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.

This document and the Curriculum Support pages on the Techlink website was fully updated in April 2009 and subsequently in April and October 2010.

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INTRODUCTION

The Ministry of Education developed the Technology Curriculum Support package in 2007 to support schools and teachers with the implementation of the technology curriculum in *The New Zealand Curriculum*. The papers included in the package were developed to explain and exemplify the underpinning ideas within the technology curriculum in *The New Zealand Curriculum* and reflected a significant body of research and classroom practice.

The Technology Curriculum Support package has had additional material added from 2008 and some earlier material was reviewed in April 2009. This is now the third version of the package and it has been updated to incorporate the Technological Knowledge and Nature of Technology: Implications for teaching and learning (TKNoT: Imps) research findings related to the Indicators of Progressions for Technological Knowledge and the Nature of Technology.

As of April 2010, the Indicators of Progressions for all three strands are now ready for use by teachers to support programme planning, formative and summative assessment, and reporting. They have also been used to inform the development of the newly aligned NCEA Technology Achievement Standards.

The Ministry of Education would like to thank all those involved in the work of developing, revising and adding to 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 welcomes feedback on the usefulness of this package and/or on additional material schools and teachers would find useful. Please email any feedback to **geoff.keith@minedu.govt.nz**

Ministry of Education

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 area for student learning in 1995. It 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 increased as our population has become more diverse, technologies have become more sophisticated, demands of the workplace have become more complex, and New Zealand needs to become more innovative to enable social and 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 fundamental 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* 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* 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.'

Ministry of Education

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* and provides overall guidance for teaching and learning, including some specific guidelines for schools to consider when implementing the technology curriculum in *The New Zealand Curriculum* from 2010.

It also provides specific guidance and suggestions for schools offering programmes for students in years 1-6, years 7-8, years 9-10, and for senior secondary courses.

OVERALL GUIDANCE

Technology is one of the eight learning areas included in *The New Zealand Curriculum.* 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. In line with *The New Zealand Curriculum*, this paper provides advice and guidance for the development of learning programmes for years 11 – 13.

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.* 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*.

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 included in the canon of subjects for university entrance. Senior secondary courses should where possible, provide appropriate and targeted pathways into the tertiary sector for all students with the potential to further their technology education; as well as providing foundational technological literacy for those moving directly into employment.

A new suite of Technology Achievement Standards has recently been developed to align with *The New Zealand Curriculum*. These standards include a mix of generic technology focussed assessment tools, and those developed for specialist knowledge and skills. Technology Teaching and Learning Guides will provide additional guidance for teacher regarding the development and implementation of technology programmes in the senior secondary school curriculum.

Quality teaching and learning in technology classroom curriculum should also seek to be in keeping with *The New Zealand Curriculum* 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 supported, 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). Technology Indicators of Progression for all three strands are available to help teachers with these aspects of assessment and reporting. These Indicators of Progression have been developed from classroom based research and provide *Teacher Guidance* and student *Indicators* for each technology achievement objective in *The New Zealand Curriculum.*

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* 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* work together to provide opportunity for student's to enhance their technological literacy which is the overall aim 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). Schools are now expected to develop coherent learning programmes in technology across a broad range of contexts. These should draw from and consider a variety of fields associated with communities of technological practice.

In the senior secondary area, schools may wish to develop courses that begin to differentiate technology to allow for greater specialisation. The generic technology achievement objectives at levels 6, 7 and 8 of *The New Zealand Curriculum,* alongside the Body of Knowledge developed to support specialist knowledge and skills, provide guidance for the development of more specialised courses. Such technology courses should focus on a mix of generic technology achievement objectives, and learning objectives from within or across specialist categories, to offer learning experiences that best meet the needs of students and optimise individual schools' teaching expertise and resources.

To further increase student engagement and gain access to mentoring support networks, schools may also 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 The Technology Curriculum Support package is 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.* Until 2010, additional resource material available on Technlink to support teachers in developing programmes and pedagogical strategies has been largely focussed on the Technological Practice strand. From 2010 additional resources are being progressively added to the Techlink website to support teachers with the Technological Knowledge and Nature of Technology strands.

RECOMMENDATIONS FOR ALL TEACHERS

When developing implementation plans for technology it is recommended that you consider the following:

- All three strands of technology should be incorporated into comprehensive school technology programmes
- Technology programmes should provide a coherent structure across time. It is expected that within a learning programme individual units of work would be developed to ensure there is adequate opportunity for students to progress their learning across all eight achievement objectives over time and therefore provide students with a comprehensive education in technology
- Teaching and learning experiences should be planned to ensure contexts for learning provide robust multilevel learning opportunities related to the selected achievement objective/s. No single teaching unit is expected to focus on all eight achievement objectives
- The *Teacher Guidance* within the Indicators of Progression for each achievement objective should be used to support the planning and implementation of learning experiences
- The student *Indicators* within the Indicators of Progression for each achievement objective should be used to support diagnostic, formative and summative assessment to support student progression
- Assessing and reporting student achievement should be focussed on the achievement objectives and as

students move from one programme of technology to another, all achievement objectives should be reported on.

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 an understanding of technology education and what progression in technology learning looks like.

Working from the technology curriculum in *The New Zealand Curriculum,* student achievement can be enhanced by effective pedagogical strategies (including formative assessment strategies) and these should be guided by the achievement objectives and their associated teacher guidance and indicators. Data providing evidence of individual student achievement can be recorded and provided to subsequent teachers to ensure 'next step learning' is effectively communicated across different learning sites. This will help remove barriers that often exist at transition points and support seamless technology education. This in turn provides opportunity for all students to develop a fundamental level of technological literacy through their compulsory schooling that will help them participate fully in a technological society. This technological literacy will also support students to continue in senior secondary courses, progressing their understandings of and in technology, and improving their performance in NCEA technology achievement standards.

Years 1- 6 It is recommended that teachers consider:

- Ensuring links are made to entry and destination programmes and develop reporting mechanisms to communicate progress data that supports seamless learning for students
- Planning programmes with the aim of ensuring all students are working at a minimum of level 3 of *The New Zealand Curriculum by the end of year 6*
- Drawing from their existing pedagogical strengths to ensure they provide technology learning experiences that focus on progressing student learning in technology; and seek to increase their pedagogical content knowledge in technology
- Developing their own knowledge and skills related to all eight achievement objectives of the technology curriculum in ways that can support a broad range of contexts
- Working with their local community to access available resources and expertise
- Plan technology learning experiences that provide authentic contexts which allow for the development of key competencies and for supporting values education
- Planning technology learning experiences that enhance student general literacy and numeracy
- Planning to use technology contexts that encourage links to be made with other learning areas.

Years 7- 8 It is recommended that teachers consider:

- Ensuring links are made to entry and destination programmes and develop reporting mechanisms to communicate progress data that supports seamless learning for students
- Planning programmes with the aim of ensuring all students are working at a minimum of level 4 of *The New Zealand Curriculum by the end of year 8*
- Drawing from and expand their existing knowledge and skills to ensure provision of quality learning experiences for students in keeping with all eight achievement objectives and allow for a broad range of contexts
- Developing their pedagogical strategies to ensure effective use is made of specialist equipment, resources and facilities in ways that support progression based learning for students in technology
- Plan technology learning experiences that provide authentic contexts which allow for the development of key competencies and for supporting values education
- Planning technology learning experiences that enhance student general literacy and numeracy
- Increasing links between specialist technology and generalist classroom teachers to enhance programme planning and encourage links to other learning areas
- Making clear links for their students to technology related careers.

Years 9- 10: It is recommended that teachers consider:

- Ensuring links are made to entry and destination programmes and develop reporting mechanisms to communicate progress data that supports seamless learning for students
- Planning programmes with the aim of ensuring all students are working at a minimum of level 5 of *The New Zealand Curriculum by the end of year 10*
- Drawing from and expanding their existing knowledge and skills to ensure they provide quality learning experiences for students that are in keeping with all eight achievement objectives and allowing for a broad range of contexts
- Developing their pedagogical strategies to ensure effective use is made of specialist equipment, resources and facilities to support progression based learning for students in technology
- Working alongside other technology teachers within department or faculty to ensure coherency between learning experiences and coverage of a broad range of contexts as part of year 9 and 10 compulsory technology programmes
- Planning technology learning experiences that provide authentic contexts which allow for the development of key competencies and for supporting values education
- Planning technology learning experiences to enhance student general literacy and numeracy
- Making clear links for students to technology related careers, and support students in their future learning and/or career pathway planning.

Senior Secondary Courses: It is recommended that teachers consider:

- Planning initial courses in technology that are flexible enough to meet student interest across a range of technologies, develop student capability, and allow students a broad base for a range of choices in the future
- Providing students with the opportunity to progress to Level 6 of *The New Zealand Curriculum and gain Level 1 technology achievement standards*
- *Recognising some students may benefit from initial technology courses running over two years in order to progress to curriculum Level 6 and gain NCEA Level 1 technology achievement standards.*
- Providing students in subsequent courses with the opportunity to progress to Level 7 and/or 8 of *The New Zealand Curriculum and gain NCEA Level 2 and/or 3 technology achievement standards respectively*
- *Considering offering opportunity for students to gain additional technology related national certificates at NQF Level 1, 2 and/or 3 through technology courses from other providers such as ITO's*
- Drawing from and expanding their existing knowledge and skills to ensure they provide quality learning experiences for students that support achievement at levels 6, 7 and 8 of *The New Zealand Curriculum*
- Drawing from and expanding their existing specialist knowledge and skills to ensure they provide quality learning experiences for students to support achievement within or across the four specialist categories of technology
- Working alongside teachers from other learning areas to ensure students' overall programmes are complementary, and that opportunities for cross curricula learning are maximised. For example, a chemistry course could be taken that supports students doing food technology
- Ensuring up to date understanding of requirements/desires of relevant industry and tertiary organizations that optimize future pathways for students
- Making clear links for students to technology related careers and supporting students in exploring future education opportunities and/or career pathways
- Using mentors from communities of technological practice and encouraging students to work with real clients as appropriate.

For further explanation of the ideas presented in this paper, please refer to relevant sections contained in the Technology Curriculum Support package.

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

Written by Dr Vicki Compton under contract to the Ministry of Education to support Technology in The New Zealand Curriculum

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.

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 V.J and France B.J. (2007). Towards a New Technological Literacy: Curriculum Development with a Difference. In *Curriculum Matters 3*: 2007 158-175.Wellington: NZCER.

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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.

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

Written by Dr Vicki Compton under contract to the Ministry of Education to support Technology in The New Zealand Curriculum*. These are based on the work of Compton and France. For details of the research underpinning the components please refer to Compton V.J and France B.J. (2007). Towards a New Technological Literacy: Curriculum Development with a Difference. In* Curriculum Matters 3*: 2007 158-175.*

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 outcome's 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 the realised outcome prior to its 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/components. 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 that the final outcome, when produced, is fit for purpose as defined by the brief. Outcome Development and Evaluation can be thought of as the designing, 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 development and evaluation practices involved in the creation of a conceptual design for a potential technological outcome, and the production and testing 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 its 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; and
- prototyping - to provide evidence of the outcome's 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, allows 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.

Trialling a prototype provides data for evaluating 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 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, including both physical and social environment influences and impacts, both now and in possible future scenarios.

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 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 optimise performance. Learning from past innovations to create contemporary products, prototype testing, and ongoing modifications were key features of Graeme Addis's plan 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; and
- 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; and
- 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 unique button for fastening it. For details of this unit please see Ministry of Education's Applications Series 2005 – *Lips, Lipids and Locks* and Techlink case study Hair's your Gift.

Students achieving at level 2 could:

- develop logo designs for a gift pack and 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; and
- 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 a 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 a 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 identified needs of the recipient;
- develop a gift pack containing products that addressed the attributes identified for their recipient; and
- 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 a 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 feedback from the recipient 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 the products;
- develop a gift pack containing products that incorporated all key attributes identified; and
- gather recipient feedback to provide evidence of how well the final gift pack 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, a 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 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 a 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 the client to refine the recipe;
- develop a package of bottled ingredients, including labels for containers, that address the client's colour, taste, and 'ease of making' preferences; and
- 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 and 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 the 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 the 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 the above 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 the 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 (for example, 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 includes sensory testing of food product, functionality testing of containers, and 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 the 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; and
- 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, and 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 the 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, and gain product safety certification from a 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; and
- 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, and 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, and 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 (for example, 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, and gain product safety certification from a 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 in keeping with 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; and
- 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 the above 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 on Sandwiches' style, client preferences, and specifications associated with safety and batch production) and in terms of 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, and 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 (for example, 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 the lighting product, and gain product safety certification from a 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 in keeping with 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 the physical and social environment of Sandwiches; and
- use feedback from a range of stakeholders, including the client, teacher, 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 the above 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), in terms of the physical and social environment in which the lighting system is to be placed, and in terms of 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, and models to illustrate potential materials and how they can be modified for different effects) to illustrate the range of options available and test initial design ideas of how they may work in the environment of Sandwiches;
- use the models to gain critical feedback from the client, mentors, a range of customers, and other identified stakeholders (for example, musicians that regularly play at Sandwiches, potential 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 (for example, research findings, mentors, friends, etc.) to determine the suitability of the resources. Undertake evaluative testing procedures in line with accepted codes of practice to ensure the resources 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 the lighting product, and gain product safety certification from a 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 in keeping with 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; and
- 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 in terms of 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, and models to illustrate potential materials and how they can be modified and finished to create a range of effects) to justify the options available, 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 identified stakeholders (for example, musicians that regularly play at Sandwiches, potential 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 (for example, research findings, mentors, friends, etc.) to determine the suitability of the resources. Undertake evaluative testing procedures in line with accepted codes of practice to ensure the resources 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 model for further development;
- develop a prototype of the lighting product, and gain product safety certification from a 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 in keeping with 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; and
- 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 in this sense 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 further categorised into two types – technological products and technological systems. However, the relationship between the categories of 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 describe 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, working together to achieve a task. Alternatively, a cell phone may be described as a technological product, where the focus is no longer on the interconnected components, but on the materials used in the product.

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 phones, 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, etc.).

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 purpose. 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 production or 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 related to the physical nature of outcomes (sometimes referred to as the form of an outcome) include such things as colour, movement, pattern and rhythm, proportion, balance, harmony and contrast, and style. Design elements related to the functional nature of outcomes include such things as strength and durability, safety and stability, efficiency, reliability, nutritional value, user-friendliness, and ergonomic fit. These elements can be used to understand how physical and functional factors were prioritised in the design and development of an outcome in order for that outcome to be considered fit for purpose. Design elements are prioritised in different ways as determined by such things as a designer's intent for the outcome, understandings of materials, the socio-cultural location the outcome is to be situated, professional and personal beliefs, etc. These elements also provide guidance when deciding what factors should 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 and functional 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 a 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 malfunction, 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 operational parameters, and the environments in which technological outcomes are situated. Operational parameters refer to the boundaries and/or conditions within which the outcome has been designed to function.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

The malfunctioning of the O-rings in the Space Shuttle Challenger 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 an interconnected 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 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 (physical and functional) 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, Weet-Bix, 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 in a similar era, 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;
- identify possible users of identified technological outcomes;
- describe a technological outcome in terms of what it looks like; and
- describe a technological outcome in terms of what it does.

Students achieving at level 2 could be expected to:

- identify technological outcomes and explain how they differ to other objects;
- identify a technological outcome and describe the relationship between its physical and functional attributes; and
- describe the physical and functional attributes of a technological outcome, with the description implying who possible users may be.

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:

- explain why technological products and systems can be described as technological outcomes; and
- 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 outcomes that could provide a given function and describe their physical nature; and
- evaluate designs and explain which they consider could be described as a “good” or “bad” design.

Students achieving at level 4 could be expected to:

- identify the proper function of selected technological outcomes and suggest possible alternative uses; and
- 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 – such as wooden floors, carpet, concrete, and grass) and potential ways of being used; for example, being stood on, swung on, and/or supporting more than one person.

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 operational parameters, and what evidence and reasoning students need in order to justify design decisions with regards to the physical and functional nature of their technological outcome.

Students achieving at level 3 could be expected to:

- describe the physical nature of a technological outcome they are developing and describe how it could function and why it would be suitable for particular users; and
- 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 how the technological outcome might be able to be used by end-users for purposes other than what it was originally designed for; and
- discuss the likely impact of using technological outcomes in alternative ways.

Students achieving at level 5 could be expected to:

- explain how explorations of their own outcome in various contexts allowed them to gain a deeper understanding of how they could modify their design to reduce user misuse and/or inappropriate environmental location;
- 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
- explain why the technological outcome malfunctioned and identify changes in its design should you be developing the outcome today.

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 design elements 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 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; and
- explain what changes to the physical attributes of the technological outcome could have been made to better suit the intended user/s or physical environment.

Students achieving at level 5 could be expected to:

- explain the concept of malfunction and use the selected technological outcome to illustrate the importance of context on judging an outcome as fit for purpose;
- explain why a technological outcome malfunctioned;
- undertake a contemporary evaluation of the fitness for purpose of the technological outcome based on experiences and/or knowledge available now; and
- 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 how the interactions between the technological outcome, people, and social and physical environments impacted on the failure;
- describe the socio-technological environment that surrounds the selected technological outcome and identify relationships between other technological product and technological systems; and
- discuss the impacts and implications of the way technological outcomes, people, and social and physical environments interact in a selected socio-technological environment.

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 design elements over others;
- discuss how the failure of the technological outcome impacted on subsequent decisions for related technological developments and/or operational guidelines;
- analyse the selected technological outcome in terms of how design elements have been prioritised; and
- establish an argument for the retention or 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 and discuss how consideration of broader issues may have influenced the decision making; and
- 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, production, 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 designing, construction, processing, and evaluation practices of producing outcomes. Manufacturing practices are also important in technology as they seek to take technological outcomes and ensure their ongoing production.

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 a technological product or system, models, and 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, and physical and social location. Therefore, the social world of culture, politics, and dominant ideologies of the time, as well as the 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 and/or manufactured. This is particularly so when manufacturing raises sustainability and/or quality control issues not apparent in the development of a one-off outcome or 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 first world countries 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 critical analyses that take 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, philosophy, psychology, and ethics). 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, and material tolerances. 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, processing, manufacturing, and 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. Jared 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 history, edited by Denis Hogan and Bryce Williamson, 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 http://www.techhistory.co.nz/. Examples provide illustrative accounts of how technology is embedded in society and the resulting benefits, losses and unforeseen consequences associated with this.

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 and suggest why they may have been developed; and
- 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 impacts it has had on society and/or the environment; and
- make suggestions as to how the technological outcome may change in the future and describe how this may impact on the made, social, and natural world.

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 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 how their selected technological development has changed over time;
- identify both positive and negative impacts that the development has had on a variety of people in the past and today; and
- 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 why their selected technological development has changed over time;
- describe how their selected technological development has impacted on the social world over time;
- describe how their selected technological development has impacted on the natural world over time; and
- describe what technological knowledge is.

Students achieving at level 4 could be expected to:

- identify how their selected technological development has changed people's sensory perception and/or physical abilities and discuss the potential short and long term impacts of these changes;
- identify examples of creative and critical thinking within their selected development; and
- identify the knowledge and skills that have supported different selected developments and categorise these into different disciplines.

Junior secondary (Years 9-10)

Students could explore a contemporary technology-related controversial context (for example, genetic engineering, stem cell research, climate change, 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:

- describe how societal and/or environmental issues have arisen from their selected issue;
- describe how these issues influenced people's decision making in related technological developments; and
- identify the codes of practice relevant to their issue.

Students achieving at level 4 could be expected to:

- explain how their selected technological issue has stimulated creative and critical thinking;
- explain how their issue has led to changes in how people perceive or do things; and
- 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; and
- 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 interviews (face to face, E-mail, phone, etc.) need 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, personal influences, and sustainability issues that impact on technological developments.

Students achieving at level 4 could be expected to:

- explain how a technologist seeks to change how people perceive the world and/or their physical abilities and discuss the potential short and long term impacts of these on society and/or the environment;
- identify examples of creative and critical thinking in the decision making of a technologist; and
- identify the knowledge and skills used in the technologist's practice and categorise this into different disciplines.

Students achieving at level 5 could be expected to:

- discuss the role of creative and critical thinking in the technologist's practice;
- 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; and
- 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; and
- 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 a technologist's own background, their colleagues' backgrounds, established codes, and the influential contemporary factors from wider physical and social environments;
- discuss the influences of rapidly developing technological knowledge and capability and changing social expectations on technologists' practice; and
- 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 critique the role of technology in the development of sustainable environments; and 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 of the proposed outcome, 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 with the prototype 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 to determine whether and how the development should proceed. Prototyping is used to evaluate the outcome itself once it is realised. Technological modelling is critical in the process of identifying the outcome's potential and probable impact on the world, as it moves from conceptual idea through to being fully realised and implemented *in situ*. It also supports exploration of a range of influences that may impact on technological outcome, its development, and its future manufacture.

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 technologist2. 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, then to more formal written and/or diagrammatic explanations appropriate for a wider range of audiences. Three-dimensional mock-ups, using easily

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.

manipulated material such as clay, cardboard, Styrodur foam, and CAD software, are often used to enable design ideas to be evaluated in terms of technical feasibility and social acceptability. 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 mock-ups 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 the technical feasibility and social acceptability of any future development. These decisions need to take into account such things as known specifications, material and technique suitability, and 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 "guesstimation", 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 on the world, due to the fact it now exists in a functioning material form and can be implemented in its intended location. However, prototyping seeks to gather further evidence to inform subsequent decisions focussing 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.

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.

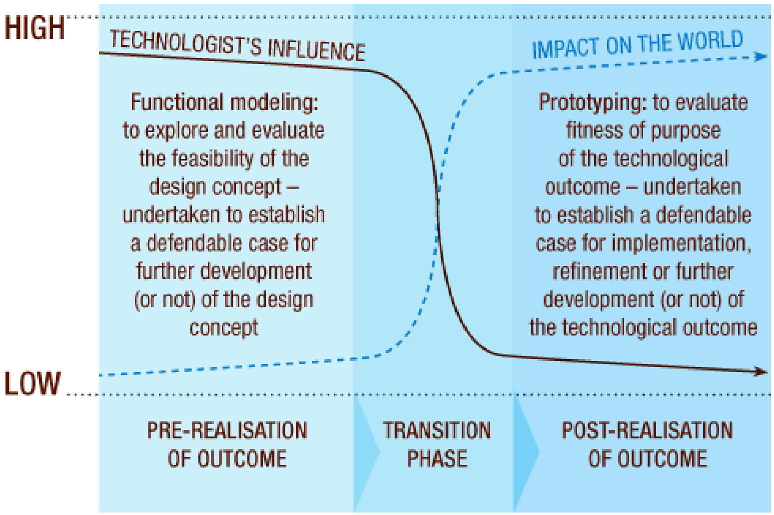

Figure 1: Technological Modelling in Technological Development

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 significantly. 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 on 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 on the world" is made, with the evaluation reflective of a balanced normative and technical understanding of fitness for purpose. *Functional reasoning* provides a basis for exploring the technical feasibility of the design concept and the outcome. 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 acceptability (related to such things as moral, ethical, social, political, economic, and environmental dimensions) 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 prioritised for any future development decisions. For an introduction to this issue, see the May/June 2006 edition of e.nz magazine.

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 (for example, the early generation hybrid cars).

Other examples show how a prototype can shift people's perceptions and stimulate other technologists to cross historical boundaries (for example, 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 modelling is and how it might be useful in technological developments. Students are then provided with an opportunity to play with

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

different modelling materials (such as LEGO, plasticine, Meccano, Connex, cardboard, concept maps, computer modelling 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 LEGO Technic, 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 and acceptable for a 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 modelling; and
- identify functional models and describe that they can help you to test design ideas.

Students achieving at level 2 could be expected to:

- describe how models can be useful to help you think about things before they happen, and how models can also make you think something is possible that isn't – or vice-versa; and
- describe the functional modelling used and identify the design ideas being tested during the class activity to make decisions about a school 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:

- describe different functional models and prototypes provided and identify the reason they were used;
- identify the design ideas being tested in particular functional models; and
- identify the specifications being used to test different prototypes.

Students achieving at level 3 could be expected to:

- identify different forms of functional models and explain why they were selected;
- identify different examples of prototyping and describe how the evidence gained allowed people to decide if the prototype needed further work or not; and
- describe the choice of modelling they undertook and how this helped and/or hindered their decision making.

Students achieving at level 4 could be expected to:

- explain a range of examples of technological modelling and discuss how each allowed the technologists to determine both what *could* and what *should* be done;
- discuss examples of functional modelling and describe the specific information they generated to help make design decisions; and
- identify the information gained from their own technological modelling (either functional modelling or prototyping) and describe how it helped them decide what to do.

Junior secondary (Years 9-10)

Students could select examples of successful (for example, Post-its, Aquada, telephones, the printing press, antibiotics, the Hamilton jet, vaccines, a past successful student outcome, etc.) and unsuccessful technological outcomes (for example, thalidomide, Chernobyl and/or Three Mile Island nuclear power plants, Cave Creek, Hindenburg airship, Titanic, Space Shuttle Columbia, Silver 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 technological modelling played in each;
- identify the benefits and limitations of functional modelling used during technological development; and
- explain why both functional modelling and prototyping are needed to support decision making in technology.

Students achieving at level 4 could be expected to:

- identify decisions that focussed on what could happen and those that focussed on what should happen and explain how these impacted on the resulting technological outcome;
- identify information that has been gathered from functional models about the suitability of design concepts and describe how this information was used; and
- 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 a successful outcome and compare this with an example where the resulting technological outcome was unsuccessful;
- discuss examples of how prototyping allowed maintenance requirements to be determined; and
- outline a case for how technological modelling could lesson 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 priorities and how they impact on their perceptions about what type of solution would be fit for purpose. Examples of issues could include the establishment of a marina, the restoration of a mining site, the reclamation of a wetlands area, the site of a new building sub-division, the need for flood protection, the need to stop sand dune erosion, the 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 scenarios 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 gather specific information about how a potential outcome might be perceived by key stakeholders;
- explain how technological modelling could be undertaken to test design ideas for stakeholder acceptability and technical feasibility; and
- present a design concept of a possible outcome that is explained in terms of both stakeholder acceptability and technical feasibility.

Students achieving at level 5 could be expected to:

- explain how different forms of functional modelling can be used to identify conflicts between key stakeholder priorities;
- explain the reasoning that led them to decide on a particular conceptual design as both acceptable and feasible; and
- 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 the 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 informed 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 relation 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 mitigated;
- use a range of evidence to 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.

Students achieving at level 8 could be expected to:

- use illustrative examples from the issue explored to explain the critical role of functional modelling in making informed predications and defensible decisions regarding an outcome's suitability to address a range of competing and contestable 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, the specific perspectives of individual stakeholders and the community as a whole, and the identified requirements of the social and physical environment in the short and long term; and
- use a range of evidence suitable for different audiences to 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, and outline feasible and acceptable safeguards that could be developed to mitigate identified risks.

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 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 how new materials are formulated. 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 as technological products and/or technological systems (see Characteristics of Technological Outcomes for an explanation of cases where the same outcome could be referred to as either a product or 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 for which it was designed.

The knowledge base underpinning these concepts will vary depending on the specific materials used in any particular product. That is, the understandings needed to develop and understand food products differ to those required to develop and understand garments or furniture. However, all materials have properties that can be measured objectively and/or subjectively and together these provide a material with its overall performance properties. Performance properties of materials refer to such things as thermal and electrical conductivity, water resistance, texture, flexibility, colour, etc. Subjective measurement is reliant on people’s perception (tasty, evokes a sense of natural beauty, warm and inviting, etc.), whereas objective measurement is not (conductivity, UV resistance, etc.). The fitness for purpose of a product relies on the material providing appropriate performance properties to ensure the product is technically feasible and acceptable (safe, ethical, environmentally friendly, economically viable, etc. – as appropriate to the product). Material properties are determined by the type and arrangements of particles that make up the material, that is, by their composition and structure.

Materials can be formed, manipulated, and/or transformed to enhance the fitness for purpose of a technological product. Forming refers to bringing two or more materials together to formulate a new material resulting in a different overall composition and structure to that of the original materials. This results in different performance properties. For example, mixing flour, water, and salt to make dough; mixing wood fibres, resin, and wax to make MDF; combining glass fibre and a polymer resin to form fibreglass or fibre reinforced polymer (FRP). Manipulating materials refers to “working” existing materials in ways that do not change their properties as their composition and structure is not altered. Instead the manipulation allows the material to be incorporated into a product in ways that will maximise the performance of the material individually and/or collectively to enhance the overall performance of the product. Manipulating often involves changing the shape, laminating materials, and/or joining them with other materials. Manipulation techniques and operations include such things as cutting, moulding, bending, jointing, gluing, painting, etc. Transforming refers to changing the structure or particle alignment within an existing material to change some of its properties, but, in terms of its composition, it remains the same material. For example, felting; beating an egg white; heat treating metals to harden or anneal them; steaming timber to soften its fibres so that it can be manipulated (bent). Techniques and operations used when developing products often result in a combination of forming, manipulation, and/or transformation. For example, sanding may both shape (manipulation) and add sheen (transform) to materials such as bone and wood.

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 decisions that can be justified in terms of the material not only being adequate, but being 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. To support the processing or construction of products, technologists often use specialised language and symbols to communicate material-related details. Material-related details include such things as what materials would be feasible for use and how they would need to be formed, manipulated, and/or transformed.

Material development refers to the development work that makes available different and/or innovative performance properties through the formulation of new materials. The contemporary field of material development 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 new materials relies on understanding such things as existing materials including their advantages and limitations; new material composition and structure possibilities; formulation procedures; future requirements, needs, and desires; and an awareness that new evaluative procedures may need to be developed to determine the suitability of new materials.

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 stimuli which may be technological or environmental 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 heat regulating clothing, light-responsive sunglasses, artificial muscles, self-cleaning textiles, self-adjusting optical lenses, colour-changing shirts, self-healing paint, 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 development 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. 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 thin film of zinc oxide adhere to substrates of glass, silicon, and metal. The thin films can act as semiconductors and emit light. This ongoing research and development is leading towards a new generation of optoelectronic 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 optoelectronics 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 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. The students could also discuss what they think may have been done to the material in the making of the product.

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, sunscreens, 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 the product to be fit for its designed purpose.

Students achieving at level 1 could be expected to:

- identify the materials that a range of products are made from;
- identify the performance properties of common materials used; and
- describe how the material might have been "worked" to make the products; for example, sliced, carved, bent, moulded, sanded, etc.

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

Students achieving at level 2 could be expected to:

- describe the performance properties of identified materials and suggest what the material might be used for based on these properties;
- discuss examples to suggest why materials might have been selected for use in different products.

Senior Primary/Intermediate (Years 5-8)

Exploring products from two different areas of technology could provide students with an opportunity to identify generic understandings about material. 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 how properties can be measured – including objective and subjective measurement techniques.

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. 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, and how fit for purpose the resultant product was for the intended function. Based on their developing understandings, they could identify how their future work may attempt to address issues around working with materials and dealing with waste.

Students achieving at level 2 could be expected to:

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

Students achieving at level 3 could be expected to:

- describe the properties of materials used in biotechnological and other products that can be measured objectively;
- describe the properties of materials used in biotechnological and other products that can be measured subjectively; and
- describe how the properties of all materials used in a selected product combine to allow the product to function as designed.

Students achieving at level 4 could be expected to:

- describe how the fitness for purpose of a product was enhanced through the way materials were manipulated;
- describe how the fitness for purpose of a product was enhanced through the way materials were transformed;
- describe how the fitness for purpose of a product was enhanced through the formulation of new materials.

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 how they have identified instruments in relation to what materials they think would have been capable of making the specific sounds they heard. They could undertake further research to establish what instruments were in fact used in the music and make links with how these have been brought together to create particular musical genres (for example, rock, blues, jazz, 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 could be made to traditional techniques of playing and instrument manufacture as based on available materials. The performance properties of the materials used 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 manipulated 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 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:

- describe how the selection of particular materials enabled an instrument to be crafted and played in certain ways; and
- discuss 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 way materials were manipulated;
- explain how the fitness for purpose of a musical instrument was enhanced through the formulation of a new material; and
- explain how the cleaning and ongoing care of a musical instrument has been enhanced by the use of a finishing technique that transformed a material.

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; and
- 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 investigate lighting products that have become available due to the development of new materials. They could explore the knowledge and techniques required for the development of these materials, including new evaluation procedures to ensure product designs were both technically feasible and socially acceptable. 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 of a lighting product for an identified client. They could present their design effectively through the use of specialised language and drawings to clearly communicate how materials would need to be selected and manipulated to ensure they upheld the design’s feasibility and acceptability.

Students achieving at level 4 could be expected to:

- describe how the formulation of new materials allowed lighting products to be developed for different purposes;
- explain how materials used in a particular lighting product were manipulated to ensure the product functions in a safe and reliable way; and
- communicate material-related details of a conceptual design for a lighting product, using specialised language

and drawings, that would allow others to create a product that meets stated technical and acceptability specifications.

Students achieving at level 5 could be expected to:

- explain why particular materials were selected for use in relation to the desired performance criteria of lighting products developed for differing purposes and environmental locations; and
- 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 and structure of the materials used in lighting products;
- explain how existing materials have been manipulated and/or transformed to increase their suitability for lighting products in particular contexts and/or for specialised functions; and
- describe how the evaluation of different materials has informed their own conceptual design.

Students achieving at level 7 could be expected to:

- explain the concepts and processes involved in the objective and subjective evaluation procedures used to determine the suitability of different materials for a range of reliable and safe lighting products;
- explain how material evaluations influenced the initial design ideas and life cycle decisions, ongoing development, maintenance guidelines, and disposal of lighting products; and
- 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 the concepts and processes involved in the development of a new material that provided an opportunity for an increase in the type and nature of lighting functions;
- explain how new materials were evaluated to ensure they would met feasibility and acceptability related specifications; and
- discuss how new materials have influenced the development of new lighting products in terms of expanding 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.

STRANDCOMPONENT 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 as technological products and/or technological systems (see Characteristics of Technological Outcomes for an explanation of why the same outcome could be referred to as both a product and system). However, in this strandcomponent, 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 strandcomponent.

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 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 heat and 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 role of subsystems is to act as a component of a larger technological system in a way that supports that system's overall function. The properties of a subsystem refer to its transformation performance and its level of connective compatibility. The role a subsystem is playing 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* of systems 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; and designed failure.

The concept of a *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 the 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 of communication tools (for example, computer software, flow diagrams, web diagrams, 3-D 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 to communicate system-related details. System-related details include such things as what components would be feasible, layout requirements, and how they would need to be connected.

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 centralised 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

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

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.

POSSIBLE LEARNING EXPERIENCES

The learning experiences suggested below have been provided to support teachers as they develop their understanding of the Technological Systems partcomponent of Technological Knowledge, and how this understanding 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 system and how they connect to each other; and
- identify the inputs and outputs of a system and that a transformation of some sort has occurred.

Students achieving at level 2 could be expected to:

- describe the change that has happened to an input for the output to be produced in a simple system; and
- 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 access 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, and interesting) analysis of making bread in a variety of ways.

Students achieving at level 2 could be expected to:

- describe type of transformation that occurs within the bread-maker; and
- describe the role each component has in the transformation occurring within the bread-maker.

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; and
- 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; and
- describe how the fitness for purpose of the bread-maker was and/or could be enhanced by the use of control mechanisms.

Junior secondary (Years 9-10)

Students could investigate the computer network within their school to identify and explore how it meets both technical feasibility and social acceptability specifications. They could also identify subsystems within the system, establish the transformation and connectivity properties of these, and the interface implications for effective integration into the 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; and
- 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 system’s fitness for purpose as a school network; and
- communicate, using specialised language and drawings, system-related details that would allow others to create a feasible and acceptable network system.

Students achieving at level 5 could be expected to:

- identify all subsystems within the network and explain their transformation and connectivity properties; and
- discuss how the interface between each subsystems allows the network to work together effectively.

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 when viewing the appliance as a product. 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:

- explain how the fitness for purpose of a particular appliance was enhanced through the use of a micro-controller; and
- communicate, using specialised language and drawings, system-related details to support their development of a feasible and acceptable electronic game.

Students achieving at level 5 could be expected to:

- explain the specialised transformation processes occurring within components that serve as subsystems within an appliance; and
- discuss how electronic interfaces support the integration of subsystems in 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; and
- 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; and
- 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 fail-safe on the operational parameters of systems used in familiar appliances; and
- 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 provide support for teachers to interpret the Achievement Objectives (AOs) 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 indicators of what students should know or be able to do at each level.

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 understandings 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 present. 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* describe generic understandings and capabilities that students should be able demonstrate consistently if they are to be considered to have met the related achievement objective. The indicators for each level should be viewed 'collectively' as indicating the AO at that level. Partial and/or inconsistent student demonstration of the indicators shows that additional and/or further consolidation learning experiences need to be provided to the student. This will ensure that future learning provides the opportunities necessary for the student to demonstrate the achievement described by all of the indicators at that level. It is expected that teachers will 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 learning goals and assessment tools inside the classroom to plan for, guide, and acknowledge student learning.

The *Teacher Guidance* and *Indicators* have been developed through classroom research and refined through subsequent trialling. They are provided 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.

All three matrices will be periodically reviewed as implementation of the three strands proceeds and further development work in technology is undertaken.

TECHNOLOGY INDICATORS OF PROGRESSION

Components of Technological Practice

The Indicators of Progress within the Technological Practice section are divided into three components:

Brief Development

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.

Planning for Practice

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.

Outcome Development & Evaluation

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.

More information on each of these components can be found in the Technological Practice Explanatory Papers.

NOTE: The Indicators of Progression for the components of Technological Practice can be used to guide and support formative and summative assessment, and provide a basis for reporting purposes. These are based on the work of Dr Vicki Compton and Cliff Harwood. For details of the research underpinning the components please refer to Compton, V.J. and Harwood, C.D. (2005) 'Progression in Technology Education in New Zealand: Components of practice as a way forward.' *International Journal of Design and Technology Education*. Vol 15, #3, 253-287.

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 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 those suitable for their use. Teachers should ensure all resources provided are appropriate for use and students should only be responsible for selecting particular materials components, and/or software from these resources.	**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 Students can: • communicate the outcome to be produced • identify attributes for an outcome.	**INDICATORS** Students can: • identify what they will do next • identify the particular materials, components and/or software they might use.	**INDICATORS** 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 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 particular materials components, and/or software will be required for each key stage Teachers should ensure all resources provided are appropriate for use.	**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 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** Students can: • identify key stages required to produce an outcome • identify the particular materials, components and/or software required for each key stage.	**INDICATORS** 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 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 (e.g. 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 identify key stages and place these on a timeline of some sort • provide resources including a range of appropriate materials, components, software, hardware, equipment, and/ or tools for students to select from and guide students to select those that will be suitable for their outcome • guide students to reflect on progress to make informed decisions regarding next steps.	**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 performance properties of the materials/components students could use • support students to evaluate their outcome against the brief.
INDICATORS 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** Students can: • identify key stages, and resources required, and record when each stage will need to be completed to make sure an outcome is completed • explain progress to date in terms of meeting key stages and use of resources, and discuss implications for what they need to do next.	**INDICATORS** 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 • select materials/components, based on their performance properties, 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 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 • support students to understand the physical and functional nature required of their 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 resources including a range of appropriate stakeholders, materials, components, software, hardware, equipment, and/or tools for students to select from and support students to select those that will be suitable for their outcome • provide planning tools and support students to use these to record key stages and resources needed, including when they will need to access stakeholder feedback, and to (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 regularly) • support students to identify regular review points and to review their progress at these points • guide students to manage time and organise their selected resources .based on regular reviews of progress	**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 support students to develop the necessary knowledge and skills to test and use them • guide students to evaluate outcomes in situ against key attributes.
INDICATORS 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** Students can: • use planning tools to manage time, identify and record key stages, associated resources, and actions to be undertaken, with progress review points clearly indicated • review progress at set review points, and revise time management as appropriate to ensure completion of an outcome.	**INDICATORS** 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 • test the key performance properties of materials/components 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 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 their 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 manage and efficiently record their planning • support students to review and evaluate progress to inform their ongoing planning decisions • guide students to ensure appropriate resources are available (stakeholder/s, materials, components, software, equipment, tools and/or hardware) suitable for their outcome • support students to manage time and resources, including stakeholders interactions.	**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 support students to develop the necessary knowledge and skills to evaluate and use them • guide students to evaluate outcomes in situ against brief specifications.
INDICATORS 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** Students can: • analyse own and others use of planning tools to inform the selection of tools best suited for their use to plan and monitor progress and record key decisions • use planning tools to identify and record key stages, and manage time and resources (including stakeholder interactions) to ensure completion of an outcome • use planning tools to record key planning decisions regarding the management of time, resources and stakeholder interactions.	**INDICATORS** 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 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 • support students to identify a need or opportunity relevant to the given issue and context • support students to understand the physical and functional nature required of their 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 • support students to select planning tools that will provide appropriate support for their practice and efficient recording of why key planning decisions were made • support students to ensure appropriate resources are available (stakeholder/s, materials, components, software, equipment, tools and/or hardware) suitable for their outcome • support students to use selected tools to manage resources to ensure completion of an outcome.	**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 • support students 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 • support students to explore a range of materials/ components and to develop the necessary knowledge and skills to evaluate and use them • support students to undertake prototyping to evaluate the outcome's fitness for purpose and identify any further development requirements • support students to gain targeted stakeholder feedback.
INDICATORS 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** Students can: • critically analyse own and others use of planning tools to inform the selection of planning tools best suited for their use to plan and monitor progress and record reasons for planning decisions • use planning tools to establish and review key stages, identify and manage all resources, and to determine and guide actions to ensure completion of an outcome • use planning tools to record initial plans and ongoing revisions in ways which provide reasons for planning decisions made.	**INDICATORS** 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 • guide 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. • support students to identify a need or opportunity relevant to the issue • support students to understand the physical and functional nature required of their 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 select and use planning tools to make effective planning decisions and establish and manage all resources (including time, money, stakeholder/s, materials, components, software, equipment, tools and/or hardware etc). Effective planning decisions enable the outcome produced to successfully meet the brief. • support students to select and use planning tools which will allow for the efficient recording of justifications for key planning decisions made. • support students to ensure appropriate resources are available (stakeholder/s, materials, components, software, equipment, tools and/or hardware) suitable for their outcome.	**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 • support students 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 • support students to explore a range of materials/ components, and to develop the necessary knowledge and skills to evaluate and make effective use of 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 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** Students can: • critically analyse existing planning tools and project management practices to inform the selection of planning tools appropriate for the technological practice to be undertaken, and for recording evidence to support any revisions to planning • use planning tools to set achievable goals, manage all resources, plan critical review points, and revise goal and resources as necessary to ensure the effective completion of an outcome • use planning tools to provide evidence for any revisions made at critical review points and justifies the appropriateness of planning tools used.	**INDICATORS** 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 outcome's 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 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. Context refers to the wider social and physical environment in which technological development occurs. Contexts may include but are not limited to: storage, afterschool snacks, outdoor living, sustainable energy, sport, educational software, streetwear, portability, furniture. • support students to identify considerations that will need to be taken into account when making judgments of fitness for purpose in its broadest sense. Fitness for purpose in its broadest sense refers to judgments of the fitness of the outcome itself as well as the practices used to develop the outcome. Such judgments may include but are not limited to considerations of the outcome's technical and social acceptability, sustainability of resources used, ethical nature of testing practices, cultural appropriateness of trialling procedures, determination of life cycle, maintenance, ultimate disposal, health and safety. • support students to select an authentic issue within their selected context • support students to identify a need or opportunity relevant to the issue and context • support students to understand the physical and functional nature required of their 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.	**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 • support students to critically analyse a range of project management practices and explore how project scheduling is used to manage technological practice • support students to establish and implement a coherent project schedule that allows for the coordination and management of the: regular review of goals, planning tools, all resources required (time, money, stakeholder/s, materials, components, software, equipment, tools and/or hardware etc) and review points • support students to provide evidence of effective and efficient planning decisions. Effective and efficient planning decisions ensures that the use of resources is optimised during the development and production of an outcome produced to successfully meet 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 • support students 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 • support students to explore a range of materials/components and to develop the necessary knowledge and skills to evaluate and make effective use of them. • support students to establish which materials/components 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 • 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 Students can: • identify and evaluate a range of contexts to select an authentic issue • explore context to identify considerations related to fitness for purpose in its broadest sense • 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** Students can: • establish a coherent project schedule suitable for the physical and social environment where the outcome is to be developed and implemented, informed by critical analysis of existing project management • implement project schedule, undertaking reflection at critical review points to revise or confirm schedule to ensure the effective and efficient completion of an outcome • manage the project to provide evidence of the coordination of goals, planning tools, resources and progress review points and justify planning decisions.	**INDICATORS** 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 outcome's 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

The Indicators of Progress within the Nature of Technology section are divided into two components:

Characteristics of Technology

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.

Characteristics of Technological Outcomes

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.

More information on each of these components can be found in the Nature of Technology Explanatory Papers.

NOTE: The Indicators of Progression for the components of the Nature of Technology can be used to guide and support formative and summative assessment, and provide a basis for reporting purposes. These were originally based on the work of Compton and France. For details of the research underpinning these components please refer to Compton V.J and France B.J. in *Curriculum Matters 2007.* The teacher guidance and indictors have been revised and further developed by Dr V Compton and A Compton as a part of the Ministry of Education funded research project: *Technological Knowledge and Nature of Technology: Implications for teaching and learning*.

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 below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand that technology is purposeful intervention through design

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, natural, and social world and guide them to identify technological outcomes as making up a significant part of the made 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 organising 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 aim of technology is to design and make outcomes for an identified purpose.

INDICATORS

Students can:

- identify that technology helps to create the made world
- identify that technology involves people designing and making 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.

Characteristics of Technological Outcomes

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 technolog**ical outcomes at level 1, teachers could:

- provide students with a range of contemporary and historical technological products and systems and encourage them to explore these through such things as: using, ‘playing’, dismantling and rebuilding as appropriate
- guide students to recognise the products and systems explored as technological outcomes developed by people to be suitable for particular users
- guide students to identify technological outcomes when presented with a collection of technological and non-technological objects and systems
- guide students to identify the physical nature of technological outcomes. The physical nature of technological outcomes refers to its physical attributes. For example; size, shape, colour, smell, texture, componentsguide students to identify the functional nature of technological outcomes. The functional nature of technological outcomes refers to its functional attributes. That is, what the outcome or part of the outcome does. For example; provides grip, transports mass, stores, joins surfaces.

INDICATORS

Students can:

- identify technological outcomes in a group of technological and non-technological objects and systems
- identify who might use particular technological outcomes
- identify the physical attributes of technological outcomes
- identify the functional attributes of technological outcomes.

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 below.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Students will: Understand that technology both reflects and changes society and the environment and increases people's capability.	**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 technology at level 2, teachers could: • provide opportunities for students to discuss the made, natural, and social world and guide them to explore how technology relates to each of these • provide students with examples of different technologist's practice and guide them to identify any social and/or environmental issues that might have influenced their practice and the nature of the outcomes they produce. For example; social attitudes to the environment has resulted in some technologists choosing to only use renewable materials, cold and windy environmental considerations requiring clothing outcomes that have insulating and close-fitting attributes • provide students with examples of technological outcomes and guide them to explore how these have changed over time and identify any changes that have resulted in terms of people's capability to do things. Examples should allow students to recognize that increasing capability to do things may result in both positive and negative impacts on the person, society and/or the environment • provide students with the opportunity to explore a range of technologies and guide them to identify examples of positive and negative impacts on people, society and/or the environment.	**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 non-technological objects and guide them to identify which of these could be described as technological outcomes and explain 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 contemporary and historical technological outcomes and encourage them to explore these through such things as: using, 'playing', dismantling and rebuilding as appropriate • guide students to identify the technological outcomes explored as products and/or systems. Identifying an outcome as a product or system will influence 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 physical attributes afforded by the shaping, cutting, finishing etc of 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 physical attributes afforded by the components within it and how they are connected • guide students to identify the relationship 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) • guide students to recognise that physical and functional attributes can give clues as to who might use the technological outcome for its intended purpose.
INDICATORS Students can: • describe the relationship between technology and the made, natural and social world • identify social and/or environmental issues that may have influenced particular technological practices and/or the attributes of outcomes produced • describe how particular technological outcomes have changed over time and identify if this resulted in changing how people do things • describe examples to illustrate when technology has had a positive impact on society and/or the environment • describe examples to illustrate when technology has had a negative impact on society and/or the environment.	**INDICATORS** Students can: • describe what technological outcomes are and explain how they are different to natural objects and other things created by people • identify a technological product and describe relationships between the physical and functional attributes • identify a technological system and describe relationships between the physical and functional attributes • describe the physical and/or functional attributes of a technological outcome that provide clues as to who might use it .

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 below.

Characteristics of Technology	Characteristics of Technological Outcomes
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.	**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 technology at level 3, teachers could: • provide students with examples of different technologist's practice and guide them to identify how social and environmental issues could have influenced their decision making about; what should be made and why, how planning should be done and what resources should be used, how materials could be manipulated and tested, how outcomes should be evaluated, and manufacturing considerations • provide students with the opportunity to explore a range of technologies and guide them to determine why they have changed over time. Reasons for changes include such things as changing needs, fashions, attitudes, ethical and environmental stances etc., or the development of new materials, skills and knowledge • guide students to determine the impacts different technologies have had on society and/or the environment over time • provide students with opportunities to discuss technological knowledge as knowledge that technologists agree is important for the development of a successful outcome and that if this knowledge is useful for a number of situations it can be codified for quick reference. For example; material tolerances, ratios, dosage.	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 3, teachers could: • provide students with a range of technological outcomes with unknown functions to explore and guide them to make informed suggestions regarding who might use them and the possible function they could perform, as based on an exploration and analysis of their physical nature • provide students with the opportunity to explore a range of technological outcomes that are similar in their functional nature but have differences in their physical natures and vice versa • support students to understand that the intended use and users, socio-cultural and physical locations all combine to determine how the physical and functional attributes can be best matched for optimum fitness for purpose. For example; a selection of brooms could be described as having similar functional attributes (clean an area by sweeping unwanted material to another location, able to be used while standing) but whether they are for a young child to sweep dust of the kitchen floor or for an adult to sweep water off driveways will mean quite different physical attributes will be decided upon to ensure the broom is fit for its purpose. Alternatively, 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 (for example a chair for a child will constrain the dimensions of the chair) and the physical nature options will set boundaries around what functional nature is feasible for a technological outcome at any time (for example heavy cast iron pots will not be suitable for everyday use by the elderly) • guide students to understand that the judgment of a technological outcome as a 'good' or 'bad' is related to the match between its physical and functional nature, its intended user/s and the context they would normally use it in.
INDICATORS Students can: • describe how societal and/or environmental issues can influence what people decided to make, how they would undertake planning, the selection of resources, and how they would make and test an outcome • explain why particular technological outcomes have changed over time • describe examples of how technology has impacted on the social world over time • describe examples of how technology has impacted on the natural world over time • identify that technological knowledge is knowledge that technologists agree is useful in ensuring a successful outcome.	**INDICATORS** Students can: • describe possible users and functions of a technological outcome based on clues provided by its physical attributes • 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 why a technological outcome could be called a 'good' or 'bad' design..

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 below.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Students will: Understand how technological development expands human possibilities and how technology draws on knowledge from a wide range of disciplines.	**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 technology at level 4, teachers could: • provide students with opportunities to examine a range of technologies that have and/or could expand human possibilities by changing people's sensory perception and/or physical abilities. Examination of technologies should allow students to gain insight into how decisions are based on both what *could* and what *should* happen • guide students to understand that 'expanding human possibilities' can result in positive and negative impacts on societies and natural environments and may be experienced differently by particular groups of people • provide students with opportunities to examine and debate examples of innovative technologies 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. • provide students opportunity to explore the wide range of knowledge and skills from diverse disciplines that support technology • provide students opportunity to explore differences between technological knowledge and knowledge from other disciplines • guide students to analyse a range of examples of technological practices and to identify the knowledge and skills that informed initial design decisions and ongoing manufacturing decisions. Examples should be drawn from within their own and others' technological practice and allow students to gain insight into how technological knowledge and skills, and knowledge and skills from other disciplines, can support technology.	**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 guide 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 negative impacts. Impacts may be in terms of expected action not resulting, damage to the outcome, injury to the user, the damage to the social or physical environment – or any combination of these • provide students with a description of an identified purpose (e.g. a stated need or opportunity) and other relevant details. These details should include such things as intended users and the environment in which it is to be situated. Support students to generate potential designs for a technological outcome and describe the physical and functional attributes it would require if it could be justified as a good design leading to an outcome that was fit for purpose.
INDICATORS Students can: • identify examples where technology has changed people's sensory perception and/or physical abilities and discuss the potential short and long term impacts of these • identify examples of creative and critical thinking in technological practice • identify and categorise knowledge and skills from technology and other disciplines that have informed decisions in technological development and manufacture	**INDICATORS** Students can: • explain the proper function of existing technological outcomes • explain how technological outcomes have been successfully used by end-users for purposes other than what they were originally designed for • explain how technological outcomes have been unsuccessfully used by end-users for purposes other than what they were originally designed and discuss the impacts of this • explain possible physical and functional attributes for a technological outcome when provided with intended user/s, a purpose, and relevant social, cultural and environmental details to work within.

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 below.

Characteristics of Technology	Characteristics of Technological Outcomes
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.	**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 technology at level 5, teachers could: • provide students with opportunities to examine and debate examples of innovative technological developments. Examples should draw from the past and present and allow students to explore how creative and critical thinking impacts on developments and how what could happen and what should happen were considered • guide students to analyse a range of examples of technologies to examine how people's perceptions and/or level of acceptance has influenced the practices and decisions underpinning their development and implementation. Examples should be drawn from the past and present to allow students to gain insight into the influence past experiences have on the perception and acceptance of existing and future technological practice and outcomes • guide students to analyse a range of examples of technological practices to identify codified technological knowledge that was used to inform design and manufacturing decisions. Technological knowledge becomes codified when technological experts consider it is useful for a number of situations. Codified technological knowledge refers to such things as codes of standards, material tolerances, and codes of practice including codes of ethics, intellectual property codes, 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 provides others with access to established knowledge and procedures that have been shown to support successful technological developments in the past and can serve to remind technologists of their responsibilities. In this way codified knowledge can be used to provide constructional, ethical and/or legal compliance constraints on contemporary technological practice • provide students with opportunities to discuss 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.	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 5, teachers could: • guide 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 • guide 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 outcome's designed lifespan • guide 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. Operational parameters refer to the boundaries and/or conditions within which the outcome has been designed to function.
INDICATORS Students can: • discuss examples of creative and critical thinking that have supported technological innovation • explain how people's past experiences of technology (both in terms of the nature of practices undertaken and the initial development and ongoing manufacturing of outcomes) influences their perception of technology • explain how people's perception of technology influences their acceptance of technology • explain how people's perception of technology impacts on future technological development • explain how and why technological knowledge becomes codified • explain the role codified knowledge plays in technological practice.	**INDICATORS** Students can: • explain why time and context are important criteria for judging the fitness for purpose of technological outcomes • evaluate past technological outcomes in the light of experiences subsequent to their development and/or contemporary understandings • explain what is meant by the malfunction of technological outcomes • explain the cause/s of particular technological outcome malfunction.

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 below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand the interdisciplinary nature of technology and the implications of this for maximising possibilities through collaborative practice.

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 technological development and explain how different disciplines have impacted on the nature of the technological practice undertaken and how this in turn has influenced understandings of the contributing disciplines. Examples should include those from the students own work and others' technological practice and allow students to gain insight into the interdisciplinary nature of technological practice
- support students to explore 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 include those from the students own work and others' technological practice and allow students to gain insight into the way idea generation and exploration can be enhanced through collaboration
- support students to understand that interdisciplinary collaboration provides exciting opportunities to 'work at the boundaries' of established fields and appreciate that this may lead to situations where no codified technological knowledge exists to guide practice, tensions between people may arise, and a greater number of unknown consequences may result
- provide students with opportunities to discuss how the interdisciplinary nature of technology and the need for collaboration can influence how technology is understood and accepted by different groups in both positive and negative ways.

INDICATORS

Students can:

- explain how different disciplines have impacted on technological practice
- explain why collaboration is important in technological developments that involve interdisciplinary work
- explain how interdisciplinary collaboration in technology can enhance and/or inhibit technological development and implementation
- describe examples of interdisciplinary collaboration in technology that has influenced, or could influence public understanding and acceptance of technology.

Characteristics of Technological Outcomes

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 technological outcomes at level 6, teachers could:

- support students to discuss 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 describe, and/or analyse it
- guide students to explore examples of socio-technological environments to explain how technological outcomes (products and systems) and non-technological entities and systems (people, natural environments, political systems etc.) interact together . 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.
- support students to understand that interactions in socio-technological environments are complex and result in dynamic relationships between technological outcomes, entities and systems. Guide students to explore the influences and impact of these relationships on the way technological outcomes are developed and manufactured.

INDICATORS

Students can:

- explain why some technological outcomes can be described as both a product and a system
- describe socio-technological environments and the relationships of technological outcomes involved
- discuss the interactions between technological outcomes, people, and social and physical environments within particular socio-technological environments
- explain why understanding socio-technological environments allow technological outcomes to be better understood.

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 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: • provide students with opportunities to discuss the inseparable nature of technology and society and guide them to explore examples to analyse instances of the complex intertwining of society and technology. Contexts for exploration could be selected from areas such as; communication practices and communication technologies, life experiences and medical technologies, sporting endeavours and equipment/enhancement technologies • provide students with opportunities to discuss technology as a field of on-going contestation and competing priorities that require resolution through complex decision making and guide students to recognise the role of functional and practical reasoning in such decision making • guide students to critically analyse examples of technological practice to gain insight into how technologists identify and deal with contestable issues by understanding socio-cultural influences. Socio-cultural influences include such things as: social; cultural; political; environmental; and economic influences. This can be done through understanding the socio-cultural influences on fundamental aspects of technology in a particularly defined setting. Aspects of technology include such things as: problem identification and refinement to establish needs and opportunities; the development of designs and technological outcomes; resource selection and justification; post development manufacturing; implementation and ongoing in situ evaluation; maintenance and disposal; and ethical, social and moral responsibilities • guide students to critically analyse examples of technological practice to gain insight into how technologists take competing priorities into account during decision making. Competing priorities include such things as: innovation versus acceptance/continuation; time versus quality; majority acceptance versus acceptable to all; social versus environmental benefit; ethical versus legal compliance etc. • guide 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 can support innovative decision making and outcomes. Opportunity should also be provided to critique innovative developments in terms their impact on how technology is understood and accepted by different groups in both positive and negative ways.	**TEACHER GUIDANCE** To support students to develop understanding of characteristics of technological outcomes at level 7, teachers could: • provide students with opportunities to discuss how malfunction can impact on the design or manufacturing of similar and related technological outcomes • provide students with opportunities to identify that form refers to the physical nature of a technological outcome and function refers to the functional nature of the outcome. Design elements related to an outcome's physical nature include such things as: colour; movement; pattern; proportion; harmony; taste etc. Design elements related to an outcome's functional nature include such things as strength; durability; stability; efficiency; nutritional value etc. Design elements are prioritised in different ways as determined by such things as a designer's intent for the outcome, understandings of materials, the socio-cultural location the outcome is to be situated, professional and personal beliefs etc. • support students to critically analyse the physical and functional nature of technological outcomes to identify how design elements appear to have been prioritised and to explain how such a priotisation could be justified • support students to analyse the prioritisation of design elements in particular technological outcomes with respect to the intended purpose of the technological outcome, intended users and specific context, the wider socio-technological environment it was a part of, and the era of its development and to make informed judgments as to the outcome's fitness for purpose.
INDICATORS Students can: • discuss examples to illustrate how socio-cultural factors influence technology and in turn technology influences socio-cultural factors in complex and ongoing ways • explain technology as a field of on-going contestation and why competing priorities arise • explain how influences and priorities have been managed in technological decisions of the past • explain how critical evaluation, informed creativity and boundary pushing impacts on technological development and public views of technology.	**INDICATORS** Students can: • explain how malfunction can impact on the design and/or manufacture of similar and related technological outcomes • justify how the design elements appear to have been prioritised in technological outcomes • justify the fitness for purpose of technological outcomes in terms of their physical and functional nature and socio-technological environment/s they are used within.

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 below.

Characteristics of Technology

ACHIEVEMENT OBJECTIVE

Students will:

Understand the implications of technology as intervention by design and how interventions have consequences, known and unknown, intended and unintended.

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 and 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.
- support students to explore and critique the role of technology in the creation of sustainable environments. This would include discussion of 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.

INDICATORS

Students can:

- discuss technology as intervention by design and explain the impacts and implications of this
- discuss why technology can challenge people's views of what it is to be 'human'
- critique the role of technology in the development of sustainable environments
- discuss future scenarios where technology plays out different roles and justify projected impacts.

Characteristics of Technological Outcomes

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 technological outcomes at level 8, teachers could:

- provide students with opportunity to extend their understanding of fitness for purpose. This extended notion is called 'fitness for purpose in its broadest sense' and refers to the 'fitness' of the outcome itself as well as the practices used to develop the outcome (e.g. such things as the sustainability of resources used, ethical nature of testing practices, cultural appropriateness of trialing procedures, determination of lifecycle and ultimate disposal)
- support students to explore the implications of a commitment to developing technological outcomes that are fit for purpose in the broadest sense on the design, development and manufacturing of technological outcomes
- support students to critically analyse a range of technological outcomes to evaluate their fitness for purpose, in its broadest sense. The evaluation 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
- support students to explore possible benefits and disadvantages of employing the notion of fitness for purpose in its broadest sense in different contexts related to the design and development, manufacture, evaluation and analysis of technological outcomes.

INDICATORS

Students can:

- discuss the implications of viewing fitness for purpose in its broadest sense on the design and development of technological outcomes
- discuss the implications of viewing fitness for purpose in its broadest sense on the manufacture of technological outcomes
- justify the fitness for purpose, in its broadest sense, of technological outcomes
- debate the value of employing the notion of 'fitness for purpose in its broadest sense' as related to: the design and development, manufacture, evaluation and analysis of technological outcomes.

Components of Technological Knowledge

The Indicators of Progress within the Technological Knowledge section are divided into three components:

Technological Modelling

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 focusses on 'how to make it happen' and 'how it is happening'. Practical reasoning focusses 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.

Technological Products

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.

Technological Systems

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.

More information on each of these components can be found in the Technological Knowledge Explanatory Papers.

NOTE: The Indicators of Progression for the components of Technological Knowledge can be used to guide and support formative and summative assessment, and provide a basis for reporting purposes. These were originally based on the work of Compton and France. For details of the research underpinning these components please refer to Compton V.J and France B.J. (2007). Towards a New Technological Literacy: Curriculum Development with a Difference. In *Curriculum Matters 3*: 2007158-175.Wellington: NZCER. The teacher guidance and indictors have been revised and further developed by Dr V Compton and A Compton as a part of the Ministry of Education funded research project: *Technological Knowledge and Nature of Technology: Implications for teaching and learning*.

COMPONENTS OF TECHNOLOGICAL KNOWLEDGE: INDICATORS OF PROGRESSION LEVEL ONE

Teachers should establish if students hold any misconceptions or partial understandings that would inhibit them 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 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: • provide students with the opportunity to discuss why technological modelling is important to the development of technological outcomes and that it involves both functional modelling and prototyping. • guide students to identify that functional models are representations of potential technological outcomes and that they exist in many forms (e.g. thinking, talking, drawing, physical mock-ups, computer aided simulations etc) • provide students with the opportunity to discuss that design concepts includes design ideas for parts of an outcome, as well as the conceptual design for the outcome as a whole • provide students with the opportunity to interact with a variety of functional models and guide them to identify that the purpose of functional modelling is to test design concepts to see if they are suitable for use in the development of an outcome • guide students to identify that prototypes are the first versions of fully completed technological outcomes • provide students with a range of prototyping examples and guide them to identify that the purpose of prototyping is to test the outcome. • examples should include the modelling practices of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 1, teachers could: • provide students with a range of technological products and encourage them to explore these through such things as: using, ‘playing’, dismantling and rebuilding as appropriate • guide students to identify the materials that the products explored are made from • provide opportunity for students to discuss that performance properties of materials refer to such things as thermal and electrical conductivity, water resistance, texture, flexibility, colour etc. • provide students with the opportunity to explore common materials and guide them to identify their performance properties • provide students with a range of technological products to explore and guide them to identify ways in which materials have been manipulated to make the product. For example, in a wooden toy the wood has been shaped, sanded and painted; In a sandwich, the bread dough has been shaped, cooked and sliced; in a cushion the fabric has been cut and sewn together.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 1, teachers could: • provide students with a range of technological systems and encourage them to explore these through such things as: using, ‘playing’, dismantling and rebuilding as appropriate • guide students to identify the components and how they are connected in the systems explored • guide students to identify the inputs and outputs of technological systems and provide opportunity for them to recognise that a controlled transformation has occurred.
INDICATORS 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** Students can: • identify materials that technological products are made from • identify performance properties of common materials • identify how the materials have been manipulated to make the product.	**INDICATORS** 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 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: • guide students to understand that design concepts refers to design ideas for parts of an outcome, as well as the conceptual design for the outcome as a whole • provide students with the opportunity to explore a variety of functional models and identify the specific design concept/s being tested • guide students to discuss the sorts of things that could be explored and tested using functional modelling • provide students with a range of prototyping examples and guide them to identify the specifications that were used to evaluate the prototype • provide students with the opportunity to discuss how specifications provide a way of measuring the fitness for purpose of the prototype • examples should include the modelling practices of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 2, teachers could: • guide students to understand that performance properties of materials refer to such things as thermal and electrical conductivity, water resistance, texture, flexibility, colour etc. • provide students with the opportunity to research and experiment with a range of materials and guide them to describe how their performance properties relates to how they could be useful. For example, a material that was water and UV resistant, durable, and easily cleaned could be useful for outdoor furnishings • provide students with the opportunity to research and experiment with a range of materials and guide them to describe how particular materials can be manipulated. • provide students with a variety of technological products to explore and encourage them to explore these through such things as: using, ‘playing’, dismantling and rebuilding as appropriate • guide student to describe the relationship between the materials selected and their performance properties. For example, a school lunch box is made of plastic because plastic can be molded into different shapes, and is hard, durable, lightweight and easily cleaned.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 2, teachers could: • provide students with the opportunity to identify that simple technological systems are systems that have been designed to change inputs to outputs through a single transformation process • provide students with a range of simple technological systems and encourage them to explore these through such things as: using, ‘playing’, dismantling and rebuilding as appropriate • guide student to understand the role of each component and to identify the changes that are occurring in the 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 Students can: • describe the sorts of things that functional modeling can be used for in technology • identify the design concept being tested in particular functional models • identify why prototyping is important in technology • identify the specifications used to evaluate particular prototypes.	**INDICATORS** Students can: • describe the performance properties of a range of materials and use these to suggest things the materials could be used for • describe feasible ways of manipulating a range of materials • suggest why the materials used in particular technological products were selected.	**INDICATORS** 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 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 different forms of functional modelling and guide students to gain insight into the different types of information that have been gathered • provide students with the opportunity to discuss how functional modelling informs decision making and guide them to identify the benefits and limitations of functional modelling in examples provided • provide students with the opportunity to understand that benefits include such things as reducing the risk of wasting time, money and materials and 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 discuss that specifications include both acceptability and feasibility considerations related to the outcome's fitness for purpose • provide students with the opportunity to explore a range of examples of prototyping and guide them to gain insight into how appropriate information can be gained to evaluate a technological outcome's fitness for purpose against the specifications • provide students with the opportunity to discuss the role of functional modelling and prototyping to develop an understanding of the importance of both in technological development. • examples should include the modelling practices of technologists and should provide students with the opportunity to explore both successful prototypes and those that did not meet specifications.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 3, teachers could: • provide students with the opportunity to discuss that performance properties of materials can be measured objectively and subjectively. Subjective measurement is reliant on people's perception (tasty, evokes a sense of natural beauty, warm and inviting etc) where as objective measurement is not (conductivity, UV resistance etc). The fitness for purpose of a product relies on the material providing appropriate performance properties to ensure the product is technically feasible and acceptable (safe, ethical, environmentally friendly, economically viable, etc -as appropriate to particular products) • provide students with a variety of technological products to explore and guide them to identify the performance properties of all the materials used, and to explain if these could be measured objectively or subjectively • provide students with a variety of technological products and guide them to explain how properties combine to make the product both technically feasible and socially acceptable.	**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 • guide students to understand that a 'black box' is a term used to describe a part of a system where the inputs and outputs are known but the transformation process is not known • provide examples of technological systems that contain unknown transformation processes (black boxes) and guide them to understand the role these play in terms of the advantages and/or disadvantages for developers and users • provide opportunity for students to discuss that the fitness for purpose of a technological system relies on the selection of components, and how they are connected to ensure the system is technically feasible and acceptable (safe, ethical, environmentally friendly, economically viable, etc -as appropriate to particular systems) • 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 Students can: • discuss examples to identify the different forms of functional models that were used to gather specific information about the suitability of design concepts • identify the benefits and limitations of functional modelling undertaken in particular examples • describe examples of particular prototypes that did not meet specifications. • explain why functional modelling and prototyping are both needed to support decision making when developing an outcome.	**INDICATORS** Students can: • describe the properties of materials used in particular products that can be measured objectively • describe the properties of materials used in particular products that can be measured subjectively • describe how the properties combine to ensure the materials allow the product to be technically feasible and socially acceptable.	**INDICATORS** Students can: • describe what 'black box' refers to within a technological system and the role of particular black boxes within technological systems • identify possible advantages and disadvantages of having black boxed transformations within particular technological systems • describe how the components, and how they are connected, allow particular systems to be technical feasible and socially acceptable • describe particular 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 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: • provide students with the opportunity to explore how using different media influences the type of information that can be gathered • provide students with the opportunity to discuss how different possibilities can be explored through functional modelling of design concepts and prototyping in order to make socially acceptable as well technically feasible decisions • guide students to examine examples of functional modelling practices to identify how these were used to explore possibilities and gather different types of information to justify design decisions • guide students to examine examples of prototyping and identify how information from these were used to justify the fitness for purpose of technological outcomes or to identify the need for further development • examples should include the modelling practices of technologists and should include instances where refinements to the prototype were required to meet specifications.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 4, teachers could: • provide students with the opportunity to discuss what is meant by materials being formed, manipulated and transformed. Forming refers to bringing two or more materials together to formulate a new material resulting in a different overall composition and structure to that of the original materials. This results in different performance properties. For example: mixing flour, water and salt to make dough; mixing wood fibres, resin and wax to make MDF; glass fibre and a polymer resin combined to form fiberglass or fibre reinforced polymer (FRP). Manipulating materials refers to 'working' existing materials in ways that do not change their properties as their composition and structure is not altered. For example: cutting; molding; bending; jointing; gluing; painting. Transforming refers to changing the structure of an existing material to change some of its properties, but in terms of its composition, it remains the same material. For example: felting; beating an egg white; steaming timber to soften its fibres and allow it to be manipulated (bent) • guide students to understand that for materials to be selected for use in a technological product, their performance properties must align with the desired specifications of the product. • guide students to recognise that during development of a product, specifications are established that will require the manipulation, and in some cases, transformation and formation, of materials. • provide students with a variety of technological products to explore and guide students to identify examples of when materials needed to be manipulated, transformed and/or formed to enable material linked specifications of the product to be met and contribute to the product's fitness for purpose. • provide students with a scenario outlining technical and acceptability specifications for a product and support them to explore and research materials to determine what material would be suitable and how they could be manipulated and/or transformed to meet product specifications • support students to communicate material related details effectively. Material related details include such things as what materials would be feasible and how they would need to be formulated, manipulated and/or transformed. Effective communication uses specialised language and symbols.	**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 guide them to identify how transformation processes are controlled • support students to understand that control mechanisms can function to enhance the fitness for purpose of technological systems by maximising the desired outputs and minimising the undesirable outputs • provide students with a scenario outlining technical and acceptability specifications for a system and support them to explore and research components and connectivity factors to determine what components would be suitable and how they could be connected to meet system specifications • support students to communicate system related details effectively. System related details include such things as what components would be feasible, layout requirements, and how they would need to be connected. Effective communication uses specialised language and symbols.
INDICATORS Students can: • explain how functional modelling and prototyping allows for consideration of both what 'can' be done and what 'should' be done when making decisions • discuss examples to illustrate how particular functional models were used to gather specific information about the suitability of design concepts • identify information that has been gathered from functional models about the suitability of design concepts and describe how this information was used • describe examples to illustrate how prototypes were tested to evaluate a technological outcome's fitness for purpose • identify information that has been gathered from prototyping and describe how this information was used.	**INDICATORS** Students can: • describe examples to illustrate how the manipulation of materials contributed to a product's fitness for purpose • describe examples to illustrate how the transformation of materials contributed to a product's fitness for purpose • describe examples to illustrate how the formulation of new materials contributed to a product's fitness for purpose • communicate, using specialised language and drawings, material related details that would allow others to create a product that meets both technical and acceptability specifications.	**INDICATORS** Students can: • explain how transformation processes within a system are controlled • describe examples to illustrate how the fitness for purpose of technological systems can be enhanced by the use of control mechanisms • communicate, using specialised language and drawings, system related details that would allow others to create a system that meets both technical and acceptability specifications.

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 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: • provide opportunity for students to identify practical and functional reasoning underpinning technological modelling. *Functional reasoning* provides a basis for exploring the technical feasibility of the design concept and the realised outcome. 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 acceptability (including socio-cultural and environmental dimensions) surrounding the design concept and realised outcome. That is, the reasoning around decisions as to 'should it happen?' in functional modelling and 'should it be happening?' in prototyping. • provide opportunity for students to explore how informed and justifiable design decision making relies on both functional and practical reasoning and draws from evidence provided from modelling • guide students to analyse examples of functional modelling practices to explain how these were used to gain evidence to justify design decisions with regards to both technical feasibility and acceptability. Such justifications will rely on the synthesis of evidence gained from modelling that sought feedback from different stakeholders. • guide students to analyse examples of prototyping to explain how results were to used justify an outcome as fit for purpose or requiring refinement. • provide opportunity for students to understand that maintenance requirements can be identified through prototyping and guide them to identify that maintaining an outcome can involve controlling environmental influences and/or undertaking ongoing refinements of the technological outcome • support students to gain insight from prototyping examples into how testing procedures can provide information regarding maintenance requirements of a technological outcome • examples should include the modelling practices of technologists and should include instances where refinements to the prototype were required to meet specifications.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 5, teachers could: • guide students to understand that the composition of materials determines what performance properties it exhibits. Composition relates to such things as the type and arrangement of particles that make up the material. • support students to analyse examples of how materials have been selected to gain insight into how this selection relies on understanding the composition of the materials available and using this knowledge to help decide which materials in combination would provide the best 'fit' with the product specifications • examples should include the material selection practices of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 5, teachers could: • guide students to understand that the properties of a subsystem relate to its transformation performance and its level of connective compatibility and that additional interface components may be required to ensure a subsystem can be effectively integrated into a system • provide students with the opportunity to analyse a range of examples of complex technological systems that contain at least one subsystem. Complex technological systems are those designed to change inputs to outputs through more than one transformation process • guide students to identify subsystems within technological systems and explain them in terms of their properties • support students to use examples to gain insight into how the selection and interfacing of subsystems relies on understanding the transformation and connective properties of subsystems to ensure the best 'fit' with the required system specifications • examples should include the subsystem selection and interfacing practices of technologists.
INDICATORS Students can: • identify examples of functional and practical reasoning within design decision making • explain how evidence gained from functional modelling was used to justify design decisions • identify examples of functional and practical reasoning underpinning prototype evaluations and the establishment of maintenance requirements • explain how evidence gained from prototyping was used to justify outcome evaluation as fit for purpose or in need of further development.	**INDICATORS** Students can: • discuss examples to illustrate how the composition of materials determines performance properties • explain the link between specifications of a product and the selection of suitable materials for its construction • discuss examples to illustrate how decisions about material selection take into account the composition of the material and the specifications of the product.	**INDICATORS** Students can: • identify subsystems within technological systems and explain their transformation and connective properties • discuss how transformation and connection properties of subsystems impact on system layout and component selection • discuss examples to illustrate how interfaces take into account the connective compatibility between subsystems and other system components.

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 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 explain how practical and functional reasoning underpin technological modelling. *Functional reasoning* provides a basis for exploring the technical feasibility of the design concept and the realised outcome. 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 acceptability (including socio-cultural and environmental dimensions) surrounding the design concept and realised outcome. That is, the reasoning around decisions as to 'should it happen?' in functional modelling and 'should it be happening?' in prototyping. • 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. • 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 • support students to analyse examples of technological modelling to understand how risk is explored and identified within particular technological developments. • examples should include the modelling practices of technologists and should include instances where modelling was undertaken to explore and identify risk.	**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 the composition and structure of materials impacts on how they can be manipulated and/or transformed, or combined to formulate a new material. • guide students to 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. • support students to analyse examples of how materials have been evaluated to determine their suitability for use in particular technological products • examples should include the material evaluation practices of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 6, teachers could: • guide students to understand the role subsystems play in the design, development and maintenance of complex technological systems. Complex technological systems are those designed to change inputs to outputs through more than one transformation process. • support students to indentify why subsystems may be 'black boxed' for development and/ or maintenance purposes and guide them to understand how 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). • guide students to understand how control and feedback at a system level allow 'back up' or 'shutdown' subsystems to be employed to reduce malfunction and/or component damage • support students to analyse examples of how subsystems have been selected and used in particular complex technological systems. • support students to use examples to gain insight into how the use of subsystems can impact on system design, development and maintenance • examples should include system design, development and maintenance practices of technologists.
INDICATORS Students can: • describe practical and functional reasoning and discuss how they work together to enhance decision making during technological modelling • explain the role of technological modelling in the exploration and identification of possible risk/s • discuss examples to illustrate how evidence and reasoning is used during functional modelling to identify risk and make informed and justifiable design decisions • discuss examples to illustrate how prototyping provides information to determine maintenance requirements to ensure minimal risk and optimal performance over time.	**INDICATORS** Students can: • explain how the composition and structure of different materials enables them to be manipulated in specific ways • explain how the composition and structure of materials determines the ways they can be transformed • explain how the composition and structure of materials impacts on how they can be combined to formulate a new material • describe the role of material evaluation in determining material suitability for use in a technological product • discuss examples to illustrate how material evaluation informed the selection of materials in particular product development.	**INDICATORS** Students can: • explain the variety of roles played by subsystems in complex technological systems • explain the implications of using subsystems during the design, development and maintenance of complex technological systems • describe examples to explain how control and feedback requirements impact on subsystem use. • discuss 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 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 explore how context impacts on the perception of the validity of evidence presented. Therefore, shifting from one context to another can change the status of the evidence provided by technological modelling. • support students to explore how and why 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 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 analyse examples of technological modelling to understand how risk is ascertained and mitigated within particular technological developments • examples should include the modelling practices of technologists and should include instances where modelling was undertaken to mitigate risk.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 7, teachers could: • support students to 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 • support students to explore a range of subjective and objective evaluative procedures used to identify the suitability of materials for different uses • support students to describe the underpinning concepts and processes related to subjective and objective evaluative procedures • support students to understand the selection of appropriate material evaluation procedures relies on understanding the composition and structure of materials, how their properties can be enhanced through manipulation or transformation, the performance criteria required by technological products and an understanding of the physical and social context within which the technological product will be situated • support students to identify and analyse examples of how materials have been evaluated to allow material selection decisions that maximize the potential fitness for purpose of particular technological products and to gain insight into how material evaluation procedures can be used to identify product maintenance and disposal implications and therefore inform design, development and post production care decisions • examples should include the material evaluation practices of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 7, teachers could: • support students to understand the concepts of redundancy and reliability in relation to technological systems. *Redundancy* relates to the inclusion of more time, information and/or resources than would strictly be needed for the successful functioning of the technological system. *Reliability* relates to the probability that a system will perform a required function under stated conditions for a stated period of time • support students to identify and analyse a range of examples of technological systems to gain insight into how redundancy and reliability factors have impacted on system design, development and maintenance decisions • examples should include system design, development and maintenance practices of technologists.
INDICATORS Students can: • discuss examples to illustrate why the status of evidence gained from technological modelling might change across contexts • explain why different people accept different types of evidence as valid and how this impacts on technological modelling • 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** Students can: • discuss a range of subjective and objective evaluative procedures used to determine the suitability of materials and describe the underpinning concepts and processes involved in particular procedures • discuss examples of material evaluation procedures undertaken to support material selection decisions and justify the appropriateness of these procedures • discuss examples to explain how material evaluation impacted on design and development decisions • discuss examples to explain how material evaluation impacted on maintenance and disposal decisions.	**INDICATORS** Students can: • explain the concept of redundancy in relation to technological systems • discuss examples of particular technological systems to illustrate how factors related to redundancy impacted on system design, development, and/or maintenance decisions. • explain the concept of reliability in relation to technological systems • discuss examples of particular technological systems to illustrate how factors related to reliability impacted on system design, development, and/or maintenance decisions.

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 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 decisions are made during the design, development and any subsequent manufacturing of technological outcomes. • support students to critically analyse examples of technological modelling practices that were undertaken to address 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. • examples should include the modelling practices of technologists and should include instances where modelling was undertaken to deal with competing and contestable factors.	**TEACHER GUIDANCE** To support students to develop understanding of technological products at level 8, teachers could: • support students to understand that material evaluation enables decisions to be made about what material would be optimal to ensure the fitness for purpose when taking into account both the technical feasibility and social acceptability of the product. • support students to critically analyse a range of subjective and objective evaluative procedures used to justify material suitability and to explain the underpinning concepts and processes involved in these procedures • support students to understand why the selection of appropriate material evaluation procedures relies on understanding the composition and structure of materials, how their properties can be enhanced through manipulation or transformation, the performance criteria required by technological products and an understanding of the physical and social context within which the technological product will be situated. • support students to understand that the development of new materials relies on understanding: existing materials including their advantages and limitations; new material composition and structure possibilities; formulation procedures; future requirements, needs and desires; and an awareness that new evaluative procedures may need to be developed to determine the suitability of new materials • support students to identify and analyse examples where new materials have been developed, including past and contemporary examples, to gain insight into how material formulation and subsequent evaluation procedures are used to address performance, maintenance and disposal implications and inform design and development decisions • examples should include material development (including formulation procedures) and evaluation practices of technologists.	**TEACHER GUIDANCE** To support students to develop understanding of technological systems at level 8, teachers could: • support students to understand what operational parameters are and the role they play in the design, development and maintenance of technological systems. *Operational parameters* refer to the boundaries and/or conditions within which the system has been designed to function and are influenced by a number of factors associated with the technical feasibility and social acceptability of the system. • support students to identify and differentiate highly complex systems. Highly complex systems include self-regulatory and intelligent systems. *Self regulatory* systems are those that have been designed to adjust the functioning of transformation processes in response to feedback from any part of the system to produce desirable and known outputs. *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. • support students to identify and analyse a range of technological systems including simple, complex and highly complex technological systems • support students to use examples to gain insight into underpinning operational parameters and how these have impacted on and been influenced by system design, development and maintenance decisions. • examples should include system design, development and maintenance practices of technologists.
INDICATORS Students can: • explain the role of technological modelling in making informed, responsive and defensible design and development decisions • explain the role of technological modelling in making informed, responsive and defensible manufacturing decisions • discuss examples to illustrate a range of technological modelling practices that have been undertaken in situations with competing and contestable factors • critique examples of technological modelling practices in terms of how well they address underpinning factors.	**INDICATORS** Students can: • discuss examples of the formulation of new materials and explain the underpinning concepts and processes involved in their development • discuss examples of evaluation procedures undertaken to determine the suitability of new materials and explain the underpinning concepts and processes involved in particular evaluations • discuss examples of past material developments and explain how these impacted on product design, development, manufacturing, maintenance and disposal • discuss examples of contemporary material developments and suggest probable implications for future technological product design, development, manufacturing, maintenance and disposal.	**INDICATORS** Students can: • explain what operational parameters are in relation to technological systems • explain the operational parameters established for particular technological systems and explain the factors that influenced these • discuss examples of technological systems to illustrate how operational parameters impacted on system design, development and maintenance • discuss examples of simple, complex and highly complex technological systems to illustrate the demands that increasing complexity in system design requires in terms of establishing operational parameters.

TECHNOLOGY AND VALUES

INITIAL DISCUSSION OF THE RELATIONSHIP

Written by Dr Vicki Compton under contract to the Ministry of Education to support Technology in The New Zealand Curriculum

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

Written by Dr Vicki Compton under contract to the Ministry of Education to support Technology in The New Zealand Curriculum

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.