students hold any misconceptions or partial understandings that would inhibit students meeting the level one achievement objectives for the nature of technology and plan learning experiences to challenge and/or progress these as guided by the level one Indicators of Achievement below.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Students will: Understand that technology is purposeful intervention through design	**ACHIEVEMENT OBJECTIVE** Students will: Understand that technological outcomes are products or systems developed by people and have a physical nature and a functional nature.
TEACHER GUIDANCE To support students to develop understanding of characteristics of technology at level 1, teachers could: • provide opportunities for students to discuss what is meant by the made world and the natural world • provide students with examples of technologists and guide them to identify the sort of things they do as part of their technological practice. Technological practice involves the defining practices underpinning the development of a brief, the organizing practices underpinning planning, and the production and evaluation practices involved in the development of an outcome that is fit for purpose as defined by the brief. • guide students to identify that the purpose of technology is to design and create outcomes to carry out specific functions	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 1, teachers could: • provide students with a range of contemporary and historical technological products and systems and guide them to recognise these as examples of technological outcomes developed by people to be a part of the made world. • guide students to describe the physical nature of technological outcomes. The physical nature of technological outcomes refers to such things as size, shape, colour, smell, texture, components etc. • guide students to describe the functional nature of technological outcomes. The functional nature of technological outcomes refers to what the outcome does.
INDICATORS OF ACHIEVEMENT Students can: • identify that technology involves people designing and creating technological outcomes for an identified purpose • identify that technological practice involves knowing what you are making and why, planning what to do and what resources are needed, and making and evaluating an outcome	**INDICATORS OF ACHIEVEMENT** Students can: • explain that technological outcomes are made by people • describe selected technological outcomes in terms of their physical nature • describe selected technological outcomes in terms of their functional nature.

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL TWO

Teachers should establish if students have developed robust level one understandings and are ready to begin working towards level two achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level two Indicators of Achievement below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand that technology both reflects and changes society and the environment and increases people's capability.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technology at level 2, teachers could:

- provide opportunities for students to discuss the made world, the natural world and the social world and relationships between them
- provide students with examples of technological outcomes and guide them to understand how they can increase people's capability to do things. Examples should allow students to recognize that increasing capability may result in both positive and negative impacts on society and/or the environment
- provide students with examples of technological developments and guide them to identify how society and the environment influenced the decisions made
- provide students with the opportunity to explore a range of technological developments and guide them to identify examples of positive and negative impacts on people and/or the environment

INDICATORS OF ACHIEVEMENT

Students can:

- identify influences on particular technological developments
- identify how particular technological outcomes have changed how people do things
- describe examples to illustrate how a technological development has had a positive impact on society and/or the environment
- describe examples to illustrate how a technological development has had a negative impact on society and/or the environment

Characteristics of Technological Outcomes

ACHIEVEMENT OBJECTIVE

Students will:

Understand that technological outcomes are developed through technological practice and have related physical and functional natures.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technological outcomes at level 2, teachers could:

- provide students with a range of technological outcomes and other objects and guide them to identify which of these could be described as technological outcomes and why. Technological outcomes are defined as fully realised products and systems, created by people for an identified purpose through technological practice. Once the technological outcome is placed in situ, no further design input is required for the outcome to function. Taking this definition into account, technological outcomes can be distinguished from natural objects (such as trees and rocks etc), and works of art, and other outcomes of human activity (such as language, knowledge, social structures, organisational systems etc).
- provide students with a range of technological outcomes and guide them to identify them as technological products or systems. Identifying an outcome as a product or system will determine the description of its physical nature. For example, if a technological outcome is identified as a product, the focus for describing its physical nature will be on the materials it is made from. If a technological outcome is identified as a system, the focus for describing its physical nature will be on the components within it and how they are connected.
- guide students to identify that link between physical and functional attributes in technological outcomes. For example the flat bottom of a cup (physical attribute) allows it to be stable on a flat surface (functional attribute).

INDICATORS OF ACHIEVEMENT

Students can:

- explain how a technological outcome can be distinguished from other things created by people
- identify a technological outcome as a product and describe its physical nature in terms of the materials it is made from
- identify a technological outcome as a system and describe its physical nature in terms of the components within it and how they are connected
- identify links between the physical and functional attributes of particular technological outcomes

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL THREE

Teachers should establish if students have developed robust level two understandings and are ready to begin working towards level three achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level three Indicators of Achievement below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand how society and environments impact on and are influenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technology at level 3, teachers could:

- provide students with examples of technological practice and guide them to understand how social and/or environmental issues have influenced the development of the brief, planning decisions, and the development and evaluation of outcomes
- provide students with the opportunity to explore a range of technological developments and support them to determine why changes in technological outcomes have occurred over time. Reasons for changes refer to such things as changing needs, fashions, attitudes and the development of new materials, skills and knowledge
- support students to determine the impacts different technological developments have had on society and/or the environment over time
- provide students opportunity to identify that knowledge is valued for what it can do and support students to identify that knowledge in technology is considered to be of value if it allows for a technological outcome to function successfully

INDICATORS OF ACHIEVEMENT

Students can:

- describe examples to illustrate how social and/or environmental issues have influenced the technological practice undertaken.
- explain why particular technological outcomes have changed over time
- describe examples to illustrate how technological developments have changed society over time
- describe examples to illustrate how technological developments have changed physical environments over time
- explain that technological knowledge is evaluated in terms of how effective it is in supporting an outcome to function successfully

Characteristics of Technological Outcomes

ACHIEVEMENT OBJECTIVE

Students will:

Understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technological outcomes at level 3, teachers could:

- provide students with a description of a need or opportunity for a potential technological outcome and other details related to its use. These details should include such things as purpose, intended users and the environment in which it is to be situated. Support students to generate potential options for the outcome's physical nature and functional nature and to explain which of these could be justified as fit for purpose.
- provide students with the opportunity to examine a range of technological outcomes with similar functional natures but with different physical natures and support them to understand that the intended use will determine which physical nature will be fit for purpose. For example, a selection of brooms could be described as having a similar functional nature (to sweep) but whether they are to sweep dust of the kitchen floor or water off the driveways will necessitate a different physical nature.
- provide students with the opportunity to examine a range of technological outcomes with similar physical natures but with different functional natures. For example, a selection of brushes could be described as having similar physical natures (all have flexible bristles) but the way in which they are used will determine their functional nature as to whether they function to clean, act as a reservoir to spread a substance, or to separate something.
- guide students to understand the relationship between the physical and functional nature in a technological outcome. That is, the functional nature requirements set boundaries around the suitability of proposed physical nature options, and the physical nature options will set boundaries around what functional nature is feasible for a technological outcome at any time.

INDICATORS OF ACHIEVEMENT

Students can:

- describe possible physical and functional nature options for a technological outcome when provided with a need or opportunity
- describe examples of technological outcomes with different physical natures that have similar functional natures
- describe examples of technological outcomes with different functional natures that have similar physical natures
- explain the relationship between the physical and functional nature of selected technological outcomes.

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL FOUR

Teachers should establish if students have developed robust level three understandings and are ready to begin working towards level three achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level three Indicators of Achievement below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand how technological development expands human possibilities and how technology draws on knowledge from a wide range of disciplines.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technology at level 4, teachers could:

- provide students with opportunities to examine a range of technological developments that have and/or could expand human possibilities by changing people's sensory perception and/or physical abilities. Examination of technological developments should allow students to gain insight into how decisions are based on what could and what should happen.
- support students to understand that expanding human possibilities can result in positive and negative impacts for particular groups of people, and the wider social and natural environment
- provide students with opportunities to examine and debate examples of innovative technological developments that resulted in new possibilities. Examples should draw from the past and present and allow students to identify the creative and critical thinking that underpinned the developments, and how what could happen and what should happen were considered.
- support students to analyse a range of examples of technological developments and to identify the knowledge and skills that informed design decisions. Examples should be drawn from within their own and others' technological practice and allow students to gain insight into the range of disciplines that can support technological developments

INDICATORS OF ACHIEVEMENT

Students can:

- describe examples to illustrate how technological developments have expanded or have the potential to expand human possibilities and discuss the possible short and long term impacts of this
- discuss examples of innovative technological development to illustrate the role of creative and critical thinking
- identify the knowledge and skills that have informed design decisions in particular technological developments

Characteristics of Technological Outcomes

ACHIEVEMENT OBJECTIVE

Students will:

Understand that technological outcomes can be interpreted in terms of how they might be used and by whom and that each has a proper function as well as possible alternative functions.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technological outcomes at level 4, teachers could:

- provide students with the opportunity to explore examples of technological outcomes and support them to identify their proper function. Proper function can be determined from an analysis of both the design intent that drove the outcome's development as well as how it is most commonly used
- provide students with examples of technological outcomes where the proper function of a technological outcome has changed over time because an alternative use was successful and then became socially accepted as the norm
- provide students with examples of technological outcomes that have been used unsuccessfully for other purposes and/or in different environments and support them to identify the impacts. Impacts may be in terms of the outcome, the user, and /or the social and physical environment

INDICATORS OF ACHIEVEMENT

Students can:

- explain the proper function of existing technological outcomes
- describe examples that illustrate technological outcomes that have been successfully used by end-users for purposes other than what they were originally designed for
- describe examples that illustrate technological outcomes that have been unsuccessfully used by end-users for purposes other than what they were originally designed and discuss the impacts of this

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL FIVE

Teachers should establish if students have developed robust level four understandings and are ready to begin working towards level five achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level five Indicators of Achievement below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand how people's perceptions and acceptance of technology impact on technological developments and how and why technological knowledge becomes codified.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technology at level 5, teachers could:

- support students to analyse a range of examples of technological developments to examine people's perceptions and/or level of acceptance has influenced the developments. Examples should be drawn from past, present and possible future technological developments to allow students to gain insight into the influence that perceptions and past experiences have on the acceptance of existing and future technological practice and outcomes
- support students to analyse a range of examples of technological developments and to identify codified technological knowledge that was used to inform design and production decisions. Codified technological knowledge refers to such things as codes of practice, codes of ethics, intellectual property codes, codes of standards, material tolerances etc. Examples should be drawn from within their own and others' technological practice
- provide students with opportunities to discuss the role of codified knowledge in technology and understand why and how particular knowledge becomes codified. Codified knowledge serves to remind technologists of their responsibilities and provide them with access to established knowledge and procedures that have been shown to support successful technological development in the past. In this way codified knowledge can be used to provide constructional, ethical and/or legal compliance constraints on contemporary technological developments. Technological knowledge becomes codified when technological experts consider they have adequate evidence to validate it.
- support students to understand how established codified knowledge can be challenged and that ongoing revision is important due to the changing made, social and natural world. For example, the development of new materials, tools, and/or techniques, shifting social, political and environmental needs and understandings, and technological outcome malfunction, can all serve to challenge existing codified knowledge.

INDICATORS OF ACHIEVEMENT

Students can:

- explain how people's perception of and experiences with past technological developments (both in terms of practice and technological outcomes) influences their acceptance of technology
- explain how people's perception of and experiences with past technological developments (both in terms of practice and technological outcomes) impacts on future technological developments
- identify examples of codified technological knowledge and explain its role in particular technological developments
- explain how and why technological knowledge becomes codified

Characteristics of Technological Outcomes

ACHIEVEMENT OBJECTIVE

Students will:

Understand that technological outcomes are fit for purpose in terms of time and context. Understand the concept of malfunction and how "failure" can inform future outcomes.

TEACHER GUIDANCE

To support students to develop understanding of characteristics of technological outcomes at level 5, teachers could:

- support students to analyse a range of examples of how technological outcomes have been evaluated as fit for purpose according to its appropriateness to the time and context of its development. Examples should be drawn from within students own and others' technological practice and allow students to examine the criteria used to make the judgment.
- support students to explore a range of examples of technological outcome failure and support them identify those that are examples of malfunction. Malfunction refers to a single event failure of a technological outcome as opposed to failure due to 'wear' or reaching the end of the designed lifespan.
- support students to analyse examples of technological outcome malfunction to gain insight into how such events can inform decisions about the future of the outcome. Decisions may be made to withdraw or modify the technological outcome or retain the outcome with modified operational parameters.

INDICATORS OF ACHIEVEMENT

Students can:

- explain why time and context are important criteria for judging the fitness for purpose of technological outcomes
- determine if particular past technological outcomes would be considered fit for purpose if developed today
- explain what is meant by the malfunction of technological outcomes and how such failures can inform future outcomes
- explain the cause of particular technological outcome malfunction and the resulting consequences

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL SIX

Teachers should establish if students have developed robust level five understandings and are ready to begin working towards level six achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level six Indicators of Achievement below.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Students will: Understand the interdisciplinary nature of technology and the implications of this for maximising possibilities through collaborative practice.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that some technological outcomes can be perceived as both product and system. Understand how these outcomes impact on other outcomes and practices and on people's views of themselves and possible futures.
TEACHER GUIDANCE To support students to develop understanding of characteristics of technology at level 6, teachers could: • support students to analyse a range of examples of interdisciplinary technological developments and identify the impact the interdisciplinary nature had on the technological practice undertaken. Examples should be drawn from within student own and others' technological practice and allow students to gain insight into the way disciplines have been combined to support technological practice • support students to identify examples of where collaborative work between technologists and/or other people has led to new possibilities for technological practice and/or outcome design. Examples should be drawn from within students own and others' technological practice and allow students to gain insight into the way idea generation and exploration can be enhanced through collaboration. • ensure students understand that interdisciplinary collaboration provides exciting opportunities to 'work at the boundaries' of established fields, however this may cause situations where no codified technological knowledge exists to guide practice, tensions between people may arise, and unknown consequences may result	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 6, teachers could: • provide students with opportunity to describe particular technological outcomes as a product and a system and support them to understand that the categorization of product or system is not an inherent property of the outcome, but rather how it is perceived by people in order to analyse and understand it. • ensure students understand that if a technological outcome is identified as a product, the focus for describing its physical nature will be on the materials it is made from. If a technological outcome is identified as system, the focus for describing its physical nature will be on the components within it and how they are connected. • support students to identify examples of socio-technological environments to examine how technological outcomes (products and systems) and non-technological entities and systems (people, natural environments, political systems etc) work together to ensure the environment is successful. Examples should be drawn from past, present and possible future socio-technological environments. Socio-technological environments include such things as communication networks, hospitals, transport systems, waste disposal, recreational parks, factories, power plant etc.
INDICATORS OF ACHIEVEMENT Students can: • explain examples of technological developments that are interdisciplinary in nature to demonstrate how the range of disciplines involved impacted on the technological practice • explain examples of technological developments to demonstrate how collaborative practices of technologists have enhanced and/or inhibited technological developments	**INDICATORS OF ACHIEVEMENT** Students can: • explain that some technological outcomes can be perceived as both a product and a system • describes examples to illustrate how technological outcomes and non-technological entities and systems work together to create socio-technological environments

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL SEVEN

Teachers should establish if students have developed robust level six understandings and are ready to begin working towards level seven achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level seven Indicators of Achievement below.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Students will: Understand the implications of ongoing contestation and competing priorities for complex and innovative decision making in technological development.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that technological outcomes are a resolution of form and function priorities and that malfunction affects how people view and accept outcomes.
TEACHER GUIDANCE To support students to develop understanding of characteristics of technology at level 7, teachers could: • support students to critically analyse examples of technological practice to gain insight into how technologists identify and deal with contestable issues and competing priorities. Examples should allow students access to such things as how changing attitudes, values and ethics, new and/or different knowledge and materials, impact on technologists' decision making • support students to understand technology as a field of on-going contestation and competing priorities that require resolution through complex decision making and balancing of resources against stakeholder needs and desires • guide students to recognise the role of functional and practical reasoning in complex decision making • support students to critically analyse examples of innovative technological developments. Examples should draw from the past and present and allow students to gain insight into how informed creativity, critical evaluation and the pushing of boundaries allows for innovative decision making and resulting in innovative outcomes	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 7, teachers could: • support students to critically analyse the physical and functional nature of technological outcomes to identify what design elements have been prioritised. Support students to discuss why these prioritisation decisions may have been made with respect to the intended purpose of the technological outcome, the context of its use and the time of its development. • support students to analyse examples of technological outcome malfunction to gain insight into how such events can impact on future decision making in technology. Impacts can include such things as the decision to withdraw or modify the technological outcome, or retain the outcome with modified operational parameters. Wider impacts may also result, such as changes to codified knowledge and influences on the development of related technological outcomes
INDICATORS OF ACHIEVEMENT Students can: • explain technology as a field of on-going contestation and competing priorities and explain how this impacts on technological development • describe examples to demonstrate how critical evaluation, informed creativity and boundary pushing impacts on innovative technological practice and/or technological outcomes	**INDICATORS OF ACHIEVEMENT** Students can: • discuss examples of technological outcomes to demonstrate how design elements have been prioritised and why these decisions enabled it to be fit for purpose • describe examples of technological outcome malfunction to demonstrate how malfunction can impact on subsequent technological developments

COMPONENTS OF NATURE OF TECHNOLOGY: INDICATORS OF PROGRESSION — LEVEL EIGHT

Teachers should establish if students have developed robust level seven understandings and are ready to begin working towards level eight achievement objectives for the nature of technology and plan learning experiences to progress these as guided by the level eight Indicators of Achievement below.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Students will: Understand the implications of technology as intervention by design and how interventions have consequences, known and unknown, intended and unintended.	**ACHIEVEMENT OBJECTIVE** Students will: Understand how technological outcomes can be interpreted and justified as fit for purpose in their historical, cultural, social, and geographical locations.
TEACHER GUIDANCE To support students to develop understanding of characteristics of technology at level 8, teachers could: • support students to critically analyse examples of technological developments and their consequences (known and unknown, intended and unintended), to gain insight into the social responsibility technologists have due to the interventionist nature of technology. Examples should allow students to gain insight into how technology has real and long term impacts for the made, natural and social world. Students should be supported to discuss the implications this has for technologists' collective responsibility • support students to understand that technology can challenge people's views of what it is to be 'human'. Contexts for exploration could include contemporary developments in the area of communication technologies, artificial intelligence, human-robotic interfaces, second-life gaming, genetic engineering, nanotechnology etc) • ensure students explore and discuss such things as the ethics of designing for limited technological outcome lifespan, designing to comply with minimal engineering ideals, utilizing and developing sustainable materials, reducing energy consumption and waste, developing and managing socio-technological environments etc.	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 8, teachers could: • support students to critically analyse a range of technological developments to interpret the fitness for purpose, in its broadest sense, of technological outcomes. The interpretation will be based on the physical and functional nature of the outcome, the historical, cultural, social, and geographical location of the final outcome as well as its development, and any information available regarding its performance over time. • ensure students understand that fitness for purpose in its broadest sense refers to the 'fitness' of the outcome itself as well as the practices used to develop the outcome (eg, such things as the sustainability of resources used, ethical nature of testing practices, cultural appropriateness of trialing procedures, determination of lifecycle and ultimate disposal).
INDICATORS OF ACHIEVEMENT Students can: • discuss technology as intervention by design and use examples to demonstrate the impacts and implications of this • describe examples to demonstrate how technology can challenge people's views of what it is to be 'human'	**INDICATORS OF ACHIEVEMENT** Students can: • interpret the fitness for purpose, in its broadest sense, of existing technological outcomes and provide justification of the interpretation

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION — LEVEL ONE

Teachers should establish if students hold any misconceptions or partial understandings that would inhibit students meeting the level one achievement objectives for technological knowledge and plan learning experiences to challenge and/or progress these as guided by the level one Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand that functional models are used to represent reality and test design concepts and that prototypes are used to test technological outcomes.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that technological products are made from materials that have performance properties.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that technological systems have inputs, controlled transformations, and outputs.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 1, teachers could: • guide students to understand that functional models are representations of potential technological outcomes and that they can take many forms (eg, thinking, talking, drawing, physical mock-ups, computer aided simulations etc) • provide students with the opportunity to interact with a variety of functional models and guide them to identify that the common purpose of functional modelling is to test design concepts. Design concepts include design ideas for parts of an outcome as well as a complete conceptual design for the outcome as a whole • guide students to understand that a prototype is the first version of the fully completed technological outcome • provide students with a range of prototyping examples and guide them to identify that the common purpose of prototyping is to test the outcome	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 1, teachers could: • provide students with a range of technological products to explore and guide them to identify the materials they are made from • provide students with the opportunity to explore common materials and guide them to determine what the materials can do and how they can be manipulated • guide students to use knowledge of materials to suggest why a material would be selected for use in a particular product, and how it has been shaped, joined and/or finished to make the product	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 1, teachers could: • provide students with a range of technological systems to explore and guide them to identify system components and how they are connected • Guide students to identify the inputs and outputs of technological systems and recognise that a controlled transformation has occurred
INDICATORS OF ACHIEVEMENT Students can: • describe what a functional model is • identify the purpose of functional modelling • describe what a prototype is • identify the purpose of prototyping	**INDICATORS OF ACHIEVEMENT** Students can: • identify materials that technological products are made from • suggest why the materials used in particular technological products were selected • identify that materials have been shaped, joined and/or finished to make a technological product	**INDICATORS OF ACHIEVEMENT** Students can: • identify the components of a technological system and how they are connected. • identify the input/s and output/s of particular technological systems. • Identify that a system transforms an input to an output

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL TWO

Teachers should establish if students have developed robust level one understandings and are ready to begin working towards level two achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level two Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand that functional models are used to explore, test, and evaluate design concepts for potential outcomes and that prototyping is used to test a technological outcome for fitness of purpose.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that there is a relationship between a material used and its performance properties in a technological product.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that there are relationships between the inputs, controlled transformations, and outputs occurring within simple technological systems.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 2, teachers could: • provide students with the opportunity to interact with a variety of functional models and support them to identify the design concept being tested and if it related to the physical and/or functional nature of the potential outcome. Design concepts include design ideas for parts of an outcome as well as a complete conceptual design for the outcome as a whole • provide students with examples of evaluations from prototyping and support them to identify whether the technological outcome tested was fit for purpose • guide students to reflect on the role of functional modelling and prototyping to develop an understanding of the importance of both in technological development	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 2, teachers could: • provide students with the opportunity to research and experiment with a range of materials and guide them to identify their performance properties. Performance properties of materials refer to such things as conductivity, water resistance, warmth, texture, flexibility etc. • provide students with a variety of technological products and guide them to identify the performance properties particular materials provides for that product.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 2, teachers could: • provide students with a range of simple technological systems to explore and guide them to understand the role of each component and to identify the changes that are occurring in the transformation process. Simple technological systems are defined as systems that have been designed to change inputs to outputs through a single transformation process. • guide students to understand that sometimes transformation processes may be difficult to determine or understand and these can be represented as a 'black box'. That is, a black box is described as a way of depicting a part of a system where the inputs and outputs are known but the transformation process is not known
INDICATORS OF ACHIEVEMENT Students can: • explain that the purpose of functional modelling of design ideas allows for the gathering of specific information about the possible nature of a potential technological outcome • describe examples to illustrate how functional modelling has been used to test design ideas and develop conceptual designs • describe examples to illustrate how prototyping has been used to test technological outcomes • discuss the importance of functional modelling and prototype testing in the development of technological outcomes	**INDICATORS OF ACHIEVEMENT** Students can: • describe the performance properties of particular materials • identify the performance properties of materials used in particular technological products	**INDICATORS OF ACHIEVEMENT** Students can: • describe the change that has occurred to the input to produce the output in simple technological systems • identify the role each component has in allowing the inputs to be transformed into outputs within simple technological systems

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL THREE

Teachers should establish if students have developed robust level two understandings and are ready to begin working towards level three achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level three Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand that different forms of functional modelling are used to inform decision making in the development of technological possibilities and that prototypes can be used to evaluate the fitness of technological outcomes for further development.	**ACHIEVEMENT OBJECTIVE** Students will: Understand the relationship between the materials used and their performance properties in technological products.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that technological systems are represented by symbolic language tools and understand the role played by the “black box” in technological systems.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 3, teachers could: • provide students with the opportunity to explore a range of examples of functional modelling and support students to gain insight into the different types of evidence that can be generated and to explore the impact that the media used can have on the way evidence is generated • support student discussion of how functional modelling informs decision making and guide them to identify the benefits and limitations of functional modelling in examples provided. Benefits include such things as reducing the risk of wasting time, money and materials. Limitations arise due to the representational nature of modelling. That is, what is being tested is necessarily partial and therefore prototyping is required to fully test the outcome • provide students with the opportunity to explore a range of examples of prototyping to gain insight into how appropriate evidence can be gained to evaluate a technological outcome’s fitness for purpose and establish if there is a need for any further development.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 3, teachers could: • provide students with the opportunity to research and experiment with a range of materials and support students to develop understandings of why materials have particular performance properties. These understandings will based on the combination of a material’s structural (conductive, ductile etc) and sensory (colour, texture etc) qualities. • provide students with a variety of technological products and support them to investigate how the materials used in the product combine to allow the product to function as designed. • provide students with a range of technological products with unknown functions and support them to make informed suggestions for possible function.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 3, teachers could: • provide students with the opportunity to investigate a range of technological systems and guide them to understand that technological systems do not require further human design decision making during the transformation process for the inputs to be transformed to outputs. That is, a technological system will produce particular outputs in an automated fashion once the inputs have initiated the transformation process • provide examples of technological systems that contain unknown transformation processes (black boxes) and support students to understand the role these play in terms of the advantages and/or disadvantages for developers and users. • provide students with examples of how technological systems can be represented and guide students to interpret the specialised language and symbol conventions used. • provide students with opportunity to use specialised language and symbol conventions to represent technological systems to others
INDICATORS OF ACHIEVEMENT Students can: • explain that different forms of modelling provide different types of evidence. • discuss examples to illustrate how particular models were developed to gather specific data to inform decision making • identify the benefits and limitations of functional modelling undertaken in particular examples • describe examples to illustrate how prototypes were tested to evaluate a technological outcome’s fitness for purpose and to identify any need for further development	**INDICATORS OF ACHIEVEMENT** Students can: • identify the structural and sensory qualities of particular materials and how these combine to provide the performance properties of the materials • explain how all the materials used in a technological product work together to allow the product to function as designed. • suggest possible functions of a technological product based on an understanding of the materials used in its construction.	**INDICATORS OF ACHIEVEMENT** Students can: • describe what a ‘black box’ is within a technological system • identify possible advantages and disadvantages of having black boxed transformations within particular technological systems • describe technological systems using specialised language and symbol conventions

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL FOUR

Teachers should establish if students have developed robust level three understandings and are ready to begin working towards level four achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level four Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand how different forms of functional modelling are used to explore possibilities and to justify decision making and how prototyping can be used to justify refinement of technological outcomes.	**ACHIEVEMENT OBJECTIVE** Students will: Understand that materials can be formed, manipulated, and/or transformed to enhance the fitness for purpose of a technological product.	**ACHIEVEMENT OBJECTIVE** Students will: Understand how technological systems employ control to allow for the transformation of inputs to outputs.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 4, teachers could: • support student discussion about the importance of using modelling to explore whether an outcome should be developed as well as whether it could be developed • support students to examine examples of extensive and diverse functional modelling practices used to support particular technological developments – both within their own and other's technological practice. • guide students to gain insight into how design decisions are justified with regards to both feasibility and acceptability. Such justifications will rely on the synthesis of evidence gained from diverse forms of modelling seeking multiple perspectives. • support students to identify and examine examples of prototyping from both within their own and other's technological practice. • support students to gain insight from examples of how evidence gained can used to justify an evaluation of a technological outcome's fitness for purpose or its requirement for further development.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 4, teachers could: • provide students with the opportunity to research and experiment with a range of materials and support students to develop understandings of how materials have been formed, manipulated and/or transformed in ways to enhance the fitness for purpose of particular technological products over time. • ensure students understand that 'forming' refers to how materials can be shaped (cut, molded, bent, carved etc) to the 'form' required for use in the product, and manipulating and transforming refers to how materials can be joined and/or 'finished' in ways that change their performance properties.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 4, teachers could: • provide students with the opportunity to investigate a range of technological systems and support them to identify how transformation processes are controlled. • support students to understand that control mechanisms can work to in ways to enhance the fitness for purpose of technological systems by maximising the desired outputs and minimising the undesirable outputs.
INDICATORS OF ACHIEVEMENT Students can: • explain why it is necessary to consider both what 'can' be done and what 'should' be done when making design decisions • explain why different forms of functional modelling are needed to fully explore possibilities and gather different types of data • discuss examples of prototyping to explain how evidence gathered provided justification for evaluating a technological outcome as fit for purpose or in need of refinement	**INDICATORS OF ACHIEVEMENT** Students can: • describe examples to illustrate how a technological product's fitness for purpose was enhanced by the way a material was shaped • describe examples to illustrate how a technological product's fitness for purpose was enhanced by the way a material was joined with other materials • describe examples to illustrate how a technological product's fitness for purpose was enhanced by the way a material was finished	**INDICATORS OF ACHIEVEMENT** Students can: • explain how processes are controlled to enable the inputs to be transformed to outputs • describe examples to illustrate how a technological system's fitness for purpose was enhanced by the use of control mechanisms.

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL FIVE

Teachers should establish if students have developed robust level four understandings and are ready to begin working towards level five achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level five Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand how evidence, reasoning, and decision making in functional modelling contribute to the development of design concepts and how prototyping can be used to justify ongoing refinement of technological outcomes.	**ACHIEVEMENT OBJECTIVE** Students will: Understand how materials are selected, based on desired performance criteria.	**ACHIEVEMENT OBJECTIVE** Students will: Understand the properties of subsystems within technological systems.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 5, teachers could: • ensure students understand that informed and justifiable decision making relies on reasoning and evidence. • support students to examine examples of extensive and diverse functional modelling practices used to support particular technological developments – both within their own and other's technological practice. • support students to gain insight from examples into how design decisions are justified with regards to both feasibility and acceptability. Such justifications will rely on the synthesis of evidence gained from diverse forms of modelling seeking multiple perspectives. • support students to identify and examine examples of prototyping from both within their own and others technological practice. • support students to gain insight from examples into how testing procedures can provide information regarding maintenance requirements of a technological outcome. Maintenance requirements involve addressing environmental influences on, and/or ongoing refinements of, the technological outcome.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 5, teachers could: • support students to examine examples of how materials have been selected to ensure the fitness for purpose of particular technological products – both within their own and other's technological practice. • support students to use examples to gain insight into how selecting an appropriate material relies on understanding the composition of materials. The composition of materials relates to such things as the type and arrangements of particles that make up the material. • ensure students understand that for materials to be selected for use in a technological product, their particular performance properties must align with the desired performance specifications of that product.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 5, teachers could: • provide students with the opportunity to investigate a range of technological systems that contain one or more subsystems both from within their own and other's technological practice. • support students to identify subsystems within technological systems and describe them in terms of their properties. The property of a subsystem refers to the role it provides in the technological system as a whole and can be established by examining what has happened to the input to become the output at the subsystem stage. • support students to understand that interfaces between subsystems have an important role in enabling the technological system to work effectively as a whole.
INDICATORS OF ACHIEVEMENT Students can: • discuss examples to illustrate how evidence and reasoning is used in informed and justifiable decision making during functional modelling. • discuss examples to illustrate how prototyping provides information to determine maintenance requirements to ensure optimal performance over time.	**INDICATORS OF ACHIEVEMENT** Students can: • describe examples to illustrate how the performance specifications of technological products determine the performance properties required of materials that might be suitable for the product's construction • discuss examples to illustrate how decisions about material selection take into account the composition of the material	**INDICATORS OF ACHIEVEMENT** Students can: • identify subsystems within technological systems and explain their properties. • discuss examples to illustrate how interfaces between subsystems support the way the technological system works.

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL SIX

Teachers should establish if students have developed robust level five understandings and are ready to begin working towards level six achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level six Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand the role and nature of evidence and reasoning when managing risk through technological modelling.	**ACHIEVEMENT OBJECTIVE** Students will: Understand how materials are formed, manipulated, and transformed in different ways, depending on their properties, and understand the role of material evaluation in determining suitability for use in product development.	**ACHIEVEMENT OBJECTIVE** Students will: Understand the implications of subsystems for the design, development, and maintenance of technological systems.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 6, teachers could: • guide students to understand the concept of risk as it relates to reducing instances of malfunctioning of technological outcomes, and/or increasing levels of outcome robustness • support students to examine examples of technological modelling to understand how risk is explored and identified within particular technological developments • guide students to understand practical and functional reasoning • guide students to understand how functional and practical reasoning influences technological modelling particularly in terms of identifying the focus for testing and the interpretation of evidence. • guide students to understand how technological modelling is used to manage risk through exploring and identifying possible risk factors associated with the development of a technological outcome • ensure students examine their own technological modelling as well as technological modelling undertaken by a other technologists	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 6, teachers could: • provide students with the opportunity to research and experiment with a range of materials to develop understandings of how their composition impacts on how they can be formed, manipulated and/or transformed. • ensure students understand that materials can be formed, manipulated and/or transformed to enhance the fitness for purpose of a technological product. 'Forming' refers to how materials are shaped (cut, molded, bent etc) to the 'form' required for use in the product. Manipulating and transforming refers to how materials are joined and/or finished in ways that change their performance properties. • support students to examine examples of how materials have been evaluated to ensure the fitness for purpose of particular technological products – both within their own and other's technological practice. • support students to use examples to gain insight into how material evaluation procedures rely on understanding the composition of the materials to be evaluated and the performance criteria of a technological product. • ensure students understand that material evaluation enables decisions to be made about how a material would support, or not, the fitness for purpose of particular technological products, and decrease the probability of a product malfunction.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 6, teachers could: • provide students with the opportunity to investigate a range of technological systems that contain one or more subsystems both from within their own and other's technological practice. • support students to use examples to gain insight into how the use of subsystems can impact on system design, development and maintenance particularly in relation to the development of self-regulatory systems. • support students to understand that subsystems can allow the design of complex technological systems where some subsystems are 'black boxed' for development and or maintenance purposes. This can result in both advantages (reduced need to understand all aspects of the system, ability to replace faulty subsystem without disrupting the entire system) and disadvantages (trouble shooting can be difficult). • support students to understand the role of subsystems for reducing malfunction and/or system componentry damage through such things as 'back up' or 'shutdown' subsystems.
INDICATORS OF ACHIEVEMENT Students can: • explain practical and functional reasoning and how they work together to enhance technological modelling • explain the role of technological modelling in the exploration and identification of possible risk/s • describe examples to illustrate the strengths and weaknesses of technological modelling for risk exploration	**INDICATORS OF ACHIEVEMENT** Students can: explain how the composition of different materials enables them to be shaped in different ways explain how the composition of materials determines the way it can be joined explain how the composition of materials determine the types of 'finishing' techniques suitable for use describe the role of material evaluation in determining material suitability for use in a technological product	**INDICATORS OF ACHIEVEMENT** Students can: • explain the implications of using subsystems, for the design, development and maintenance of technological systems. • describes examples to illustrate how control and/or feedback subsystems allows for the design of self-regulatory technological systems. • describe examples to illustrate the advantages and disadvantages of subsystems employed in particular technological systems.

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL SEVEN

Teachers should establish if students have developed robust level six understandings and are ready to begin working towards level seven achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level seven Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand how the "should" and "could" decisions in technological modelling rely on an understanding of how evidence can change in value across contexts and how different tools are used to ascertain and mitigate risk.	**ACHIEVEMENT OBJECTIVE** Students will: Understand the concepts and processes employed in materials evaluation and the implications of these for design, development, maintenance, and disposal of technological products.	**ACHIEVEMENT OBJECTIVE** Students will: Understand the concepts of redundancy and reliability and their implications for the design, development, and maintenance of technological systems.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 7, teachers could: • support students to understand that different people and communities accept different types of evidence as valid. That is, the status given to evidence is dependent on a range of factors including ethical views and the perceived authority of people involved in the presentation of the evidence • support students to understand how the context impacts on how valid evidence is perceived to be. This means that shifting from one context to another can change the status of the evidence provided by technological modelling. • support students to understand how decisions underpinning technological modelling based on what should and could happen, rely on an understanding of how evidence gained may differ in value across contexts and/or communities. • support students to understand how technological modelling is used to ascertain and mitigate risk. Ascertaining risk involves establishing the probability of identified risks. Mitigation involves taking steps to reduce the probability of the risk being realised and/or severity of the risk should it be realised. • support students to examine examples of technological modelling to understand how risk is ascertained and mitigated within particular technological developments. • ensure students examine their own technological modelling as well as a technological modelling undertaken by a range of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 7, teachers could: • support students to identify and examine examples of how materials have been evaluated to allow material selection decisions that maximize the potential fitness for purpose of particular technological products. • ensure students understand that material evaluation enables decisions to be made about what material would be optimal to ensure the fitness for purpose of particular technological products. • ensure students understand that concepts and processes employed in evaluating a material are related to the composition, the required performance properties of the material and an understanding of the context within which the technological product will be situated • support students to use examples to gain insight into how material evaluation procedures can be used to identify maintenance and disposal implications and inform design and development decisions.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 7, teachers could: • support students to identify and examine a range of technological systems both from within their own and other's technological practice. • support students to understand the concepts of redundancy and reliability. • support students to use examples to gain insight into issues associated with how redundancy and reliability have impacted on system design, development and maintenance.
INDICATORS OF ACHIEVEMENT Students can: • explain why different people accept different types of evidence as valid • discuss examples to illustrate why the status of evidence gained from technological modelling might change across contexts • explain the influences on decision making underpinning technological modelling that ensures both what 'should' and 'could' be done are fully explored and justified • explain the role of technological modelling in ascertaining and mitigating risk • describe examples to illustrate the strengths and weaknesses of technological modelling for risk mitigation	**INDICATORS OF ACHIEVEMENT** Students can: • explain the concepts and processes that underpin the evaluation of a particular material. • describe examples to illustrate how materials have been evaluated to determine their suitability for specific products and the environments in which they are situated.	**INDICATORS OF ACHIEVEMENT** Students can: • explain the concept of redundancy and the implications for the design, development, and maintenance of technological systems. • explain the concept of reliability and the implications for the design, development and maintenance of technological systems.

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION — LEVEL EIGHT

Teachers should establish if students have developed robust level seven understandings and are ready to begin working towards level eight achievement objectives for technological knowledge and plan learning experiences to progress these as guided by the level eight Indicators of Achievement below.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Students will: Understand the role of technological modelling as a key part of technological development, justifying its importance on moral, ethical, sustainable, cultural, political, economic, and historical grounds.	**ACHIEVEMENT OBJECTIVE** Students will: Understand the concepts and processes employed in materials development and evaluation and the implications of these for design, development, maintenance, and disposal of technological products.	**ACHIEVEMENT OBJECTIVE** Students will: Understand operational parameters and their role in the design, development, and maintenance of technological systems.
TEACHER GUIDANCE To support students to develop understanding of technological modelling at level 8, teachers could: • support students to develop a critical and informed understanding of why technological modelling is an important aspect for ensuring responsible and defensible technological development • ensure students examine examples of technological modelling that involve a range of competing and contestable factors to gain insight into how these factors can be handled. These factors arise from such things as differing moral, ethical, cultural, and/or political views and the way in which people adhere to and understand issues such as sustainability, globalisation, democracy, global warming etc. • ensure students examine their own technological modelling as well as a technological modelling undertaken by a range of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 8, teachers could: • support students to identify and examine examples of material innovation including past and contemporary examples. • ensure students understand that material innovation can refer to both the development of a new material, or the use of an existing material in a 'new' way. • support students to use examples to gain insight into how material innovation and evaluation procedures are used to address performance, maintenance and disposal implications and inform design and development decisions. • support students to understand the implications for the evaluation of innovative materials whereby new procedures may need to be developed and codes established. • ensure students understand that material evaluation enables decisions to be made about how a material would support, or not, the fitness for purpose in of particular technological products. • ensure students understand that concepts and processes employed in material innovation and evaluation are related to composition, the required performance properties of the material and an understanding of the context within which the technological product will be situated.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 8, teachers could: • support students to identify and examine a range of technological systems both from within their own and other's technological practice. • support students to understand operational parameters and the role these play in the design, development and maintenance of technological systems. • support students to use examples to gain insight into operational parameters and explore how they influence and impact on system design, development and maintenance. • support students to understand the difference between self-regulatory systems and intelligent systems. Intelligent systems have been designed to adapt to environmental inputs in ways that change the nature of the system components and/or transformation processes in known and unknown ways to produce desirable but unspecified outputs. • provide students with the opportunity to investigate intelligent technological systems and support student to understand how the operational parameters enable these systems to function.
INDICATORS OF ACHIEVEMENT Students can: • explain the critical role of technological modelling in making informed, responsive and defensible design and development decisions within technological developments. • describe examples to illustrate how technological modelling has allowed for justifiable and defensible technological practice that takes account of often competing and contestable factors.	**INDICATORS OF ACHIEVEMENT** Students can: • explain the concepts and processes that underpin an identified material innovation and its evaluation. • describe examples to illustrate how material innovations have been evaluated to determine their suitability for specific products and the environments in which they are situated. • discuss examples of past material innovations and explain how these impacted on subsequent technological development. • discuss examples of contemporary material innovations and suggest probable implications for future technological product development.	**INDICATORS OF ACHIEVEMENT** Students can: • explain the concepts and processes underpinning the operational parameters of particular technological systems • explain how the establishment of operational parameters impact on the design, development and maintenance of technological systems • discuss examples of self-regulatory and/or intelligent systems and explain how operational parameters have been developed to support such systems

TECHNOLOGY PROGRAMME DESIGN

Discussion ideas for future programme development

ABSTRACT

Technology programmes are at the level of school curriculum development and as such provide a school specific framework to work from for all teachers involved in teaching technology. This paper provides some ideas and examples for discussion to support technology programme development during the 2008-2010 transition period as schools move from technology programmes based on technology in *The New Zealand Curriculum* (1995) to those based on technology curriculum in *The New Zealand Curriculum* (2007).

INTRODUCTION

A technology programme should provide opportunity for the incorporation of *The New Zealand Curriculum* (2007) principles, values, and key competencies alongside the opportunities to address the requirements of the technology learning area statement and achievement objectives. The foci for contexts chosen as suitable for the programme should reflect the school's resources. This includes the knowledge and skills of the teachers, physical and consumable resources, and the available community resources. As a compulsory learning area for all students from year 1 to the end of year 10, every school in New Zealand should be developing their own technology programmes. The nature of existing technology programmes being delivered to address the *Technology in the New Zealand Curriculum* (1995) will need to undergo a shift to align with the technology curricullum in *The New Zealand Curriculum* (2007). A transition time is being provided until 2010 to enable schools to develop teacher understanding of *The New Zealand Curriculum* (2007) and bring these into their technology programmes. During this time, it is recommended teachers focus on ensuring their technology programmes support and report on progression of student learning in terms of the three components of Technological Practice. This strand pulls together the three previous strands of *Technology in the New Zealand Curriculum* (1995). Over this transition time teachers are also encouraged to begin to explore the five components within the two new strands (Technological Knowledge and the Nature of Technology) but will not be expected to formally assess or report on student progression of these before 2010.

Section One focuses on programme duration and the role of achievement objectives and assessment to support and report student progression. Section Two focuses on classroom programmes. Section Three provides possible ideas of what programmes might look like as they transition towards supporting a technological literacy based on all three strands of the technology curriculum in *The New Zealand Curriculum* (2007). Further information will be gathered from future classroom research with regards to pedagogical strategies and resources that best support learning within these two additional strands. As this information becomes available further papers will be written to communicate this to all teachers and case study resources will be produced using student data to illustrate different levels of student achievement in terms of the Technological Knowledge and Nature of Technology achievement objectives.

SECTION ONE

PROGRAMME FOCUS AND DURATION

The duration of a technology programme should be determined by wider school structures in order to maximise the opportunity to plan for and monitor student progression. From 2010 this progression will be focused on developing student technological literacy as evidenced by their achievement across all three strands (and therefore eight components) of technology. For 2008 and 2009 however, teachers are encouraged to develop programmes that focus on formally assessing and reporting on students' progression within Technological Practice as evidenced through their achievement in terms of Brief Development, Planning for Practice and Outcome Development and Evaluation.

Contexts should be identified at the school programme level to provide coherent and comprehensive opportunities to meet the purpose of the programme focus. The selection of contexts rests on a balance between providing students with variety and interest, and providing enough richness to sustain progression of learning both within and across components. Teacher interest, teacher and others' expertise and classroom resourcing should also be key factors in context selection to ensure learning experiences are informed and manageable.

Currently it is common for programmes in technology to be planned to cover a one or two-year time period. For example, in primary school a technology programme may be planned separately by syndicates – that is, the junior syndicate may plan to cover years 1 and 2, the middle syndicate to cover years 3 and 4, and the senior syndicate to cover year 5 and 6. Similarly, intermediate schools often plan a programme for their year 7 and 8 students, and junior secondary for their year 9 and 10 students. Senior secondary tend then to plan one-year programmes for year 11, year 12 and year 13. Recent work in technology suggests such planning is not helping students' overall progression in technology as the transition points within and between schools tend to be particularly disruptive to seamless learning in technology.

To address this, it is suggested that schools begin to increase the scope of their programmes to cover more year groups and to link to programmes that provide entry and exit points. For example, primary schools could look to plan a programme of learning that has a duration of six years (or eight in schools that cater for year 1-8). Secondary schools could look to plan their technology programme to cover five years (or seven in schools that cater for year 7-13) with multiple exit points for students from year 10 onwards to reflect the optional nature of technology at years 11, 12 and 13. Intermediate schools will continue to be bound to a two-year programme, however these programmes should be seen to link with programmes from both contributing and destination schools. Those schools who cater for students from years 1-13 could work towards a coherent 13-year programme.

The transition to planning programmes that are more conducive to providing students with a seamless technology education will need to be well supported by the development of shared teacher understandings of technology education, and the development of robust assessment and reporting mechanisms. Some strategies that can support the development of shared understandings include teachers being involved in ongoing discussions about technology generally, joint planning and team teaching, and internal moderation of student work. The development of professional learning communities within and across schools has many benefits including the establishment of common reporting mechanisms for student achievement that are effective and manageable.

An example of a school that has been exploring programme planning of lengthier duration Is available on Techlink at Programme Planning.

ACHIEVEMENT OBJECTIVES AND REPORTING

Achievement objectives in technology have been developed for each component to provide a focus for progression within the programme. They also provide guidance to teachers for the development of a series of coherent learning experiences that could sit within the programme and may be organised into interlinking units of work. Achievement objectives require interpretation by teachers to plan for and deliver multiple-level teaching to address student learning needs within their technology programme. Levelled achievement objectives are not specific learning intentions. Achievement objectives are statements that need to be broken down by teachers into learning intentions to support the planning and delivery of learning experiences, formative assessment and for reporting purposes.

Formative assessment information gained by teachers throughout the learning experiences should provide a picture of student achievement in terms of the achievements objectives. As teachers develop a shared understanding of what student achievement looks like at each level, reporting mechanisms can be effectively developed to ensure this information, along with suggested next steps in learning, is communicated to students, caregivers and subsequent teachers within or across schools. Communicating this level of information is critical to ensure student learning is not disrupted by a change in school and/or teacher.

SECTION TWO

LEARNING INTENTIONS

Programmes of learning may include a varying number and range of contexts within which a series of coherent learning experiences will be developed. These may be organised as units and/or projects, however care should be taken to ensure such organisational structures are clearly interlinked to support the programme as a whole. The time allocated to learning experiences is determined by both the intended learning planned by the teacher, and student learning needs in relation to this learning focus. For example, a series of lessons may be planned whereby students disassemble a product developed locally, visit or are visited by a technologist involved in the product's development, and review their initial analysis in order to develop an understanding of brief development prior to developing their own brief for as part of their own technological practice.

When planning for 2008 and 2009, teachers are encouraged to develop learning experiences focused on one or more of the components from the technological practice strand, as well as any other knowledge and skills identified as 'key' to student learning. The identification of other knowledge and skills will be determined by the specific context selected and the nature of the student's technological practice. While some of these will be common across all students, others may vary between students as dependent on their needs.

Learning intentions can therefore be pre-determined by the teacher prior to the delivery of the learning experiences to ensure students have access to generic knowledge and practice that takes into account students' prior learning. However, during the delivery of learning experiences, opportunity should be left to develop negotiated learning intentions that are responsive to student technological practice, and additional specific contextualised learning needs and/or their interests that arise from the experiences offered.

As learning intentions represent the learning that the teacher has determined to be 'key' within the context, they provide the main focus for teacher interactions within the classroom. However, they do not represent all the learning experiences the context will provide. For example, when students are undertaking technological practice within a specific context they will clearly be increasing their capability and knowledge of all three of the components of technological practice. However, the 'focus' for teacher interaction, and therefore assessment and monitoring of student learning, may be on only one or two of these components. This will increasingly be the case as the five new components from the two additional strands become part of the school technology programme.

PEDAGOGICAL STRATEGIES

All teaching in technology should be based on an understanding of students' current level of achievement and interest and an awareness of what their next learning steps should be. Pedagogical strategies that have been found to be particularly useful in supporting technological practice include:

- Explanation and demonstration of skills and techniques followed by scaffolded opportunities for students to develop these themselves.
- Exploration of and free 'playing' with a wide range of materials.
- Demonstration of equipment use, followed by multiple opportunities for students to use the equipment safely for a range of appropriate purposes.
- Investigation of multiple perspectives underlying own and others' decision making.
- Research into current understandings of how things work.
- Analysis of past and contemporary technological developments.
- Technological product and system analysis.
- Open debate of personal ideas and contentious issues.
- Questioning (from teacher, peer and self) to encourage justification for decisions made.
- Introducing and revisiting concepts, skills and practices across a range of contexts to aid students develop more generic understandings.
- Explicit discussion of similarities and differences across contexts.

Learning environments which provide students with authentic tasks and the opportunity to interact with a range of people (for example, team teaching situations, outside 'experts', clients) have also been shown to increase motivation and raise the standard of the outcomes produced.

SECTION THREE

EXAMPLES OF PROGRAMME CHANGE

The following examples illustrate possible ideas for a year 3/4 and 9/10 programme. Figures 1a and 2a reflect how programmes may currently look as based on technological practice alone. Figures 1b and 2b reflect how these may change over the next two years of transition time. Figures 1c and 2c reflect possible future programmes once all three strands of the technology curriculum in *The New Zealand Curriculum* (2007) become features of the technology programme. These examples represent the shift to include the additional five components from the nature of technology and technological knowledge. As indicated earlier, teachers would also be encouraged to extend the programme duration to include year groups before and/or after as part of a more coherent programme that supports seamless learning in technology.

In these examples, the component-related learning intentions sit on the brown horizontal line. These represent the generic knowledge and practices inherent in the achievement objectives for technology that need to be progressed for all students as they develop their technological practice initially (as shown in Figures 1a, 1b, 2a and 2b), and later, their technological literacy (as shown in Figures 1c and 2c). In an attempt to keep the diagrams simple, Figures 1c and 2c show each of the components only once ('on the line'). However, it is expected these would be revisited in a range of contexts to support the progression of understandings and capabilities.

Those aspects that appear 'off the line' represent context specific knowledge and skills that might be identified as essential for students to know and/or be able to do in order to fully engage in the context. For the transition period the additional components are also shown 'off the line' to show they may be explored during this time but need not be focused on for progression and reporting purposes.

The context-specific knowledge and skills show a mix of technological knowledge and skills, as well as additional knowledge and skill that may come from other disciplines such as science, social science, mathematics. These will range in number according to the time available for each context and will be determined by the decisions teachers make about what they consider to be 'key' and the resources they have available. Therefore the examples provided are indicative suggestions only.

Figure 1: Example of a Year 3-4 Programme

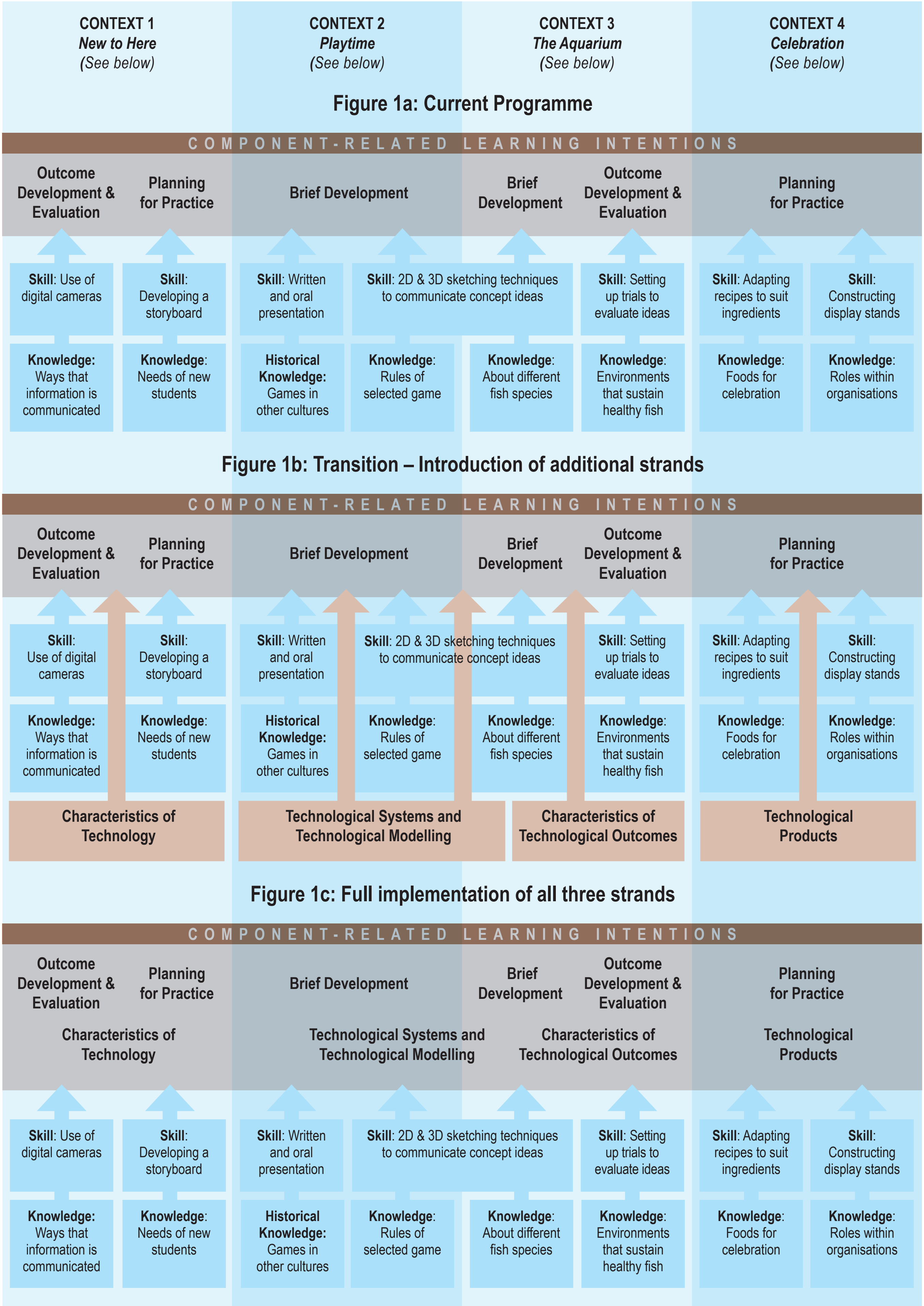
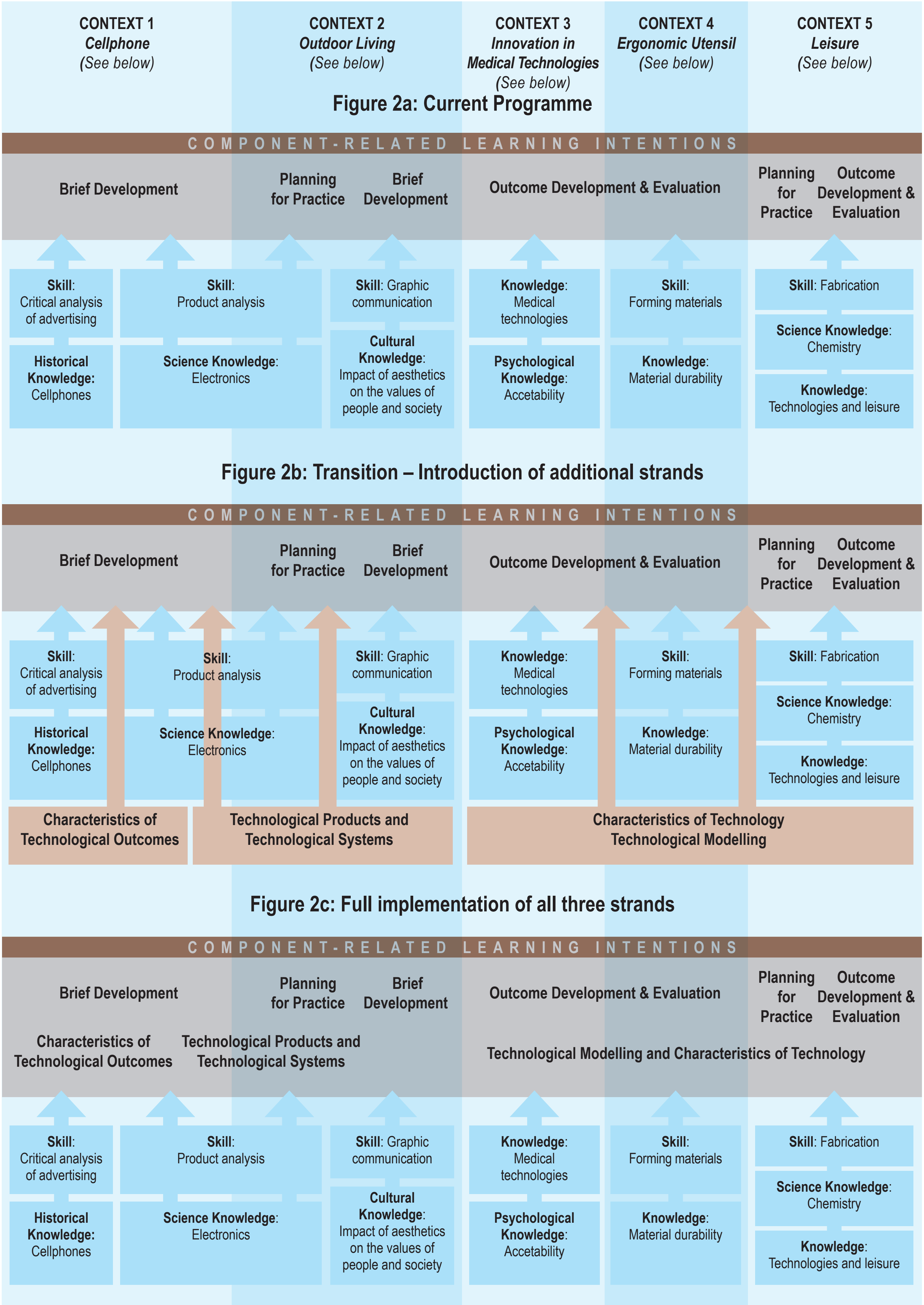


Figure 2: Example of a Year 9-10 Programme



CONTEXTS FOR FIGURES 1 AND 2

Taken from Discussion Document: Design Ideas for Future Technology Programmes by Compton and Harwood, available at www.tki.org.nz/r/nzcurriculum/draft-curriculum/technology_e.php

Figure 1: Example of Ideas for a Possible Year 3-4 Programme

The first context, New to Here, provides opportunity for teachers to focus on two components as students undertake technological practice to develop an intranet page for students new to the school. The focus on outcome development and evaluation allows learning experiences to centre on students finding out what people new to their school need to know, and developing content (suggestions/pictures/maps) that can be put up in a user-friendly way for students with a range of reading abilities and English literacy capabilities. Exploring the use of multimedia as a means of effectively communicating to others also allows students to gain an understanding of how technology both reflects and changes society, as part of the characteristics of technology component.

The second context, Playtime, also relates to characteristics of technology by looking specifically at games – and how and why different games have developed in different cultures. The other component focused on in the second context is brief development. The inclusion of this component ensures students explore a range of ideas for an area outside their building, which has in the past been used for different ball games but is currently under-utilised. By accessing the views of the students in the middle school (for whom the area is designated), the students are able to develop an outline of the attributes any solution would need to have, taking into account resources available (including money and time), and issues such as safety and pedestrian flow. The outcome of this technological practice may not necessarily result in the completion of the area given time and money constraints. However, it should allow for future completion through an oral and written presentation of a collective brief to the Parent Teacher Association (PTA) as based on the students experimenting with materials and trialing of ideas. This may include the use of a range of modelling techniques, for example, scale 3D models, computer simulations, perspective landscape drawings etc.

The third context picks up on a newly acquired aquarium for the classroom, and includes a focus on three components. The students focus on technological systems as they explore the relationship between the inputs, transformation, and outputs of the water filtration system needed to keep their fish healthy. As part of this context the students will develop science understandings in order to identify fish that can co-habit and that will survive best in a simple cold water aquarium. The students are encouraged to explore the characteristics of technological outcomes in general, and select appropriate ‘toys’ for the selected fish as based on an understanding of their material and functional nature. A focus on technological modelling is also included whereby students explore functional modelling to evaluate the potential impact of adding different ‘toys’ and other non-technological additions (rocks/plants) to the aquarium before physically adding them – thereby addressing ethical concerns with regards to care of their fish. Once satisfied that their selected toys for the aquarium will not impact on the health of the fish, the students explore how the selected products can be trialed in the aquarium to see how the fish interact with them as part of their overall environment, and how they serve to enhance the aesthetic value of the aquarium. From this basis, the students can then set up their new aquarium in the classroom from an informed basis and make plans to ensure it is maintained as a suitable environment for their fish.

The final context, Celebration, recognises the importance of valuing achievement and provides opportunity for students to plan an afternoon to share their achievements over the year with parents. A focus on planning for practice provides opportunity for the students to plan the event efficiently, allocating roles to themselves and helpers as appropriate. The event also provides opportunity for students to work to a set deadline. A key part of the celebration will be the inclusion of a display of work and an afternoon tea. Gaining an understanding of this context’s second component, technological products (in terms of both food products and display stands), will aid the students in ensuring their planning identifies appropriate resources to make the afternoon a safe, enjoyable, and successful occasion.

Figure 2: Example of Ideas for a Possible Year 9-10 Programme

The first context, the Cell phone, provides opportunity for teachers to focus on three components. The characteristics of technological outcomes focus allows students to explore the concept of malfunction and develop their understanding that technological outcomes are 'fit for purpose' in terms of time and context. The context provides opportunity for students to gain technological knowledge about the component technological products, specifically about how technological products can be recognised by the relationship between their material and functional properties. The context also allows for an exploration of technological systems – both those internal to the cell phone as a product, and the wider communicative technological system of which the cell phone is a system 'component'. The rapidly changing nature of the cell phone makes this a rich context for such learning, as does the marketing aspects (for example, when do 'opportunities' become perceived as 'needs'), which are also explored as part of developing skills of critical analysis of advertising. All these understandings will provide a good basis for the students as they undertake their own technological practice within the next learning context.

The second context, Outdoor Living, includes a focus on two components. Focusing on brief development provides students with an opportunity to design and develop conceptual ideas for outdoor lighting to address a specific stakeholder need. To ensure that students possess knowledge that will enable them to effectively address this need and develop appropriate specifications, the component of technological systems is revisited, with a specific emphasis on the science knowledge underpinning lighting systems. The context also allows for negotiated learning experiences that centre on students' development and awareness of how the culture of a community both influences and validates what is aesthetically and functionally acceptable.

In order to enable students to communicate and test their conceptual ideas for lighting, a learning experience that focuses on skills in graphic communication has also been identified as essential for this group of students. This will enable them to gain effective feedback from stakeholders to further develop their brief, and undertake the subsequent development work to create an appropriate outdoor living environment for their stakeholder.

The third context, Innovation in Medical Technologies, allows teachers to focus learning on the component characteristics of technology. Such learning experiences enable students to develop an understanding of how technological developments enable human possibilities to be expanded, and why technology must draw knowledge from a wide range of disciplines. Psychological knowledge of people's views of risk and its link to acceptability is identified as a 'key' knowledge to assist students to work in this context, along with the need for students to develop skills in identifying all stakeholders (direct and indirect, current and future) associated with innovations. Students will draw from these understandings in order to generate their own designs for new or modified utensils, as they develop these for trialing in context four.

Context four, Ergonomic Utensils, provides opportunity for students to gain an understanding of technological modelling as they undertake technological practice to develop an ergonomic utensil for an identified purpose. Learning experiences supporting this component focus on developing student knowledge about how functional modelling contributes to the development of design concepts, through enabling evidence to be gathered to inform decision making specifically around feasibility. Exploring a wide range of similar products will provide key experiences for students, with prototyping being focused on in this exploration. This will allow students to explore the success or otherwise of pre-realisation predictions that were formed as a result of earlier functional modelling, and to analyse if prototype modelling of the utensils resulted in the need for subsequent changes. This will in turn inform their own trialing of prototype utensils when evaluating their utensils ergonomic features. A focus on the skills of forming materials will provide students with the opportunity to extend their knowledge of how materials can be shaped and allow them to develop a range of techniques for shaping different materials. Knowledge of material durability as linked to repetitive use and environmental factors is also identified as a focus key within this context. Both this knowledge, and the previous skills focus, will allow students to make informed selections of materials and techniques in the development of their own utensil.

The final context, Leisure, contains two components – planning for practice and outcome development and evaluation. The inclusion of these two components provides teachers with the opportunity to focus learning experiences on ensuring students develop an outcome that addresses an identified need or opportunity to do with a leisure activity. Learning experiences for the planning for practice component focus on students analysing their own and others' planning practices so that they are informed in the selection and use of planning tools. This will support them to justify the technological practice they undertake to address the need/opportunity, and demonstrate they can use planning tools to make decisions about resources needed – for example, materials, equipment, tools, time and money. Outcome development and evaluation will provide a focus on ensuring that students develop an ability to justify the nature of their intended outcome based on relevant codes of practice and from their own exploration of materials.

To ensure that students have a broad basis from which to effectively address the identified need or opportunity, a focus on developing historical understandings of technologies associated with leisure, the impact of 'new' innovations (for example, smart materials), and the chemistry of materials is included. Learning experiences focused on skills of fabrication are also provided to ensure capability issues are addressed.

TECHNOLOGY AND VALUES

Initial discussion of the relationship

ABSTRACT

Values education is a clear focus of *The New Zealand Curriculum* (2007). The values section of the curriculum provides a direction for learning for all schools, to embed values in their school curriculum. This paper summarises key points from the values section of the curriculum and discusses how values education links with technology education. Examples are provided to illustrate these links.

VALUES EDUCATION IN NEW ZEALAND

Values are described in The New Zealand Curriculum (2007) as ‘deeply held beliefs about what is important or desirable. They are expressed in the ways that people think and act’.

The curriculum suggests that all schools should encourage students to value:

- excellence
- innovation, enquiry and curiosity
- diversity
- equity
- community and participation for the common good
- ecological sustainability including care for the environment
- integrity
- respect for themselves, others and human rights

Teachers are encouraged to develop learning experiences that provide students with opportunities to learn about values and develop value-related capabilities.

Learning about values refers to students learning about:

- their own and others values
- different kinds of values such as moral, social, cultural, aesthetic and economic values
- those values upon which New Zealand’s cultural and institutional traditions are based.

Developing value-related capabilities refers to students developing the ability to:

- express their own values
- explore the values of others
- critically analyse values and actions based on them
- discuss disagreements that arise from differences in values, and negotiate solutions
- make ethical decisions and act on them

THE RELATIONSHIP BETWEEN TECHNOLOGY AND VALUES EDUCATION

Technology, as an essential learning area, has a responsibility to work with all other learning areas, to ensure the intent of the values education section of the national curriculum is mediated into the classroom curriculum.

Technological literacy is at the heart of technology education and is both values laden and values dependent. This means that technological learning experiences can provide a natural and authentic site to embed values education, as the two are mutually enhancing. Examples of how values education intentions can be embedded within technology learning experiences are provided below. These are linked to each of the components of the technology strands.

THE COMPONENTS WITHIN THE TECHNOLOGICAL PRACTICE STRAND

Brief Development

This component allows students opportunity to understand the values of others, as they identify an authentic need or opportunity based on a comprehensive exploration and critical analysis of a context, associated issues, and a wide range of stakeholders' desires.

In defining specifications, students will be required to understand a range of different values in order to ensure that fitness for purpose is established in its broadest sense. Stakeholder values from the wider community will therefore need to be analysed and compared, and any areas of contestation identified and resolved. Through such analysis, the brief can be developed in a way that is acceptable to all key stakeholders and for those who may be impacted on, indirectly or in the future.

Having the opportunity to work with students who were wheelchair bound allowed a student to develop empathy for others as she came to appreciate specific challenges they face. Valuing the perspectives and values, alongside the physical requirements of her client group, was essential in developing a brief that guided the development of an outcome that was empowering for the client group and not merely functional.

Planning for Practice

This component necessitates that students have a strong focus on caring for the environment as they develop capability to manage resources efficiently, and make ethical decisions around sustainable development. Ongoing reflection and evaluation of past practice is critical to this component, ensuring the exploration of their own and others' values, and developing an understanding of how these values impact on decision-making. In order to work most effectively, ethically, and responsively, specific planning mechanisms need to be recognised as of value throughout the developmental work.

When planning how to upgrade school toilets, students spent a lot of time exploring why their current toilets were not valued by the users, and in turn how misuse of them impacted on others' views. A key aspect of developing a successful plan was that of incorporating a focus on educating the users on the impact of their actions, on others and the environment.

Outcome Development and Evaluation

This component allows for a strong focus on students achieving excellence and showing perseverance in producing an outcome of worth. Not all technological practice results in technological outcomes. This component therefore allows for a range of creative and innovative ideas to be taken to various stages appropriate to the context. Such a focus allows student to arrive at a 'no go', decision when there is no defensible reason to use resources for a particular purpose.

Decisions underpinning the selection of particular outcomes for further development rely on extensive reflective and critical analysis of what is of value and why. This helps students to develop their capability in ethical decision making and acting, in accordance with these decisions. Exploration of materials in terms of functional and aesthetic value against environmental cost should be undertaken as extensively as possible, in order to interrogate designs and resourcing prior to the selection of materials and the development of any final outcome.

Outcomes, and the practice undertaken to develop them, should be critically reflected on and evaluated from a range of perspectives to ensure fitness for purpose. This in turn provides opportunities for students to explore stakeholder responses to outcomes, and to understand these in terms of the values that are embedded in them. Justification of decisions made will provide opportunity for students to clearly identify and articulate their own values and explain how these are reflected, or not, in other social groups.

The development of souvenirs for the Te Papa store provides a range of examples of how the students had to explore and understand a range of issues associated with values, in order to develop prototypes of souvenirs appropriate for their clients. Not only did they need to understand what was of value for New Zealanders, they also needed to understand the values of potential customers across a range of ages and cultures. Issues associated with economic worth and profit margins were also critical in the discernment and development of high quality but affordable souvenirs.

THE COMPONENTS WITHIN THE NATURE OF TECHNOLOGY STRAND

Characteristics of Technology

This component demands that students explore a range of different types of values. Analysing the history of technological development provides insight into the way that different values, as held by individuals as well as those that have been institutionalised, have influenced past technological decision making, and how these in turn impact on the values of others.

The growth of Living Nature, as a commercial entity in New Zealand, and the influences on the specific products developed by this company, can be analysed in this way. It provides clear examples of how technological decision making brings together personal values and serves to reflect, and possibly change, the values held by others with respect to personal care and care for the environment.

This component also provides opportunities for informed debate of contentious issues concerned with technology, and the complex moral and ethical aspects involved in taking a particular position. The influences behind past technological developments can be explored and analysed to develop understandings of issues of diversity, equity, and respect for others.

Looking at examples from the past, where such issues have been ignored as well as when they have been addressed, allows students to more clearly identify the importance of these issues in contemporary society. Clashes between indigenous people and colonising forces provide a number of examples of past and contemporary contentious issues. One of these is the devaluing of indigenous knowledge and customs, particularly in regards to imposed technologies.

Exploring technological developments in the area of medicine allows students to explore how people's different religious, cultural and environmental values interact in complex ways, resulting in negative outcomes for some groups. It also allows for an exploration of how benefits can be derived for all if a more consultative and informed approach is taken, whereby alternative views and values are afforded respect.

The Gift of Rongoa (Learning Media Applications edition published in 2005) provides a good starting point for such discussions.

Characteristics of Technological Outcomes

This component provides opportunity to examine the fitness for purpose of technological outcomes in the past, and to make informed predictions about future technological directions, based on social and personal values, and potential technological advancements.

Interpreting technological outcomes relies on an ability to identify the purpose for the outcome, and the values that underpinned its development and continued presence. Examining a range of historical, contemporary and potential future technological outcomes provides opportunities for students to interrogate notions of what is valued as being fit for purpose across people, time and place. It also allows for a critical review of the fitness of any purpose, and how this may change as the values of both designers and users evolve over time and place.

The History Makers (Learning Media Applications edition published in 2007) discusses examples of the way things are valued differently across time, and how different social and cultural values can influence what is seen as appropriate in contemporary situations.

THE COMPONENTS WITHIN THE TECHNOLOGICAL KNOWLEDGE STRAND

Technological Modelling

This component provides opportunity to recognise and value both functional and practical reasoning. Understanding the role of all types of values, in determining whether any development should progress, is critical. A decision may be made to terminate a development in the short or long term, to continue as planned, or to change/refine a design concept or technological outcome. This can be analysed against the values of different people, groups and institutions, and the value of the arguments put forward as to the ethical nature of the actions taken.

In the context of designing and developing high quality models of a cell phone to communicate their design ideas, students were faced with a range of ethical issues associated with working with a client and designing for a fickle teenage market. Environmental impacts of material selection, use and disposal were all important values issues associated with this work, as were cost effectiveness when designing a commercially viable product.

Technological Products

This component allows for an in-depth exploration of the materials used in a particular product and their perceived value to the designer and user. Appropriate material development and use can be analysed with regards to the values of stakeholders. The opportunity to analyse material use and development in terms of product life cycles allows for students to explore values associated with sustainability, and the way caring for the environment is considered a worthy value, or not, by different stakeholders.

In the context of developing new materials for use in a 'Kiwi Made' unit, environmental, social and ethical issues naturally arose as the unit progressed. Students were able to explore the fitness for purpose of past materials, in terms of values associated with care of the environment and animals and those associated with wearing animal based materials. They also considered the values inherent in the concept of 'being in fashion' generally, and were required to identify what New Zealanders value, and how and why this has changed from the past, and may change in the future.

Technological Systems

This component provides opportunity for students to explore how system development can be deemed appropriate and how acceptable it is to integrate technological systems with other systems – for example, robotic technologies integrated into human physiological systems.

Understanding the values associated with a wide range of stakeholders, and how they prioritise their own and others' needs when taking positions on such issues, allows students to explore their own reactions in a more informed manner.

Redundancy and reliability within technological system design and performance can be critiqued, in terms of how they are perceived by people and evaluated in terms of risk acceptability.

Exploring the use of black boxes, when working with technological systems, provides opportunity for students to understand the advantages and disadvantages of black boxing system components. For example, understanding the possible advantages of using a black box approach to gain a holistic understanding of a complex system, versus the possible disadvantages for the end-user should the system malfunction.

Understanding how the components of a technological system work together was imperative when modifying a grabbing tool for a disabled client. Exploring the specific needs of the client allowed the student to prioritise the factors that were of most value to the client, and thereby ensure the final outcome was valued by the client as a 'third arm' rather than a frustrating tool.

TECHNOLOGY AND KEY COMPETENCIES

Initial discussion of the relationship

ABSTRACT

The key competencies are a clear focus of *The New Zealand Curriculum* (2007). They provide an overarching series of competencies for all schools to embed in their school curriculum. This paper presents the key competencies and discusses how they link with technology education in a mutually enhancing manner.

KEY COMPETENCIES IN NEW ZEALAND

The key competencies are described in *The New Zealand Curriculum* (2007) as 'the capabilities people need in order to live, learn, work and contribute as active members of their communities'.

The curriculum identifies five key competencies. These are:

- thinking
- using language, symbols, and texts
- managing self
- relating to others
- participating and contributing

THE RELATIONSHIP BETWEEN TECHNOLOGY AND THE KEY COMPETENCIES

Technology, as an essential learning area, has a responsibility to work with all other learning areas, to ensure the key competencies are mediated into the classroom curriculum. The capabilities captured in the identified five competencies are all essential underpinning capabilities for the development of a technological literacy that is broad, deep and critical, in nature, and one that will result in increasing student empowerment for future citizenship.

Key competencies cannot be developed or evidenced outside of a context. Technology provides a range of diverse contexts, where students can develop their capability with regards to these five foci as well as use these capabilities to support their learning in technology. In this way, technology-specific learning intentions and the competencies become integrated within the learning environment.

All aspects of technology education would support and be supported by an increase in sophistication across the key competencies. Examples of how the key competencies are embedded within technology learning experiences are discussed below.

Thinking

Critical and creative thinking are essential in technology education, as is the development of a high level of awareness of the nature of thinking underpinning any decisions. Being able to step back from a situation and answer questions such as 'what is happening?', 'why is it happening?', 'should it be happening?' and 'how could it be done differently?' rely on sophisticated thinking skills.

These thinking skills are required across all three strands of technology education. Such thinking is essential for making informed decisions that are based on ethical, as well as functional grounds, allowing for an understanding of fitness *for* purpose, as well as explorations of the fitness *of* any stated purpose.

For example, opportunities for the enhancement of such thinking are clearly identifiable when:

- undertaking technological practice within innovative problem solving situations
- understanding the nature of technology through exploring examples of existing technological outcomes or developments, debating contentious issues, or projecting into alternative scenarios
- developing key technological knowledge that is then used to evaluate within technological modelling, or to explain how and why products and/or systems work

Using Language, Symbols, and Texts

The specialised language of technology provides significant opportunities for enhancing students' competency in using language, symbols and texts. This will be reinforced through informed technological practice where critical evaluation, as part of ongoing experimentation, analysis, testing and final evaluative judgement, requires students to understand specialised language, symbols and texts. They will also need to use such language to explain and justify their thinking across a diverse range of contexts.

Because technology draws knowledge and skills from across a range of learning areas, and additional disciplines, it allows students to appreciate how and why language, symbols, and texts differ across disciplines and contexts, and why what is thought of as accepted knowledge and skills, also differs across disciplines and contexts. Understanding these differences supports students in their ability to interpret and use language, symbols and texts in appropriate and informed ways in their own lives.

Managing Self

When undertaking their own technological practice, whether individually or as part of a group, students are required to develop *self management* skills in order to effectively plan ahead and manage resources efficiently. The ability to understand and undertake technological practice that takes account of wider social and physical environmental factors allows students to develop a strong sense of self, and recognise how they can manage themselves within and across a range of life situations inside and outside of formal education communities.

Relating to Others and Participating and Contributing

Technology programmes provide opportunities to develop ongoing and mutually beneficial community relationships critical for developing student competency in *relating to others* and *participating and contributing*. Because of the inclusion of a range of knowledge and skill bases in technology, both technological and those from other disciplines, it is common practice in technology education to draw expertise from the community and/or industry. Inviting people in as valued experts provides a meaningful opportunity for the development of relationships with a range of people from local and extended communities. Students also often work alongside service organisations, local businesses and other community groups to meet an identified school or community need. This type of working relationship allows all parties the opportunity to develop a better understanding of the ethics, beliefs and understandings of respective groups and individuals, and thus enhance future interactions.

All technological practice and resulting outcomes are situated in specific social and physical environments, resulting in both opportunities and constraints. Conflicts and the need for collaboration are common factors that students in technology have to deal with. In turn, students become empowered to operate across a wide range of social groups. This is key to increasingly sophisticated technological practice, and the development of a broad and critical understandings of technology's role in contemporary society.