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.

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INTRODUCTION

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

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

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

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MINISTRY OF EDUCATION OVERVIEW

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

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

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

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

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

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

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

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MINISTRY OF EDUCATION GUIDANCE

Introduction

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

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

Overall Guidance

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

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

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

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

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

Implementation of the Technology Curriculum

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

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

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

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

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

Recommendations for Teachers

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

In 2008–2009:

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

From 2010:

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

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

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

Years 1-6: Recommendations for consideration by Teachers:

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

Years 7-8: Recommendations for consideration by Teachers:

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

Years 9-13: Recommendations for consideration by Teachers:

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

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

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EXPLANATION OF TERMS

Levels of Curriculum

National Curriculum

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

School Curriculum

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

Classroom Curriculum

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

Introductory Learning Area Statement

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

Technology Curriculum Strands

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

Components of Technological Practice Strand

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

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

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

Components of the Nature of Technology Strand

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

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

Components of Technological Knowledge Strand

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

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

Technological Outcomes

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

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

Achievement Objectives

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

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

Specific Learning Intentions

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

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

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

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

Technology Indicators of Progression

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

Context

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

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

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

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

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

Issue

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

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

Need or Opportunity

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

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

Attributes and Specifications

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

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

Fitness for Purpose in its Broadest Sense

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

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

Stakeholders

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

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

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

A NEW TECHNOLOGICAL LITERACY

Abstract

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

Technological Literacy in the *Technology in the New Zealand Curriculum* (1995)

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

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

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

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

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

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

Technological Literacy in *The New Zealand Curriculum* (2007)

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

- Technological Practice
- Nature of Technology
- Technological Knowledge

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

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

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

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

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

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

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

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

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

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

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

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

EXPLANATORY PAPERS

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

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

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

EXPLANATORY PAPER

The Technological Practice Strand:

Brief Development

Abstract

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

Component descriptor

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

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

Key Ideas

A brief in technology is defined as a succinct guiding document that is comprised of a conceptual statement that communicates, via any appropriate means (e.g. 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. A brief may also include additional constraints that impact on both the outcome, and the practice that must be adhered to when developing a technological outcome.

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, (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:

- explain what they had decided to develop and why they had chosen this particular type of snack, 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:

- explain the issue selected and why it is topical for the ICT community
- 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:

- 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:

- 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
- justify initial specifications for their presentation as a starting point for development work
- refine their conceptual statement and specifications as they undertook further research into the issue and its impact on the wider ICT community, and developed further skills and understandings of presentation design, typography and image manipulation
- develop a range of models to communicate different presentation ideas for trialling with key stakeholders within their target audience, to gain evidence of how both the information and its presentation impacted (positively and/or negatively) on the development of understandings of the issue
- establish specifications for their presentation in terms of aesthetics and performance, and evaluate their effectiveness in allowing for their own, their teacher's and key stakeholders' evaluation 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, 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 3 could:

- explain the need or opportunity identified from the selected issue and why it was important to Edges
- describe the key attributes required for an appropriate outcome that allowed them and their teacher to evaluate their progress, and the development of conceptual ideas of potential outcomes
- refine their conceptual statement and key attributes as they developed greater knowledge of the issue and the needs and preferences of the Edges' personnel

Students achieving at level 4 could:

- 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 into the issue within which the identified need or opportunity sat, explored techniques for developing and communicating conceptual ideas, and gained feedback from personnel working at Edges
- describe the key attributes required for potential outcomes and their presentation 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:

- justify the focus and nature of potential outcomes, based on understandings of the need or opportunity and discussions with key stakeholders associated with Edges
- justify initial specifications for potential outcomes that would resolve the need or realise the opportunity, and how they could be effectively communicated, as a starting point for development work
- refine their conceptual statement and specifications as they undertook further research into the issue within which the identified need or opportunity sat, experimented with a range of techniques for developing and communicating conceptual ideas, and gained feedback from key stakeholders associated with Edges
- present conceptual ideas to key stakeholders, to gain insight into what outcomes would be preferable and determine how effective their presentations were in conveying the key features of the design ideas
- establish specifications for any potential outcome, and for the communication of conceptual ideas of possible outcomes, 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:

- justify the focus and nature of potential outcomes, based on understandings of the need or opportunity, 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
- justify initial specifications for potential outcomes that would resolve the need or realise the opportunity, and how they could be effectively communicated 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
- establish specifications for any potential outcome, and for the communication of conceptual ideas of possible outcomes, that allowed them, their teacher, key stakeholders, and the wider community to provide critical evaluation regarding 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 7 could:

- 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
- justify initial specifications for potential outcomes that would address the issue, and how they could be effectively communicated to a range of audiences to provide evidence for future decision making
- refine their conceptual statement and specifications as they undertook further research into the issue as it relates to Edges, and the physical and social environment within which Edges functions
- explore and experiment with a range of sophisticated techniques for generating, developing, communicating and trialling conceptual ideas with different stakeholders such as Edges' staff, customers (past, current and potential future); utilise these techniques in trials. to gain critical feedback on both the conceptual ideas and the success of the techniques in communicating them
- establish specifications for any potential outcome, and for the communication of conceptual ideas of possible outcomes, that allowed them, their teacher, key stakeholders, and the wider community to provide critical evaluations regarding the effectiveness of their communicative drawings/displays to convey key design features, and the potential fitness for purpose of the conceptual ideas presented

Students achieving at level 8 could:

- justify the focus and nature of potential outcomes based on understandings of the wider context within which the selected issue sits, as well as understandings specific to Edges' physical and social environment
- justify initial specifications for potential outcomes that would address the issue, and how they could be effectively communicated to a range of audiences to collect a comprehensive evidence base for future decision making
- refine their conceptual statement and specifications, as they undertook further research into the issue as it relates to the wider context as well as that specific to Edges
- explore and experiment with a range of sophisticated techniques for generating, developing, communicating and trialling conceptual ideas with different stakeholders, such as Edges' staff, customers (past, current and potential future); utilise these techniques in trials, to gain critical feedback and capture any new ideas to further develop conceptual ideas and the techniques being used to communicate them
- establish specifications for any potential outcome, and for the communication of conceptual ideas of possible outcomes, that allowed them, their teacher, key stakeholders, and the wider community to provide critical evaluations regarding the effectiveness of their communicative drawings/displays to convey key design features, and the potential fitness for purpose in its broadest sense of the conceptual ideas presented

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 (including material, time and personnel) management, and provide appropriate documentation, and as such are critical for informed and responsive technological practice. Planning techniques can incorporate a range of specific planning tools that should be selected and/or developed on the basis that they are best suited to the nature of the practice being undertaken.

Planning tools include such things as: brainstorms, mind-maps, idea banks, reflective journals, and scrapbooks, plans of action, Gantt charts, flow diagrams, graphical organisers, and structuring / diagramming techniques. In order to work most effectively, ethically, 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. Such planning should take into account the physical and social environment into which the outcome is to be embedded, as well the environment in which the technological practice is occurring.

A significant aspect of this is the ongoing 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 historical contexts provides useful examples of a range of impacts and influences, which can help identification of impacts and influences within contemporary time periods and environments, as well as those that may be reliably forecast for potential future environments. Planning of this type maximises the potential for achieving successful outcomes, where successful is defined by fitness for purpose in its broadest sense.

Effective planning for practice should result in plans that are both flexible and robust. That is, they 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, they should be robust enough to provide clear guidance of 'where to next?', and ensure resource availability and sustainability. They should also provide a resource that can be reviewed in the future 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.

Documentation of planning/project management, and justifications of any changes required to future plans, should be through a range of strategies that best serve the purpose at the time. This may include oral, graphic, written, and electronic modes of documentation. Practice is enhanced when the documentation of planning strategies best meets the needs of all stakeholders, including the technologist themselves.

Practice should not be constrained by documentation requirements. Rather, appropriate documentation should enhance the practice undertaken and/or ensure any external requirements can be met as part of the practice itself. This is particularly important to ensure ethical or legal protocols are followed in a systematic and well managed way. For example, if developing an online resource, planning should ensure copyright issues are extensively explored, requirements noted and actions undertaken to comply well documented, for future reference.

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 extensive planning, critical evaluation of feedback, and planning for future maintenance. 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 in the process 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:

- describe 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
- describe how they plan to balance their toy by adding weight to the base of the fairy and make a storage compartment for the battery
- identify a thick piece of cardboard to use to for a heavy base, and a thinner piece of cardboard to fold into a shelf to hold the battery

Students achieving at level 2 could:

- identify the key stages required to complete an Angel toy with a spinning halo; explaining 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
- identify old pieces of card to use to make a working model of the Angel's body and the spinning mechanism, to test how well it works; identify new plain card, coloured pencils and ribbon to use in the final construction of the toy. Identify how much time it will take organise the materials they need, and make and test their toy
- record key stages and associated resources in a flow diagram

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
- identify 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
- record key stages in a plan of action and label conceptual ideas with suggested materials

Students achieving at level 3 could:

- explain the importance of the key stages and resources to the successful construction of a storage hut, within the timeframe and financial constraints
- explain the time allocated for each stage, and the knowledge that would be required for the group of students to progress their project
- record key stages and associated resources in a plan of action
- identify areas where they would require expert help, identify who could provide this help and how they could plan ahead to ensure they were available at key times
- review the initial plan of action, insert reflective comments on progress to date and revise the plan of action accordingl

Students achieving at level 4 could:

- explain and reflect on previous experiences of planning while undertaking technological practice, and use this to guide the identification of key stages and critical resources for the successful construction of a storage hut as defined in the brief
- plan future activities that would provide them with the knowledge and skill they need, and allow time for accessing additional materials and/or people as required to ensure the successful completion of a storage hut
- ensure time was allocated for meeting with stakeholders (teacher, others involved in garden, outside expert, principal, local council) to ensure ideas and materials selected were in keeping with their expectations
- document plans that incorporate associated resources, in such a way as to support ongoing reflection of progress and regular updating of planning as the project proceeds, and 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:

- explain the importance of each key stage in the development of the class capsule, and the implications of this for their own capsule in terms of size and time constraints
- explain what materials would be needed for the name stand, the resin artefact and the individual time capsule, and where they expect to access these
- draw diagrams detailing how the name stand, the resin artefact and the individual time capsule would be made and the materials needed for each
- identify particular knowledge and skills that would need to be developed personally, or accessed from another source, to complete their project
- review diagrams and modify, as a result of progress to date

Students achieving at level 4 could:

- explain and reflect on the planning decisions during the development of the class capsule, and explain how the implications of this for their own capsule have been taken into account when making initial action plans for their individual project
- 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 plan to use these to gain feedback from the teacher, technician and other students
- plan future activities that would provide the knowledge and skills they require to construct each part of their project; time with people at the museum was included in the plan, to ensure their perspectives could inform future planning
- review diagrams, develop step-by-step instructions, and compile a list of materials selected and where and how they could be accessed and/or developed
- document planning decisions and outcomes in a digital scrapbook of design ideas, including previous plans and instructions annotated with reflective comments showing why decisions had been made

Students achieving at level 5 could:

- analyse the planning decisions made during the development of the class capsule, and past planning they had been involved in to identify strengths and weaknesses
- explore the organizational practices of others and identify planning tools that were useful in allowing them to be successful; evaluate possible planning tools for use in this project and develop an action plan, Gantt chart and flow diagram template to use to support their practice. Document planning decisions and evaluations in a digital scrap book
- develop an initial action plan that included informed projections about the nature and timing of known skill and knowledge developing activities, and identified possible materials for the name stand, resin artefact and capsule
- 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. Review action plan to incorporate stakeholder feedback as required, to aid material selection based on suitability, accessibility and cost
- develop a Gantt chart to clearly align tasks to be done with their timeframes, and provide guidance for where to next
- review diagrams and further develop these to provide clear instructions on how each part of the project will be constructed and a list of final materials selected
- evaluate progress to date by reflecting on initial plan of action, drawings and Gantt chart; record in note form subsequent changes, modifications and/or refinements on the action plan and annotate with reasons why decisions were 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 3 could:

- explain the importance of key stages identified in their plans for developing a programme to meet the needs of an identified user
- explain the resources they needed to undertake each key task
- develop possible sketches and storylines for their programme
- identify particular knowledge and skills that they needed to develop
- develop a storyboard to guide the development of their programme

Students achieving at level 4 could:

- explain and 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
- 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:

- analyse previous planning decisions they had been involved in, to identify general factors that have led to successful planning
- explore the organisational practices of others and identify planning tools they had found useful
- 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' organisational 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 successful project management that take account of wider social and cultural issues
- identify personal strengths and weaknesses in relationship to project management in technology, and establish learning opportunities to develop and enhance these
- develop an initial plan that allowed for extensive exploratory work to establish the suitability of the selected context and issue within which the project was situated, with ongoing planning undertaken to ensure all aspects of the brief, and the factors identified in the wider context, taken into consideration in planning and resource decisions
- employ the use of specifically developed planning tools to support the project management of their work in an efficient 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), or any other outcome of technological practice (concepts, plans, models, etc.), involves the creative generation of design ideas and the refinement of potential outcomes. This is achieved through ongoing research, experimentation, analysis, testing, and evaluation against the specifications of the brief.

Developments should be based on the evaluation of the functional modelling undertaken during practice, and prior to the realisation of the outcome. Refinement of a realised technological outcome should be informed by evaluations from prototype testing *in situ*, in order to optimize its fitness for purpose. Outcome Development and Evaluation can be thought of as the trialling and production practices of technological practice.

Key Ideas

There are many types of outcomes of technological practice. The ultimate endpoint of any technological practice is the development of a technological outcome (that is, a technological product or system) that is fit for the purpose identified in the brief.

However, there are many situations where development work may end before this point. This component therefore, recognises that intermediate outcomes are both valid and important when technologists and students undertake technological practice.

Intermediate outcomes of technological practice could include such things as:

- a feasibility study with justified advice for future action – which may be that the development should not go ahead
- a formalised brief outlining the conceptual statement and specifications for a potential technological outcome
- concept sketches and/or working plans for a potential technological outcome or a part of the outcome
- a computer simulation of a potential technological outcome or part of the outcome
- a scale model of a potential technological outcome
- a prototype which is yet to be placed *in situ*

Technological practice to develop outcomes involves such things as: the creative generation of design ideas and the refinement of potential outcomes through ongoing research, experimentation, analysis, material testing, and evaluation against the specifications of the developing brief.

Initial trialling of ideas, both conceptually and practically, should allow for the identification of knowledge and skill required to enhance both the technological practice and the outcome, itself. This is often the point where context specific knowledge and skills are developed and evaluated for inclusion/exclusion. The development of appropriate knowledge and skills is essential for outcomes to be developed that are of a high quality.

Outcome development is enhanced through effective presentation of conceptual ideas to stakeholders, using a range of graphical and other visual communication techniques as deemed appropriate. Feedback from stakeholders should be critically analysed, to ensure it is used effectively.

Exploration of materials in terms of functionality and aesthetic impact, and in terms of current and future accessibility, availability and disposability, should be undertaken as extensively as possible. Interrogation of designs and planning should be done as fully as practicable prior to the selection of materials and their use in any final outcome.

Outcomes, and the practice undertaken to develop them, should be critically evaluated from a range of perspectives to ensure fitness for purpose is seen in its broadest sense. Evaluation of design ideas through functional modellingshould be undertaken extensively, to validate conceptual ideas as potentially being fit for purpose and to ensure stakeholder opinion is a key part of this evaluative process.

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

Evaluative data can be documented in a variety of ways: notes on mock-ups, photographs, audio/visual recordings of stakeholders' views, etc. As long as accurate evidence is presented there should be no requirement for extensive reworking of such data into formal written reports, unless this is a requirement of the specific practice being undertaken, for example as part of a feasibility study.

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

Illustrative Examples from Technology

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

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

In motor racing, ultimate advantage is gained through understanding the interaction between the technology of a vehicle and the environmental conditions within which it must perform. Once the key design features of a vehicle are decided, prototype testing is often the only way to refine the outcome to optimize performance.

Learning from past innovations to create contemporary products, prototype testing and ongoing modifications are key features of Graeme Addis's plans to win the New Zealand Sports Sedan Championship. For examples of how he developed and tested his outcome see the Techlink case study Winged Victory

Illustrative Examples from Technology Education

Learning experiences

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

Junior Primary (NE-Year 4)

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

Students achieving at level 1 could:

- draw design ideas for a seat, and develop models out of clay to represent what a selected idea may look in 3D
- identify the strengths and weaknesses of design ideas and be involved in discussions to select an appropriate design
- carry out assigned roles in developing the seat
- evaluate the Taniwha seat, in terms of how it looks in the garden setting and how comfortable it is to sit on

Students achieving at level 2 could:

- draw design ideas and explain why they would work well as a seat; create a model of the selected design that communicated the 'look' of the design idea as a potential outcome; develop a mock-up to test material use and construction techniques
- evaluate each model in terms of how well it would meet the needs of the envirogroup, and use these evaluations to participate in decision-making discussions of 'where to next?'
- offer suggestions for roles that would be required for the development of the seat, and carry out their role in an informed manner
- evaluate the Taniwha seat in terms of how it met the needs of the envirogroup

Senior Primary/Intermediate (Years 5-8)

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

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

Students achieving at level 2 could:

- develop logo designs for gift pack for use on the button and labels; trial different recipes for shampoo and wax to identify possible product ideas for recipient
- evaluate logo designs and product ideas as suitable or not for recipient, and select those appropriate for further development
- develop a gift pack containing products in keeping with the recipients needs
- evaluate the gift pack in terms of how it addressed the recipient's needs

Students achieving at level 3 could:

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

- evaluate the gift pack against key attributes identified in the brief and in terms of the recipient's needs

Students achieving at level 4 could:

- develop logo designs for gift pack that took into account the resources available, (material and manufacturing process of the button, size and material of labels); communicate design ideas to recipient to gain feedback; explore and test different recipes for shampoo and wax and research ingredients; compile a summary of findings for recipient to gather feedback on suitability, in terms of hair type and personal preferences concerning fragrance and ingredients
- evaluate logo design and product idea in terms of their ability to meet the needs and constraints identified from research into resources available and recipient feedback; 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 further refine products
- develop a gift pack containing products that incorporated all key attributes identified, and addressed the recipient's needs
- gather recipient feedback to provide evidence to use in an evaluation of the gift pack's fitness for purpose in terms of how well it addressed the opportunity

Junior Secondary (Years 9-10)

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

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

Students achieving at level 3 could:

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

Students achieving at level 4 could:

- develop designs for labels, and select a range of containers and product outcomes that reflect the selected client's colour, taste, nutritional requirements and requirements for making preferences, (i.e. ease of use, time to make); develop a functional model (for example, 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 mock-ups to gain further feedback from client on taste preferences (sensory testing using a hedonic scale) and nutritional concerns based on the ingredients used (discussion of recipes); test ingredients to identify any storage issues and explore how these may be influenced by container choice
- evaluate labels, containers and product ideas, and select a package design appropriate for further development, refine package design to ensure it incorporates key attributes.
- develop a prototype of bottled ingredients for client testing; refine product in keeping with client feedback on key attributes associated with the look and user friendliness of labelling and instructions and the quality of outcome produced

- develop a package of bottled ingredients, including labels for containers, that incorporate the key attributes as determined by the client's preferences, and address the constraints imposed by storage requirements
- gather client feedback to provide evidence to use in an evaluation of the package's fitness for purpose, in terms of how well it addressed the opportunity

Students achieving at level 5 could:

- experiment with a range of 'ready to make' food packages and analyse how labelling and packaging requirements enable the product to be successful – or not; reflect on past experiences of food preparation and use this analysis and reflection to develop a feasibility guide, to inform the generation of initial ideas for developing a 'batters in a bottle' food package
- develop designs for labels, and select a range of containers and product outcomes justified in terms of the requirements of the brief, (based on client preferences and specifications associated with storage, packaging and user friendliness); develop appropriate functional models (for example, concept diagrams, discussion prompts, photographs of container types, recipes, and photos of products); use the models to illustrate the range of options available and test initial design ideas as to how they may form a package; use models to gain critical feedback from the client on the specifications they consider essential.
- experiment with a range of labels, recipes and storage options, and seek input from additional sources, (research findings, other people who may eat the food product such as family members, friends, etc.), to determine suitability of resources in terms of the specifications
- refine package ideas, incorporating justified label designs, containers, recipes and ingredients, and undertake further functional modelling with the client to gain critical feedback to select one for further development; modelling included sensory testing of food product, functionality testing of containers, judgments on quality of label including clarity of instructions
- develop a prototype of bottled ingredients for client trialling in the environment for which the package is being developed; refine product in keeping with client feedback related to the specifications of the brief and any additional comments from others who viewed and/or used the package, or ate the food product
- use feedback from key stakeholders, including the client and teacher, to provide evidence to support an evaluation of the fitness for purpose in terms of the brief 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 3 could:

- develop design ideas for potential lighting products suitable for Sandwiches and communicate these to the client through annotated sketches and pictures and samples of possible materials
- evaluate designs based on client feedback and select one for further development
- explore possible materials to select those suitable for use in the lighting product
- develop a light that met safety requirements for certification and addressed the client's aesthetic and functional requirements
- evaluate the lighting product against key attributes identified in brief and in terms the client's needs

Students achieving at level 4 could:

- develop design ideas for potential lighting products reflective of the key aesthetic attribute established from Sandwiches 'Retro Kiwiana' style; develop a functional model (for example, using sketches, annotated diagrams, material samples, colour suggestions) to test design ideas with the client to gain feedback

- explore and test different materials for a range of potential lighting products ,taking into account key attributes of cost effectiveness and safety; create mock-ups to gain further feedback from client on preferences; explore possible means of production for different design ideas and evaluate these in terms of suitability for batch production
- evaluate design ideas, and select a design appropriate for further development; experiment with materials and design features to ensure they incorporated key attributes
- develop a prototype lighting product; gain product safety certification from registered electrician prior to trialling *in situ*, for client feedback; refine in keeping with client feedback on key attributes associated with the look and function of the lighting product
- present a final lighting product that incorporated the key attributes determined from the opportunity provided by the client's preferences and constraints imposed by budget, production and safety requirements
- gather client feedback to provide evidence to use in an evaluation of the lighting system's fitness for purpose, in terms of how well it addressed their needs/desires

Students achieving at level 5 could:

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

Students achieving at level 6 could:

- critically analyse a range of contemporary and historical lighting products for public venues, including those used in Sandwiches currently and in the past; critically reflect on experiences from previous technological practice – including tea lantern development; use this analysis and reflection to inform the generation of a range of initial ideas that explore the potential of the opportunity provided
- evaluate the design ideas to select those that are justified as appropriate in terms of the requirements of the brief (based Sandwiches style, client preferences and specifications associated with safety and batch production), and from the physical and social environment in which the lighting product is to be placed; develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, models to illustrate potential materials and their effect) to illustrate the range of options available and test initial design ideas of how they may work in the environment of Sandwiches; use models to gain critical feedback from the client, mentors and customers on the specifications they consider essential and desirable.

- experiment with a range of materials and design features, seeking guidance from additional sources (research findings, mentors, friends, etc.) to justify suitable resources in terms of the specifications related to safety, production processes, and associated costs, as well as wider considerations of physical (resource availability) and social (symbolic associations of the design) considerations
- refine design ideas incorporating justified features and materials and undertake further functional modelling with the client and other stakeholders (including customers), to gain critical feedback to select one for further development
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client, mentor and customer feedback; refine, in keeping with client and mentor feedback related to the specifications of the brief, and any additional comments from key stakeholders and customers that could enhance the product without compromising any specifications
- present a final lighting product that met the specifications of the brief and was appropriate to physical and social environment of Sandwiches
- use feedback from a range of stakeholders, including the client, teacher and mentor and customers, to provide evidence to support an evaluation of the lighting product's fitness for purpose, in terms of the brief and the physical and social environment of Sandwiches

Students achieving at level 7 could:

- explore a range of contemporary and historical lighting products, including those used in Sandwiches currently and in the past, with particular emphasis on critically analyzing their fitness for purpose; reflect on experiences from previous technological practice – including tea lantern development, critically analysing these in terms of how fit for purpose they were; use this analysis and reflection to inform the generation of a range of innovative ideas that explore the potential of the opportunity provided
- evaluate the design ideas to select those justified as appropriate, in terms of the requirements of the brief (based on Sandwiches style, client preferences and specifications associated with safety and batch production) and from the physical and social environment in which the lighting system is to be placed, and the wider context of lighting public venues. Develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, models to illustrate potential materials and how they can be manipulated to change effect) to illustrate the range of options available and test initial design ideas of how they may work in the environment of Sandwiches. Use models to gain critical feedback from the client, mentors, a range of customers and other stakeholders identified (musicians that regularly play at Sandwiches, potential future customers, neighbouring shop owners, etc.) on the specifications they consider essential and desirable.
- explore the 3-dimensional materiality of a range of resources and the implications of material selection for disposal, and critically investigate design features, including an exploration of the implications for product maintenance, seeking guidance from additional sources (research findings, mentors, friends etc) to determine the suitability of resources. Undertake evaluative testing procedures in line with accepted codes of practice to ensure they would meet the specifications related to safety, production processes, and associated costs, as well as wider considerations of physical (resource availability sustainability/disposal) and social (symbolic associations of the light product's aesthetic) considerations
- explore the implications of the changing use of the venue (during the day, early evening, late night) and refine design ideas accordingly, incorporating justified features and materials, and undertake further functional modelling with the client and other stakeholders to gain critical feedback to select one for further development.
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client, mentor and customer feedback. Refine in keeping with client and mentor feedback related to the specifications of the brief and any additional comments from key stakeholders and customers that could enhance the system without compromising any specifications
- present a final lighting product that met the specifications of the brief and was appropriate to physical and social environment of Sandwiches
- evaluate the 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 analyzing 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 analyzing these in terms of how fit for purpose they were. Use this analysis and reflection to inform the generation of a range of innovative ideas that fully exploit the potential of the opportunity provided.
- evaluate the design ideas to select those justified as appropriate in terms of the requirements of the brief (based on Sandwiches style, client preferences and specifications associated with safety and batch production), and from the physical and social environment in which the lighting system would be placed. Develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, models to illustrate potential materials and how they can be manipulated and finished to create a range of effects) to justify the options available, as allowing for a lighting product that would be fit for purpose in its broadest sense. Use models to gain critical feedback from the client, mentors, customers and other stakeholders identified (musicians that regularly play at Sandwiches, potential future customers, neighbouring shop owners, etc.) on the specifications they considered essential and desirable.
- explore the 3-dimensional materiality of a range of resources, and the implications of material selection for ultimate disposal; critically investigate design features, including an exploration of the implications for ongoing product maintenance, seeking guidance from additional sources (research findings, mentors, friends, etc.) to determine the suitability of resources. Undertake evaluative testing procedures in line with accepted codes of practice) to ensure they will be appropriate for use in a lighting product that will be fit for purpose in its broadest sense
- explore the implications of the changing use of the venue (during the day, early evening, late night), and refine design ideas accordingly, incorporating justified features and materials; undertake further functional modelling, with the client and other stakeholders, to gain critical feedback to select one for further development
- develop a prototype of lighting product; gain product safety certification from registered electrician prior to trialling *in situ* for client, mentor and customer feedback; refine, in keeping with client and mentor feedback related to the specifications of the brief, and any additional comments from key stakeholders and customers that could enhance the system without compromising any specifications
- present a final lighting product that was fit for purpose in its broadest sense
- 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 in the broadest sense

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 discusses some intuitive ideas students have about this component and suggests possible learning experiences.

Component descriptor

Technological outcomes are material products and systems developed for a specific function through technological practice. A technological outcome is evaluated in terms of its fitness for purpose. Technological outcomes can be described by their physical and functional properties. When these properties are known, a technological outcome can be interpreted when embedded in its social and historical context. The function or use intended by the technologist that developed it is known as its 'proper' function. 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.

Key ideas

Technological outcomes are defined as material products and/or systems resulting from technological practice that are fully realised *in situ*. The term material is used here to denote that the outcome must be comprised of matter of some sort – including electrons as in virtual technological outcomes.

Technological outcomes are more than a concept or plan for something to be developed. Technological outcomes include things that exist in a 'virtual' sense (such as computer software, digital images, etc.) as well as more tangible objects we more commonly associate with technology (such as computers, bridges, cars, medicines, tools, etc.).

Another defining characteristic of a technological outcome is that it has been developed by people through technological practice to perform a clearly identified function. Function includes all aspects that underpin the fitness for purpose of the technological outcome – including aesthetic aspects.

When all these defining characteristics are taken together (developed through technological practice, material in nature, and fully realised *in situ* to carry out an intended function) technological outcomes can be distinguished from other material objects (such as natural objects like trees and rocks, and other objects created by people such as works of art) and other outcomes of human activity (such as knowledge).

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

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.). This reflects the socially embedded nature of technology. For example, as a technological product, the cell phone can also be viewed as part of a more complex communication system that incorporates a range of other technological products and systems (products such as: cell phone towers, data logging computers or systems such as transmitting circuits, receiver circuits), alongside non technological systems (for example, legal and financial systems) and constituents (for example, people and energy).

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

Understanding this relationship is crucial when undertaking technological practice to develop a technological product or system for a specific function. This understanding allows technologists to recognise that several potential options exist for an outcome's physical nature. For example, should you wish to design a drinking vessel, you may explore a range of shapes (coffee mug *v* long stem wine glass) and/or materials (ceramic *v* glass). What will determine the physical nature in the end, will be the decisions made as to what would provide the 'best' fit for purpose for the drinking vessel. Purpose is defined in this case, 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.

Because of the materiality of technological outcomes their physical nature is determined by the combined properties (including their working properties) of the materials used in their manufacture and the availability of material resources for their development. Therefore, the possibilities for the physical nature will set boundaries around what functional nature is possible and/or feasible for a technological outcome at any time, and in turn the functional nature requirements will set boundaries around the possibilities for the physical nature.

The relationship between the physical and functional nature of any technological outcome is therefore complex and dynamic. This provides a useful analytical tool for establishing the fitness for purpose of a technological outcome during 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 and impacts (including knowledge and material availability) on its development. . 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. 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.

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. This function is what drove the development of the physical nature as described above. It also allows a 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.

Malfunction is a descriptive term for a technological outcome that does not carry out its proper function successfully. This is referred to as single event failure, and is usually easy to distinguish from any gradual reduction in function caused by general wear-and-tear effects on a technological outcome over time. Malfunction is also very different to what can be described as designed failure, where a product or component of a system is intentionally designed to stop working after a certain number of uses. The ethics of designing the life-time of a technological outcome must take account of complex factors such as market forces, maintaining jobs, consideration of future material developments, changing fashions, social norms, and public opinion.

Exploration of mal-functioning, 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 and the environments in which technological outcomes are situated.

Illustrative examples from technology

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

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

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

Intuitive ideas related to this component

Student understandings of what defines a technological outcome were not clearly established in this research. When asked for examples of technology, students tended to identify a very narrow range of technological outcomes, generally providing contemporary 'high-tech' tangible products only as examples. This suggests they may not have a clear view of technological systems as technological outcomes, or view historical examples as valid technological outcomes. However, the examples given appear to show an intuitive if somewhat limited understanding of the material nature of technological outcomes.

Students were more likely to focus on the physical nature when describing a technological outcome than its functional nature. When they mentioned both, they tended to describe the physical and the functional characteristics in isolation. Very few students made links between the physical and functional nature when exploring technological outcomes. In keeping with this, students found it difficult to suggest possible functions for an unknown technological outcome through considering its physical nature.

Possible learning experiences

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

Junior Primary (NE-Year 4)

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

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

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

Students achieving at level 1 could be expected to:

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

Students achieving at level 2 could be expected to:

- explain that technological outcomes are different to other objects ,because of the way they have been developed for a particular purpose, and they are made up of matter
- describe the physical attributes of a technological outcome and how these allow it to function in a certain way for a particular purpose
- describe a technological outcome in terms of how it helps and hinders people from doing things

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 they think the examples are 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 evaluate how fit for purpose each outcome appears to be and whether it should it be used in a variety of different contexts and under different conditions of use, (for example, environmental conditions and user competence).

The teacher could now 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. On the basis of this evaluation, the designs are ranked in order of potential fitness for purpose. The three highest ranked designs are then worked on to establish more clearly the physical attributes needed to ensure they will function as intended, and a presentation is produced to communicate these.

Students present their ideas and other class members critique their ideas in terms of fitness for purpose – taking into account the ease/safety of working materials, aesthetic qualities, and the cost and sustainability of the materials selected. Students discuss other functions that the design as it is, or with modification, 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 complex relationship between the physical and functional nature of technological outcomes.

Students achieving at level 2 could be expected to:

- identify technological outcomes as products or systems and explain why they have been categorized as such
- describe the physical attributes of a technological product and a technological system, and how these allow it to function in a certain way for a particular purpose
- describe a technological outcome in terms of how it impacts on people's capability to do things

Students achieving at level 3 could be expected to:

- identify examples of technological products that may include technological systems, and explain that the way we describe technological outcomes as products or systems is not always clear and relies on how important we feel it is to understand the parts of the system
- describe the fitness for purpose of a range of technological products and systems, and explain how this is linked to the relationship between each outcomes physical and functional nature
- justify a design for a specified technological outcome based on establishing the physical nature most suitable for a required function

Students achieving at level 4 could be expected to:

- explain the proper function of technological outcomes and illustrate how the fitness for purpose of a range of technological products and systems is linked to this
- explain how alternative functions may arise out of the use of technological outcomes, and how this may impact on the original outcome and subsequent developments

Junior secondary (Years 9-10)

Students could explore an historical event to introduce the idea of malfunction. For example, they could investigate the Challenger disaster. Because it is relatively recent this event could provide opportunity for students to talk to a range of people who would remember it happening, and enable them to get some local views on the impact and understandings around technological outcomes and how their use is embedded in the personal, political and economic imperatives of decision makers.

Students could select an example of an unfamiliar existing technological outcome, explore its physical nature and suggest what it might be used for and who might use it. They could then establish the proper function of the outcome and investigate its fitness for purpose in a variety of situations. For example, they could look at evaluating its performance under different environmental conditions and with various levels of user-competence. Investigations should ensure the safety of all users.

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

Students could evaluate the results and discuss ways in which they could maximise the outcome's reliability and/or efficiency across multiple contexts. Particular attention should be paid to the implications of decision making that establishes acceptable functional parameters, and how students justify decisions with regards to the physical nature of the technological outcome. Encourage students to explore possible and probably future scenarios when undertaking this analysis, and to test design ideas as fully as possible prior to making final decisions to go ahead with the development of their outcome.

Students achieving at level 3 could be expected to:

- describe the fitness for purpose of a particular technological outcome and explain how its physical attributes both enable and limit its function in a variety of contexts
- justify decisions in their own development work, around selection of physical attributes as most suitable for an identified function

Students achieving at level 4 could be expected to:

- make suggestions for what the purpose of a particular technological outcome might be and who the potential users could include, and justify these suggestions with relationship to the observable physical nature of the outcome
- explain the proper function of a selected technological outcome, and discuss how it performs in various situations that extend its use outside of that for which it was developed

Students achieving at level 5 could be expected to:

- justify the fitness for purpose (or not) of a particular technological outcome as judged in the context of its proper function, intended environment and within the era of its development
- explain the concept of malfunction and discuss examples of when technological outcome have failed, and the implications of this on the future development of related outcomes
- explain how explorations of their own outcome in various situations allowed them to gain a deeper understanding of how they could modify their design, to reduce user misuse and/or inappropriate environmental location

Senior Secondary (Years 11-13)

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

Implications of the event are explored in terms of subsequent technological outcome development, and the development of or modification to codes of practice that occurred to minimise future risks. Lessons learnt from all events investigated in the class are summarised and linked to how technological 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 3 could be expected to:

- describe how the physical attributes of a technological outcome relates to its intended function
- explain how the inclusion of other physical attributes might have reduced the chances of a technological outcome failing

Students achieving at level 4 could be expected to:

- explain how the technological outcome that failed was developed in terms of its proper function
- explain how the failure of a technological outcome occurred, and how this related to the relationship between its physical and functional nature
- suggest ways an identified technological outcome could be modified to improve it in some way

Students achieving at level 5 could be expected to:

- justify the fitness for purpose (or not) of a technological outcome that failed, as judged in the context of its proper function, intended environment, and within the era of its development
- explain why a technological outcome malfunctioned, and how this impacted on the development of related technological developments
- explain the concept of risk, and how it relates to ways of ensuring increasing levels of technological outcome reliability

Students achieving at level 6 could be expected to:

- discuss how the technological outcome that failed was part of a greater network of events, and how this impacts on the technologist's ability to identify and mitigate risk
- explain subsequent actions and/or changes to codes of practice, that occur as a result of technological malfunction
- justify suggested modifications of an identified technological outcome to increase its reliability

Students achieving at level 7 could be expected to:

- explain how decisions about the physical and functional nature of a technological outcome that failed reflects the prioritization of certain factors over others
- explain the ways in which the users of the technological outcome that failed were informed (or not) of any risks associated with the outcome
- establish an argument for the modification of an identified technological outcome to reduce risks associated with its future use and/or development; suggest how this may be perceived by various end users

Students achieving at level 8 could be expected to:

- critique the development of a technological outcome that failed, in terms of decisions made about its fitness for purpose prior to and post its failure *in situ*
- provide a feasibility study for the future development of an identified technological outcome that could be improved to reduce its propensity to malfunction; 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 discusses some intuitive ideas students have about this component and suggests possible learning experiences.

Component descriptor

Technology is a purposeful intervention-by-design human activity that results in technological outcomes that impact in the world. Technology provides potential to enhance the capability of humans to transform materials, energy and information. Technology uses and produces technological knowledge. Technological knowledge is aligned to function and validation 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. It has a profound effect on the world in which we live and on how we see ourselves. 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 a mix of need and desire. Key to this practice is its purposeful nature. This means that outcomes are arrived at through an intentional process of design, rather than through natural processes or things occurring by chance.

Also key is the creativity of technologists in developing and exploring initial design concepts, and in the way in which they realise these concepts in a material sense. This combination of ongoing informed creativity and critical reflection provides opportunities for technologists to push boundaries, learning from past developments, and developing their ideas to be able to project into future possibilities and explore these for feasibility and desirability.

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 a range of creations that reflect the decisions made by the technologist up to that point. These may take the form of ideas in a person's head, verbal, written and/or diagrammatic explanations of concepts, simulations of outcomes, or prototypes that have yet to be trialled *in situ*. All these should be seen as valid outcomes – both 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 era, and physical and social location. Current technological knowledge and capability are key influences on what is able to be developed. Social structures such as culture, politics and dominant ideologies of the time, also influence the nature of both what and how technology develops.

Needs, desires, and the identification of possible opportunities that drive technological activity, can be thought of as focusing on the transformation of materials, energy and information. That is, technological products and systems are developed in order to enhance human capability to manipulate, transport, store and to control anything in the natural or made world. 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.

Technology, understood as inseparable from society, also allows space for ways of looking at the world differently, to produce innovative solutions and create technologies that extend human capability, in ways 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 'natural' ways of being human, such as the development and use of artificial limbs or pacemakers.

Technology relies on a combination of creative and critical thought that supports 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 relies on notions of what has value, what is 'good' and 'bad', and what is considered 'right' and 'wrong'. All these notions rely on the social and cultural morals and ethics of particular groups of people within specific environments and eras.

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

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

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

Technology is interdisciplinary in nature, but it is also a discipline in its own right. Technological practice draws on technological knowledge and skills, as well as a breadth of knowledge and skills from other disciplines as required by the specific context being explored (for example, science, mathematics, art, psychology, ethics, etc.). An important part of understanding technology therefore, 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.

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. Technologists need to recognise the differences between knowledge in the disciplines they are working across, and establish the value of each within the particular contexts they are working on. Such awareness and collaboration requires technologists to engage in constructive debate, carry out informed prioritisation and employ sophisticated strategies for decision making within their practice.

Taken together, all of the above provides a philosophical understanding of technology as a form of human activity. Such a view of technology brings together two alternative perspectives that often underpin commentary on technology. 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 that technology and society are interlinked in complex and difficult-to-determine ways, and is referred to as a sociotechnological perspective.

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 sociotechnological perspective explained above. Briefly, the interaction of geography and biogeography and the technological developments that were made possible due to this, has been argued convincingly as the basis for significant ethnic differences, rather than any genetic predispositions. Jarad Diamond's popular book *Guns, germs and steel: a short history of everybody for the last 13,000 years*, details this argument, and centralises food production technologies as a critical feature in the history of the world.

New Zealand is Different: Chemical milestones in New Zealand's history provides a series of historical examples of the inter-relationship between technology and society. In particular it describes some of the chemistry and technology that has contributed to the development of New Zealand's current economic, research and development base. This book also forms the basis for a website called An History of Technological Innovation in New Zealand, which can be found at http://www.techhistory.co.nz/.

Examples provided include such things as the story of aerial topdressing in New Zealand. This provides an illustrative example of how technology is embedded in society and the resulting benefits and losses associated with this. Aerial topdressing is presented here as an innovation that literally 'took off' due to the need to make grassland more economically viable and the availability of surplus tiger moths and pilots after the war. While this was undoubtedly a success in land productivity resulting in a significant rise in the standard of living in New Zealand, the destruction of hundreds of square miles of forest (with little use being made of the timber in most cases), and subsequent overgrazing leading to dire soil erosion and runoff into lakes and waterways, means this innovation must also be viewed as an ecological disaster.

Intuitive ideas related to this component

Research has shown that few students, even from senior secondary year groups, were able to talk about technology in a generalized way, or show any understanding of technology as being linked to social, geographical or historical contexts. While many of these students described technology as a 'purposeful activity aimed at improving life', examples provided tended to be 'high-tech' technological outcomes and did not include any reference to the technological practices associated with their development.

When asked to judge a technological outcome as 'good' or bad', most students made judgments based on a personal perspective only. The majority of these students saw technology as a 'good' thing and did not show high levels of discernment around such things as to why it was good (or not), and for whom. They appear to uphold the myth of technology-equals-progress-equals-good. In the few cases that students indicated they thought technology was 'bad', their reasoning for this tended to reflect an emphasis on the impact of a specific technological outcome on them personally and/or an uncritical acceptance of a position within a contemporary debate. For example, "technology is bad because it causes global warming".

Students seem to share a general lack of understanding about how things are made, and the factors that might impact on or be taken into account, in any development process. Perhaps of even greater concern for encouraging a level of 'discerning consumerism', was the very common attitude exhibited by these students that understanding how or why things have come to exist was not important as they 'just used it'.

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 explore a range of technological products and systems. Include a range of examples that would be familiar to them (for example, lunchboxes, pencil cases, television, remote control, raincoat, sunhat, muesli bar, iPod, computer, compost heap, playground, etc.) as well as examples that are less familiar (for example, audio-tape walkman, hydroponics growing systems, speed radar guns, instant breakfast drinks, washing boards, clothing made from smart materials, gramophone, etc.). Provide an opportunity for them to 'play' with the examples as much as possible, although in order to ensure a range of examples are provided, some of these may be pictures and descriptions rather than the actual product or system.

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 it might have been developed.

Students should be encouraged to think about the types of things the technologist would have needed to know to make the selected example appropriate for particular users and environments. They should also be encouraged to think about what materials and processes would have been available, how this might have impacted on the development, and how this might change over time. 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:

- describe the purpose of their selected technological outcome and identify what other things people used in the past, or might still use today, for this purpose
- identify good and bad impacts the technological outcome may have had on different people at the time it was in common use
- identify the types of things a technologist would have had to take into account when developing the 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
- explain what the technologist may have done to make sure their design for the technological outcome would work, and how they made sure that people would want it and be able to use it
- make suggestions as to how the technological outcome may change in the future and explain why they think these suggestions are feasible

Senior Primary/Intermediate (Years 5-8)

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

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

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

Implications for future learning experiences that could help support and inform student technological practice could be identified and discussed.

Students achieving at level 2 could be expected to:

- explain their selected technological development and identify what factors influenced the decisions made at various stages of its development
- identify both good and bad impacts that the development has had on a variety of people in the past and today
- explain how things have changed/are changing since this development, and discuss what this might mean for future developments, including the student's own future technological practice

Students achieving at level 3 could be expected to:

- explain how different selected technological developments reflect the time and place of their development, and the people involved
- explain how differing developments have impacted on a variety of people, identifying and explaining 'good' and 'bad' impacts
- identify the different types of knowledge that supported the selected developments, and identify and explain which of these could be described as technological knowledge

Students achieving at level 4 could be expected to:

- explain how different examples of technological developments can be described in terms of how they seek to enhance human capability
- discuss the short and long term impacts of selected developments on individuals, society and the environment, and discuss how many of these impacts were known or anticipated before they happened
- discuss how different types of knowledge support different selected developments, and explain how collaborating with others during the design and early developmental phases of technology can help to reduce the number of unknown and/or unexpected impacts

Junior secondary (Years 9-10)

Students could develop a case study on a contemporary technology-related controversial issue (for example, genetic engineering, stem cell research, global warming, alternative energy sources, environmentally-friendly building design, etc.). 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 issue (both national and international), could be identified and their development and purpose explained and critically analysed. 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 their case studies, to develop collaboratively based affirmative or negative arguments.

Students achieving at level 3 could be expected to:

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

Students achieving at level 4 could be expected to:

- explain how a selected technological issue can be described as both positively and negatively impacting on individuals, society and the physical environment
- discuss the short and long term possible impacts of potential new technological developments within the context of a selected issue, focusing on individuals, society and the physical environment, and discuss how people may respond to unknown or unexpected impacts
- discuss how different types of knowledge are used to support different perspectives within a selected issue, and explain how collaborating with others is difficult when people hold conflicting views of the worthiness of particular technological developments

Students achieving at level 5 could be expected to:

- justify, with reference to a range of knowledge sources, a personal position within a selected technological issue in terms of its potential to enhance or detract from what it is to be human
- clearly outline how different knowledge was accessed and evaluated in order for an informed position to be reached

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 nature of the interviews (face to face, email, phone, etc.) needs to be appropriate for the technologist, and could be supplemented with additional explorations (for example, analysis of product information, websites, marketing materials, related articles, etc.). Students ask questions that will identify the details of a technological outcome the technologist is working on or has completed in the past.

It is important that the student allows the technologist to identify a technological outcome they are comfortable discussing. Issues associated with intellectual property and market sensibility could be explored by the student in relation to this. Students also work with the technologist to establish the knowledge 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 creativity explored in the context of the identified example.

After completing their individual case study, students could work with others in the class to compare and contrast their findings. The class could then develop a combined resource for their own and others' use, focused on explaining technology as a collaborative field that requires complex decision making based on different perspectives and forms of reasoning. Examples of past difficulties are critically analysed to provide insights into such things as the legal, ethical and personal influences that drive technological developments.

Students achieving at level 3 could be expected to:

- explain how a selected technologist works, and identify the knowledge they use in their work
- identify factors that impact on a selected technologist's views and their ways of working

Students achieving at level 4 could be expected to:

- explain how a technologist seeks to transform energy, information and/or materials in order to enhance human capability
- discuss the short and long term possible impacts of a selected technologist's current work, and explain how they manage risk associated with unknown or unanticipated outcomes
- discuss how different types of knowledge are used in the technologist's practice and how this impacts on their decision making

Students achieving at level 5 could be expected to:

- justify how the past experiences, attitudes and knowledge of the technologist impacts on how they undertake their work
- explain what codified knowledge is and how it is useful to technologists
- explain examples of when codified knowledge has been challenged due to new knowledge, capability or changing social pressures

Students achieving at level 6 could be expected to:

- explain how the interdisciplinary nature of technology is reflected in how contemporary technologists need to work
- 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 the complex decision making processes undertaken by technologists, and how these reflect their own backgrounds, their colleagues' backgrounds, and the influential factors from the wider physical and social environment
- discuss the influences of rapidly developing technological knowledge and capability and changing social expectations on technologists' practice
- explain how technologists view innovative practice and their role in challenging existing social boundaries

Students achieving at level 8 could be expected to:

- use a range of examples to illustrate and justify the complex decision making processes technologists employ, and explain the ways in which socio-cultural influences impact on decision making
- explain why technological developments result in unknown and/or unanticipated consequences, and how technologists manage the risks associated with this
- explain and justify the interventionist role of a technologist in a complex social world, where many domains of technology are coming together to challenge past views of what it is to be human

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 discusses some intuitive ideas students have about this component and suggests possible learning experiences.

Component descriptor

Technological modelling refers to modelling practices used within technological developments, and includes functional modelling and prototyping. Functional modelling allows for the ongoing evaluation 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. This 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 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, or changing/refining the design concept and/or the nature of the technological outcome before proceeding.

Key ideas

A model is a representation of reality. In technology, modelling is used to represent how things might be if a technological development was to continue, in order to establish if development should proceed. Therefore, technological modelling is critical for the robust exploration of influences on technological outcomes and their development. It is also important in assisting to identify the outcome's potential to impact in the world, as it moves from conceptual idea through to being fully realised and implemented *in situ*.

Technological modelling is a key tool development across all technological domains. While the specific knowledge base underpinning the implementation of technological models is particular to domains, the generic concepts of technological modelling are the same. For example, knowledge underpinning biotechnological modelling differs from that underpinning architectural modelling.

The media, or materials used, and types of procedures undertaken in technological modelling, vary depending on the stage of development, preferences, requirements, and the capability of the technologist[2][1]. The audience from which input and evaluative feedback is sought may also influence the type of model used. For example, at the early stage of development, modelling may simply involve the technologist thinking through ideas and/or discussing these with other technologists.

As the development moves on, this may progress to drawings on paper or within computer programmes, to more formal written and/or diagrammatic explanations for a range of audiences. For example, three-dimensional mockups using easily manipulated material such as clay, cardboard, styrodur, and CAD software, are often used

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.

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

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

Functional modelling is often referred to under different names. This is related to the technological domain within which the modelling is situated. For example, it may be called test or predictive modelling in biotechnology, animatics in film making, a toile in garment making, mockups or mocks in architecture and structural engineering. In all these cases, what is being modelled, or represented, is the yet to be realised technological outcome.

The purpose of all functional modelling is to explore and evaluate a design idea. Functional modelling is used to mitigate risk, by providing a means to identify influences on, and possible consequences of, potential technological outcomes *before* they are realised. Such modelling allows a technologist to simulate reality, and thus gather information around people's and/or environmental responses to possibilities.

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

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

Functional modelling provides opportunity to reduce the waste of resources that can often occur if technologists rush too quickly to the realisation phase, relying on a more 'build and fix' approach to technological development. Because of this, functional modelling can be seen as a key tool for encouraging and enabling more environmentally sensitive and potentially sustainable development. The better the functional modelling, the greater the confidence a technologist can have in the potential for the fully realised *in situ* technological outcome to function as intended, and have the desired impact on the world. While it may not result in the removal of all unknown or unexpected impacts, it can work to significantly reduce these.

In prototyping, what is being modelled, or represented, is the yet to be implemented technological outcome. The purpose of prototyping is to evaluate the fitness for purpose of a technological outcome.

Prototyping occurs at the phase of development where the technological outcome is now realised. At the point of realisation, the outcome has a significant 'impact in the world', due to the fact it now exists in a functioning material form and can implemented in its intended location. However, prototyping seeks to gather further evidence to inform subsequent implementation decisions, with a focus on improving the technological outcome. 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 physical/social environments.

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 to 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.

If a decision to proceed with the development is made after prototyping, it may result in less dramatic modifications, or refinement of the outcome to enhance performance and/or suitability *in situ*, or a decision to proceed as planned. Prototyping thereby provides the means to trial a technological outcome, in order that its fitness for purpose can be optimised, or to provide justification for the outcome to be fully implemented as fit for purpose.

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

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

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

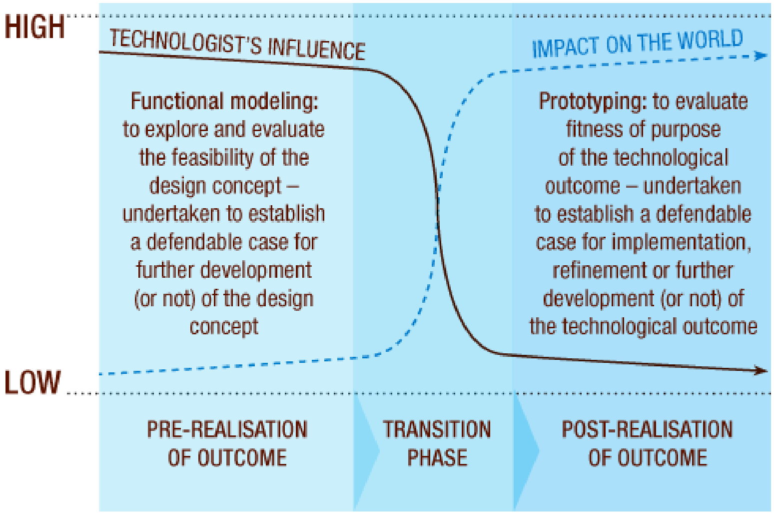


Figure 1: Technological Modelling in Technological Development

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

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

Functional reasoning provides a basis for exploring the functional potential of the design concept. That is, 'how to make it happen' in the functional modelling phase, and the reasoning behind 'how it is happening' in prototyping.

Practical reasoning provides a basis for exploring social aspects (moral and ethical) surrounding the design concept and outcome testing. That is, the reasoning around decisions as to 'should it happen?' in functional modeling 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.

Employing both these types of reasoning as part of technological modelling ensures that a holistic evaluation of a technological outcome's potential and actual 'impact in the world' is made, reflective of a balanced normative and technical understanding of fitness for purpose.

Illustrative examples from technology[3]

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

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

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

Other examples show how a prototype can shift people's perceptions and stimulate other technologists to cross historical boundaries (e.g. the New Zealand designed Aquada). Analysis of the prototyping of vehicles can highlight the complexities associated with gaining robust user feedback, and the economic and personal costs associated with poor decision making leading up to the development of a prototype that fails.

Intuitive ideas related to this component[4[]

Little data is currently available regarding student understandings of the purpose of a model in technology, as many students provided no response or stated they 'didn't know' in response to this focus. Those students, who did respond with ideas about what a model is, provided a variety of ideas. These included such things as a template, a 3D representation of a design idea, or a person (particularly 'woman on catwalk' or 'sporting role model').

Students who responded with regards to the purpose of models showed little understanding of modelling as an evaluative tool. The majority of these responses suggested models can be used to communicate ideas – or more specifically show others 'how things work'. Only a small number of senior secondary students suggested models could be used to test ideas and/or outcomes.

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)

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

4 As based on data from the Technological Knowledge and Nature of Technology research reported in Compton and France 2007 available at http://www.iteaconnect.org/Conference/PATT/PATT18/fullprog-21a[1].pdf.

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

Students could be introduced to the term model and encouraged to discuss what they think a model is, and how it might be useful in technological developments. Students are then provided with opportunity to play with different modelling materials (such as LEGO, plasticine, Meccano, Connex, cardboard, concept maps, computer modeling packages, etc.), and to explore how different materials may allow greater testing of how something might work. For example, static LEGO could be compared with technic LEGO, computer simulations could be explored with 3-D models, etc. Students could then discuss their ideal playground and undertake functional modeling, to decide as a group what ideas could be feasible for an actual playground for their school.

Students achieving at level 1 could be expected to:

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

Students achieving at level 2 could be expected to:

- explain that models can be useful to help you think about things before they happen, but can also make you think something is possible that isn't – or vice-versa
- explain how they used different types of models to come to a decision on a joint design for a playground for their school

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 fulfill 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 justify the medium to be used, and how and from whom they would get feedback to inform their decision making. Students use their model and evaluate its effectiveness against its stated purpose.

Students achieving at level 2 could be expected to:

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

Students achieving at level 3 could be expected to:

- identify different types of functional models and explain why particular materials were used in different examples
- identify different examples of prototyping and explain how the evidence gained allowed people to evaluate the

outcome's fitness for purpose

- explain the choice of modelling undertaken and how this informed their decision making

Students achieving at level 4 could be expected to:

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

Junior secondary (Years 9-10)

Students could select examples of successful (for example, Post Its, Aquada, telephones, printing press, antibiotics, Hamilton jet, vaccines, etc.) and unsuccessful technological outcomes (for example, Chenobyl and/or Three Mile Island nuclear power plants, Cave Creek, Hindenburg airship, Titanic, Columbia, Sliver Bridge, early generation hybrid cars, 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 reducing 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 historical example of a technological disaster and make a case, based on a retrospective analysis and their developing understandings, for how things might have been done differently.

Students achieving at level 3 could be expected to:

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

Students achieving at level 4 could be expected to:

- identify the reasoning behind key decisions made during the development of successful and unsuccessful technological outcomes
- explain how prototyping has played a role in supporting the implementation of a technological outcome with both successful and unsuccessful results
- outline a case for how technological modelling could have mitigated a market failure or resulting disaster, in the case of a particular technological outcome

Students achieving at level 5 could be expected to:

- explain how evidence was gathered and used in the support of the development of successful and unsuccessful technological outcomes
- explain the role that practical and functional reasoning played in the development of a range of successful and unsuccessful technological outcomes
- present and justify a different development plan for a selected technological outcome that failed, arguing how this would have guarded against this particular failure

Senior Secondary (Years 11-13)

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

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

From this basis students work to identify arguments for possible scenarios that employ both functional (what can be done) and practical (what ought to be done) reasoning, and use these to develop a series of functional models to test a range of design ideas. 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 feasible design ideas that would address some or all of the needs/opportunities provided by the issue.

Students achieving at level 3 could be expected to:

- identify how functional models could be used to get information from key stakeholders as to what types of outcomes would best address their needs/desires
- undertake functional modelling and explain why particular resources were used
- present a design concept of a possible outcome that would address some part of the issue explored

Students achieving at level 4 could be expected to:

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

Students achieving at level 5 could be expected to:

- explain how evidence can be gathered through functional modeling, to establish the views of key stakeholders with regards to a range of design ideas
- explore the decision making strategies used by key stakeholders when providing feedback in response to a functional model being employed, to help evaluate the suitability of possible outcomes
- 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:

- compare and contrast the reasoning behind key stakeholder evaluations of possible outcomes to address their needs/desires
- explain how the functional model used enhanced and/or limited their ability to ascertain the risks perceived by stakeholders, and posed to the wider social and physical environment
- present and justify a design concept for a technological outcome that would address the needs/desires of key stakeholders, and take account of predictions from the wider social and physical environment

Students achieving at level 7 could be expected to:

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

Students achieving at level 8 could be expected to:

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

EXPLANATORY PAPER

The Technological Knowledge Strand:

Technological Products

Abstract

The purpose of this explanatory paper is to define a technological product and clarify why and how technological products 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 discusses some intuitive ideas students have about this component and 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 properties of materials and their performance capability 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 new materials formulation and their potential impacts on future product function. The impact of material use and development on product life cycles/expectancy is also included with regards to understanding material sustainability in its broadest sense.

Key ideas

Technological products are a type of technological outcome developed through technological practice. They 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. Technological products therefore include things that exist in a virtual sense, (such as digital images), as well as the more familiar tangible products (such as printed images) that make up the made world.

The key concepts underpinning the technological product component are those that relate to the properties of materials, their uses and their development. The knowledge base underpinning these concepts will vary depending on the specific materials used in any particular product. For example, the understandings required to develop and understand how food products function differ significantly to those required for products made from other materials (for example, textiles, electronics, biotechnology, etc.)

To support understandings of these concepts, materials will need to be understood in relation to their performance properties. This knowledge will underpin deeper understandings of material formulation, manipulation, compatibility and transformation. The contemporary field of material technology is crossing many traditional disciplines and showing increasingly diverse and exciting possibilities for material performance, and therefore the types of functions that a technological product may have.

For example, the development of ‘smart’ materials in a range of areas allows for the exploration of the relationship between material and performance properties. The defining characteristic of a ‘smart’ material is its ability to change or adapt in response to an external prompt which may be technological in nature or from human input. The external trigger causes a change in the properties of the material itself, its structure and/or composition, or its functions.

Smart material developments are made possible through the combining of control and material technology, and is allowing for the design of a wide range of new products that can carry out functions not previously possible. For example, heat regulating clothing, light responsive sunglasses, artificial muscles, self cleaning textiles, self adjusting optical lenses, colour changing shirts etc. An example of smart material development can be seen at www.techlink.org.nz/Case-studies/Technological-practice/Materials/smart-fibres.

The impact of material use, transformation and new material development on product life cycles, and in the management of resources, is an important focus within this component. This will help develop a robust technological understanding of sustainability as it relates to justifiable resource management, length of designed-for life cycle, and recognition of 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[5]

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

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

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

Intuitive ideas related to this component[6]

No specific data is available yet, with regards to current student understanding of the concepts underpinning this component. However, their general inability to suggest how things might be made, and their limited ability to use a product's physical nature to confidently suggest possible functions, would suggest that current understanding related to this component may be under-developed.

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.

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

6 As based on data from the Technological Knowledge and Nature of Technology research reported in Compton and France 2007 available at http://www.iteaconnect.org/Conference/PATT/PATT18/fullprog-21a[1].pdf.

Junior Primary (NE-Year 4)

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

Other groups could explore a range of drinking vessels (ceramic cups, takeaway cups, wine glasses, etc.), cooking utensils (wooden spatula, metal pasta spoon, plastic fish-slice, etc.), skin creams (moisturisers, lip balms, sun-creams, etc.), cutting tools (scissors, knives, axes, etc.), balls (tennis, cricket, soccer, ping-pong, squash, etc.) and learn about the materials used and specific design features that allow them to function in different environments.

Students achieving at level 1 could be expected to:

- identify the performance properties of materials used in a range of products
- identify the materials used in a range of products that serve a similar purpose

Students achieving at level 2 could be expected to:

- explain how a range of products designed for a similar purpose differ in what they are made of, and how this allows them to perform in different ways
- explain that the properties of a material can change what a simple product is capable of doing

Senior Primary/Intermediate (Years 5-8)

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

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

Students could then explore products from another domain – for example, information and communication technology products (such as: digital images, text, photographs, animated gifs, Morse code devices, Braille, telephones, etc.) and explore these as described above. The links between materials used in contemporary information technology and those used in the past, and the change in the type and nature of functions able to be carried out, could be explored in terms of wider social and political implications. The impact of the internet on globalization would be an example of this.

Students could be involved in ongoing class discussions about the wide range of materials that are used in technology, and how these have developed over time to provide people with new options of what might be possible and how things might be done. As part of the class discussion, students could reflect on past products they have developed and critique the suitability of the materials they used, taking into account the impact of resource availability, costs and time constraints as well as how fit for purpose the resultant product was for the intended function. They could identify how their future work may attempt to address issues around material use, manipulation and waste as based on developing understandings. The students could also explore what sorts of things might be wanted/needed in the future and suggest how materials might need to be developed to meet / address these.

Students achieving at level 2 could be expected to:

- identify the materials used in a simple biotechnological and ICT product
- explain how the properties of the materials identified relate to how the product works

Students achieving at level 3 could be expected to:

- explain how the material properties of a range of biotechnological and ICT products allows the product to

carry out specific functions determined appropriate within these domains
- identify different materials that have been developed in the past to meet new performance needs
- suggest ideas for future products, and the type of properties new materials might need to have to allow these to be developed

Students achieving at level 4 could be expected to:
- identify an example of a product that was able to be realised due to the development of a new material, and explain how this new material was developed
- explain how different materials have been formed, manipulated and/or transformed to enhance the performance of a particular product

Junior secondary (Years 9-10)

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

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

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

Students achieving at level 3 could be expected to:
- explain how the selection of particular materials enables an instrument to be crafted and played in certain ways
- explain how different materials have been used in different cultures and times to create instruments that allow for the production of particular types of sounds

Students achieving at level 4 could be expected to:
- explain the properties of the materials used in a musical instrument, and how these have allowed the material to be shaped and finished in ways that increase safe use and ongoing maintenance
- explain how different materials have been formed, manipulated and/or transformed, to enhance the fitness for purpose of a musical instrument

Students achieving at level 5 could be expected to:
- explain how materials used in a range of musical instruments were evaluated as suitable for selection, in recognition of their role in the instruments fitness for purpose
- explain how different materials change under different conditions, and how this impacts on techniques for manipulating them during their development, and their subsequent care

Senior Secondary (Years 11-13)

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

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

Students achieving at level 3 could be expected to:

- explain how the material properties of a lighting product allow it to perform in a certain way
- explain how different materials are used in different lighting products as dependent on the environment in which they are to function

Students achieving at level 4 could be expected to:

- explain the properties of different materials used in a range of lighting products, and how these have allowed these products to be developed for different purposes
- explain how the materials used in a particular lighting product were developed and how they work together to ensure the product functions in a safe and reliable way, with minimal negative impact on people and the social and physical environment

Students achieving at level 5 could be expected to:

- explain why particular materials were selected for lighting products developed for differing purposes and environmental locations, in order to enhance their fitness for purpose
- explain the concept of minimal engineering as it pertains to the design of a lighting product, including an understanding of the products ongoing use and maintenance

Students achieving at level 6 could be expected to:

- explain how new materials have impacted on the possible design and performance of lighting products
- explain how existing materials have been manipulated to increase their suitability for lighting products in particular contexts and/or for specialised functions
- 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 7 could be expected to:

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

Students achieving at level 8 could be expected to:

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

EXPLANATORY PAPER

The Technological Knowledge Strand: Technological Systems

Abstract

The purpose of this explanatory paper is to define a technological system and clarify why and how technological systems 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 discusses some intuitive ideas students have about this component and suggests possible learning experiences.

Component descriptor

Technological systems are a set of interconnected parts (technological products and processes) 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 knowledge, within this component, will include an understanding of input, output, transformation processes, and control. Understanding the notion of the 'black box' is included in this component, in terms of understanding, and of developing, complex systems that involve integrated sub-systems. This component includes understandings of redundancy and reliability within system design and performance, and therefore an increased understanding of the operating parameters of systems.

Specialised languages provide important representation and communication tools. Understanding these specialised languages is important in system development, maintenance and troubleshooting.

Key ideas

Technological systems are a type of technological outcome developed through technological practice. They are defined as a set of interconnected parts 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 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 operation parameters. Over time, system feedback may lead to a need for the system's re-design.

The parts of a technological system include transformation processes as well as technological products. These products may all exist in a virtual sense (software) or may be connected to more familiar product parts of the system such as machinery or the electronic components.

The key concepts underpinning technological systems are those generic concepts that relate to inputs, outputs, transformation processes and how these are controlled. Inputs used by technological systems include people, technological products, money, raw materials, information and energy.

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

Transformation processes are those processes that occur within a system, to ensure the inputs are transformed into the outputs in a controlled and intended way, without need for additional human design input. Control elements of a system are designed to enhance the efficiency of the transformations. Adjustments to these 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.

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.

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 operating parameters. These concepts are important to understand when establishing the fitness for purpose of technological systems. Ethics plays 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 part of the system (or group) will perform a required function under stated conditions for a stated period of time. Reliability is therefore a part of that system's overall design and that of its constituent parts. Tolerances for reliability are determined by the specifics of each development and the nature of the output. For example, if the system is designed to result in an output that enhances human safety, reliability tolerances will be more stringent. Reliability as a concept underpins understandings associated with all three types of situations where a technological system no longer functions successfully. These three types being: malfunctioning, a gradual reduction in function caused by ongoing use, or designed failure.

The concept of 'black box' is important in describing technological systems. A black box can be thought of as representing a section 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, through the replacement of isolated parts of a system with little to no disruption to rest of the system. Ease of such replacement would be an inherent part of the system design and would need to take into account such things as the costs associated with the disposal of a part when repair of the part could have sufficed.

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

Technological systems are often represented in symbolic ways to communicate their constituent parts. While there are some generic symbols associated with systems, for example arrows to denote direction, specialised languages also exist and are central to the development and communication of technological systems.

Design concepts can be represented using a variety communication tools (e.g. 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.

Illustrative examples from technology[7]

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

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

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

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

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

Intuitive ideas related to this component[8]

Very limited data is available with regards to students' current understanding of the concepts underpinning this component. When student responses focused on describing a system, they did this in terms of the steps that people needed to take to make something, or they described a sequence of everyday life activities. A series of steps or procedures that people carry out does not fit with the definition of a technological system as above, and is more closely aligned to the technological practice component of planning for practice.

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

8 As based on data from the Technological Knowledge and Nature of Technology research reported in Compton and France 2007 available at http://www.iteaconnect.org/Conference/PATT/PATT18/fullprog-21a[1].pdf.

Possible learning experiences

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

Junior Primary (NE-Year 4)

Students could explore a range of familiar technological systems (such as: an electric jug, a windup toy, yoghurt maker, television, computer, fish tank, popcorn maker, compost heap, washing machine, torch, pacemaker, etc.) and identify what the system 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 purpose of a range of systems
- identify the inputs, outputs and process of transformation occurring within a simple system
- explain the differences and similarities between technological and non-technological systems

Students achieving at level 2 could be expected to:

- explain the role of the inputs identified for a particular simple system, in terms of how these allow the output to be created
- describe the process of transformation that is occurring within a simple system and how it is controlled

Senior Primary/Intermediate (Years 5-8)

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

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

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

Students achieving at level 2 could be expected to:

- explain the inputs and outputs of a bread-maker
- describe the process and type of transformation that occurs within the bread-maker and how it is controlled

Students achieving at level 3 could be expected to:

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

Students achieving at level 4 could be expected to:

- identify an example of a control mechanism within a complex technological system and explain how it influences the transformation process
- explain how different inputs are managed in a complex technological system to ensure they are transformed efficiently into outputs
- discuss ways in which systems are designed to increase wanted and minimise unwanted outputs or waste

Junior secondary (Years 9-10)

Students could investigate a complex system ('green' buildings, car, communication system, traffic light controlled intersection, plane, textile manufacturing system, vaccine production system, etc.) and build an understanding of what is happening within the system, by breaking it down into sub-systems.

The overall system could be explored in terms of which sub-systems are technological in nature and how these connect with non-technological systems. Students could explore the ways that systems can be 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 technological systems.

Students achieving at level 3 could be expected to:

- describe a range of technological sub-systems within a complex system using appropriate language tools
- explain how the black boxing of subsystems impacts on system maintenance

Students achieving at level 4 could be expected to:

- explain how control mechanisms are employed within a complex system to ensure the overall system functions successfully
- discuss ways in which complex systems are designed to allow for complex feedback loops between identified sub-systems, to maximise the intended outputs and minimize unintended outputs

Students achieving at level 5 could be expected to:

- explain the specialized transformation process occurring within a sub-system and the part it plays in a complex system
- explain the generic principles of feedback and control, in terms of supporting sub-systems to work together in ways that guard against system failure or damage should any part of a system malfunction

Senior Secondary (Years 11-13)

Students could develop an argument for why it is critical to understand the concepts of reliability and redundancy when developing technological systems. For example, the aviation industry relies on a complex series of interconnecting technological, social and natural systems. A diagrammatic representation could be developed to communicate the interconnectedness of these systems, with further breakdowns built up of the technological systems inherent within this industry. Redundancy in terms of built in 'factors of safety' and reliability is critical to the ethical operation and commercial success of this industry, and should be explored in terms of the influence on the development, use and maintenance of complex technological systems and constituent sub-systems.

Codes of practice and lines of accountability could be explored as part of determining influences. Students could draw from a mix of historical and contemporary cases and explain significant shifts in regulations and practice. The ethical aspects of decision making, around the designing of technological systems for certain time periods or where end user protocols are provided as a means of exempting the technologist from responsibility should the system fail because of user negligence and/or misuse, compared with 'legitimate' types of use, would be central to this investigation. Students could present their arguments to each other and develop a class resource that draws from illustrative examples from all the students' investigations.

Students achieving at level 3 could be expected to:

- explain how appropriate language tools and/or graphical symbols can help develop understandings, and communicate the interconnectedness complex systems
- identify a range of black boxed sub-systems within a complex system and explain how these may impact on troubleshooting

Students achieving at level 4 could be expected to:

- explain the transformation processes within a range of sub-systems and explain how they integrate with other sub-systems in a controlled manner
- explain how people involved in the development, use and maintenance of a particular complex system prioritise different factors, and how this may impact on the nature of the outputs accepted as appropriate

Students achieving at level 5 could be expected to:

- explain the way in which specialised transformation processes demand different levels of expertise within a complex system
- explain why feedback and control are critical in the development and maintenance of complex systems

Students achieving at level 6 could be expected to:

- explain the way in which sub-systems allow for the development of complex systems
- critique the use of sub-systems for system design, ongoing development and maintenance

Students achieving at level 7 could be expected to:

- explain what reliability means within technological systems and illustrate the influence this concept has had on the development and maintenance of a particular complex technological system
- explain what redundancy means within technological systems, and illustrate the influence this concept has had on the development and maintenance of a particular complex technological system

Students achieving at level 8 could be expected to:

- explain the impact of energy efficiency and failsafe on the operational parameters of technological systems in general
- explain the interactions involved in the development of complex technological systems with high safety and/or reliability requirements

TECHNOLOGY INDICATORS OF PROGRESSION

The Indicators of Progression, as presented in the matrices below, describe student competencies and the learning environment related to the Achievement Objectives of each strand of the technology curriculum within *The New Zealand Curriculum* (2007). The indicators associated with the learning environment provide opportunity to highlight the importance of teacher support of students at all levels. They also acknowledge how the nature of teaching needs to change, in order to ensure students are provided with authentic opportunities to take more responsibility for their learning in technology. As such, they recognise the importance of the learning environment and all its underpinning aspects, including the critical role of teacher action and interaction in student learning.

Taken together, the progression matrices allow teachers and students to develop a sense of how technological literacy progresses through technology education. The indicators provided in the matrices do not define specific knowledge and skills, but rather focus on generic understandings and capabilities that will be developed through working across a range of different contexts.
The Indicators of Progression provide a mechanism for managing multilevel teaching that supports individual student learning needs.

The indicators for the Components of Technological Practice (Brief Development, Planning for Practice and Outcome Development and Evaluation) have been developed through classroom research and refined through subsequent triallng. These indicators are therefore ready to be used to guide formative and summative assessment practices, planning decisions and the development of effective and efficient reporting mechanisms for multiple audiences, including the students, their caregivers, and future teachers both within and across schools.

The indicators for the Components of Technological Knowledge and the Nature of Technology (Technological Modelling, Technological Products and Technological Systems; and Characteristics of Technology and Characteristics of Technological Outcomes) are currently in draft form as they are still in their developmental stage. They have been developed to sit under the completed Achievement Objectives for the two new strands, but are yet to be validated by classroom research. It is expected these indicators will be refined over the next two years as student data becomes available. Indicators at Emergent, Level 1, 2 and 3 for Characteristics of Technological Outcomes and Technological Products have already begun to be refined, as based on findings from initial research. These indicators are therefore NOT ready to be used for summative assessment practices and or reporting purposes. They are being made available for teachers to use as discussion tools that may increase understandings of the two new strands; they also provide support for formative interactions between teachers and students when developing knowledge and skills inherent in the two new strands, for the purpose of enhancing student technological practice.

Components of Technological Practice: Indicators of Progression — EMERGENT

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- establishes the need or opportunity and defines the conceptual statement through negotiation with the students
- guides students to identify attributes for an appropriate outcome
- structures students' technological practice through a series of linked learning experiences (both pre-planned and responsive) to provide opportunity for knowledge and skill development
- provides resources, to support student's in developing their outcome
- provides students with an overview of the key stages they will undertake during their technological practice

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE No Aos for emergent.	**ACHIEVEMENT OBJECTIVE** No Aos for emergent.	**ACHIEVEMENT OBJECTIVE** No Aos for emergent.
INDICATORS OF PROGRESSION Communicate the outcome they are going to produce. Identify attributes for their outcome.	**INDICATORS OF PROGRESSION** Explain what they have done already. Suggest what they might do next. Suggest resources they might use next.	**INDICATORS OF PROGRESSION** Develop an outcome. Discuss their own and others' outcomes.

Components of Technological Practice: Indicators of Progression — LEVEL ONE

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- establishes the need or opportunity, and defines the conceptual statement through negotiation with the students
- guides students to identify attributes for an appropriate outcome
- structures students' technological practice through a series of linked learning experiences (both pre-planned and responsive) to provide opportunity for knowledge and skill development
- provides resources, that support students in developing their outcome
- provides students with an overview of the key stages they will undertake during their technological practice

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE Describe the outcome they are developing and identify the attributes it should have, taking account of the need or opportunity and available resources.	**ACHIEVEMENT OBJECTIVE** Outline a general plan to support the development of an outcome, identifying appropriate steps and resources.	**ACHIEVEMENT OBJECTIVE** Investigate a context to communicate potential outcomes. Evaluate these against attributes; select and develop an outcome in keeping with the identified attributes.
INDICATORS OF PROGRESSION Describe the outcome they are going to produce, Identify attributes for their outcome that reflect the need or opportunity to be addressed,	**INDICATORS OF PROGRESSION** Describe what they have done already and the resources they have used so far. Describe steps they have to do to complete their outcome. Identify the resources they could/will use to complete their outcome.	**INDICATORS OF PROGRESSION** Provide (either through drawing, models or verbally) conceptual ideas that communicate possible outcomes. Evaluate possible outcomes in terms of identified attributes and select an outcome to develop. Develop an outcome in keeping with identified attributes.

Components of Technological Practice: Indicators of Progression — LEVEL TWO

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- establishes the need or opportunity, and defines the conceptual statement through negotiation with the students
- guides students to identify attributes for an appropriate outcome
- structures students' technological practice through a series of linked learning experiences (both pre-planned and responsive) to provide opportunity for knowledge and skill development, and to encourage student trialling and refinement of skills and understandings
- provides a selection of resources, to support students in developing their outcome
- provides students with an overview of the key stages they will undertake during their technological practice

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** Develop a plan that identifies the key stages and the resources available.	**ACHIEVEMENT OBJECTIVE** 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.
INDICATORS OF PROGRESSION Explain the outcome they are going to produce. Describe attributes for their outcome that reflect the need or opportunity to be addressed, and their developing skills and knowledge. Describe attributes that allow them and their teacher to evaluate their outcome.	**INDICATORS OF PROGRESSION** Identify and record (in a way others can interact with) the next key stages, explaining their role to complete their outcome. Identify the resources that would be suitable to complete their outcome.	**INDICATORS OF PROGRESSION** Develop (through research, discussion, etc.) Conceptual ideas that communicate possible outcomes. Evaluate possible outcomes in terms of identified attributes and select an outcome to develop. Trial materials for the production of an outcome. Develop an outcome in keeping with the identified need or opportunity. Evaluate their final outcome in terms of how it addresses the need or opportunity.

Components of Technological Practice: Indicators of Progression — LEVEL THREE

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- establishes the need or opportunity
- guides students to define conceptual statement
- guides students to identify key attributes for an appropriate outcome
- supports students' technological practice through a series of negotiated learning experiences (both pre-planned and responsive) to provide opportunity for knowledge and skill development, and encourage student trialling and refinement of skills and understandings
- provides a selection of resources, to support the students development of an outcome

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** 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** 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.
INDICATORS OF PROGRESSION Define a conceptual statement that communicates what they are developing and why. Describe key attributes for their outcome. Undertake refinement and/or modification of their conceptual statement and key attributes based on their developing knowledge and skills, including understandings of the context and issue. Describe key attributes that allow them and their teacher to evaluate their outcome.	**INDICATORS OF PROGRESSION** Explain the importance of key stages and the reason specific resources were used in their development work to date. Identify and explain links between past and current activities and identify implications for future planning decisions. Plan, explain and record ideas for future activities to support the completion of their outcome. Identify key resources suitable to complete their outcome.	**INDICATORS OF PROGRESSION** Develop (through research and functional modelling) conceptual ideas that communicate possible outcomes that incorporate identified key attributes and address the need or opportunity. Trial materials for the development of an outcome. Carry out technological modelling to evaluate the outcome's ability to address the need or opportunity. Develop an outcome that addresses the identified need or opportunity. Evaluate their final outcome against the key attributes, and in terms of it addressing the need or opportunity.

Components of Technological Practice: Indicators of Progression — LEVEL FOUR

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- establishes the context and issue for students to undertake technological practice
- provides learning experiences to enable students to successfully structure their own practice in order to develop an appropriate outcome
- supports students in accessing resources
- provides opportunities for ongoing stakeholder/s feedback to students

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** 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** 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.
INDICATORS OF PROGRESSION Identify a need or opportunity appropriate to the established context and issue, and develop a conceptual statement to justify what they are developing and why. Establish key attributes from initial information. Undertake refinement and/or modification of their conceptual statement and key attributes as based on their developing knowledge and skills, including understandings of the context/ issue and feedback from stakeholders. Define key attributes that allow them, their teacher and stakeholders to evaluate the fitness for purpose of their outcome.	**INDICATORS OF PROGRESSION** Explain and reflect on key stages and critical resources from their previous practice, and evaluate this in order to identify implications for future activities within their current practice. Identify and explain links between their past and current practice, in terms of how they could impact on (either to assist or impair) the development of an outcome that reflects the brief requirements. Plan to ensure stakeholder feedback is accessed and used to inform development work – particularly material selection. Plan ahead to ensure completion of outcome, and undertake effective documentation to support their practice. Select and access the key resources (including knowledge and skills) required to complete their outcome.	**INDICATORS OF PROGRESSION** Determine suitability of initial resources to enable the development of their outcome. Develop (through research and functional modeling that includes feedback from stakeholders) conceptual ideas that communicate feasible outcomes that incorporate the established key attributes required to address the need or opportunity showing consideration of material availability and suitability. Carry out ongoing reflection and functional modelling to test, evaluate and refine potential outcomes. Develop an outcome, that incorporates all key attributes established and addresses the identified need or opportunity using prototyping as appropriate. Use stakeholder feedback as evidence to support the evaluation of their final outcome's fitness for purpose in terms of how it well it addresses the need or opportunity.

Components of Technological Practice: Indicators of Progression — LEVEL FIVE

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- establishes the context and issue from which students can identify a need or opportunity
- provides learning experiences to enable students to successfully structure their own practice, in order to develop an appropriate outcome
- supports students in accessing resources
- provides opportunities for students to access key stakeholders in a safe and appropriate manner

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** 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** 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.
INDICATORS OF PROGRESSION Identify a need or opportunity appropriate to the provided context and issue and develop a conceptual statement to justify what they are developing and why. Draft specifications for their outcome that are justified in terms of the context or issue. Undertake brief refinement and/or modification as based on their developing skills and knowledge, including understandings of the context/issue and feedback from key stakeholders. Develop specifications that allow them, their teacher and key stakeholders to evaluate the fitness for purpose of their outcome.	**INDICATORS OF PROGRESSION** Analyse their previous practice and the planning and organisational practices of others. Make informed projections about future activities and explore implications for planning and the selection of planning tools. Use planning tools to support, document and justify ongoing planning decisions in terms of the need or opportunity their brief is being developed to address. Select and manage resources required for specific activities within their practice to complete their outcome.	**INDICATORS OF PROGRESSION** Carry out analyses of their own and others' previous outcomes, to inform the development of ideas for feasible outcomes Develop (through research and functional modelling that includes feedback from key stakeholders) conceptual ideas to communicate feasible outcomes that are justifiable in terms of the brief (conceptual statement and specifications). Determine suitability of materials justified by evaluation against the specifications for the development of their outcome. Develop an outcome through: • functional modelling (based on developing knowledge and skills) that test, evaluate and refine their evolving outcome; • prototyping to trial and evaluate their outcome within the physical and social environment in which it will be placed. Use key stakeholder feedback to evaluate the fitness for purpose of their developing and final outcome against the brief.

Components of Technological Practice: Indicators of Progression — LEVEL SIX

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- provides a context and issue for the students to undertake technological practice
- provides learning experiences to enable students to successfully structure their own practice in order to develop an appropriate outcome
- supports students in accessing resources
- provides opportunities for students to access key and the wider community stakeholders in a safe and appropriate manner

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** 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** 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.
INDICATORS OF PROGRESSION Explore the provided context and issue in order to identify and justify a need or opportunity Develop a brief that: • clearly communicates and justifies an outcome that allows for the resolution or realisation of the need or opportunity; • reflects the opportunities and constraints on both the outcome and the practice to be undertaken. Undertake brief refinement and/or modification as based on their developing skills and knowledge, including understandings of physical and social environment and feedback from key and wider community stakeholders. Develop specifications that allow them, their teacher, and key and wider community stakeholders to evaluate the fitness for purpose of their outcome.	**INDICATORS OF PROGRESSION** Carry out ongoing critical analyses and evaluation of their own and others' past and current planning and organisational practices Make informed projections about future activities that are supported by dynamic planning tools in order to document and justify planning decisions, in terms of the physical and social environment in which their brief is embedded Justify the management of resources to undertake technological practice, in terms of the physical and social environment in which their practice is occurring, as well as the opportunities and/or constraints resulting from the specific practice they undertake	**INDICATORS OF PROGRESSION** Carry out ongoing critical analyses of their own and others' outcomes, to inform the development of ideas for feasible outcomes Develop (through research and functional modelling that includes feedback from key and wider community stakeholders) conceptual ideas to communicate feasible outcomes that are justifiable in terms of the brief (conceptual statement and specifications) and the physical and social environment in which their outcome is to be developed and finally placed. Justify the suitability of materials selected to enable the development of an outcome that meets the specifi-cations and is appropriate to the physical and social environment in which it will be developed and placed. Develop an outcome & justify key decisions through: • informed functional modelling (based on developing knowledge and skills) that test, evaluate and refine their evolving outcome • prototyping to trial and evaluate their outcome within the physical and social environment in which it will be placed. Evaluate their developing and final outcome's fitness for purpose against the brief using key and wider community stakeholder feedback to justify its suitability for the physical and social environment in which it will be placed.

Components of Technological Practice: Indicators of Progression — LEVEL SEVEN

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- provides a context for students to undertake technological practice
- supports student learning as they structure and plan activities as required to enable them to undertake their technological practice to develop an appropriate outcome
- supports students in accessing resources
- provides opportunities for students to access key and wider community stakeholders in a safe and appropriate manner

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** 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** 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.
INDICATORS OF PROGRESSION explore the provided context in order to establish an issue and identify a need or opportunity that can be justified in terms of the physical and social environment develop a brief that: • clearly communicates an outcome that allows for the resolution or realisation of the need or opportunity and justifies this in terms of the selected issue • reflects the opportunities and constraints on both the outcome and the practice to be undertaken undertake brief refinement and/or modification as based on their developing skills and knowledge, including understandings of physical and social environment and feedback from key and wider community stakeholders develop specifications that allow them, their teacher and key and wider community stakeholders to evaluate the fitness for purpose of their outcome	**INDICATORS OF PROGRESSION** Carry out ongoing critical analyses and evaluation of their own and others' past and current planning, and self and team management practices. Make informed projections about future activities that are supported by dynamic planning tools developed to manage, document and justify planning decisions in terms of the physical and social environment in which their brief is embedded Organise learning experiences to gain new knowledge and skills identified in planning as being needed to develop their outcome Justify the management of resources to undertake technological practice in terms of the physical and social environment in which their practice is occurring, as well as the opportunities and/or constraints resulting from the specific practice they undertake	**INDICATORS OF PROGRESSION** Carry out ongoing critical analyses of their own and others' outcomes, with particular regard to each outcome's fitness for purpose, to inform their outcome's development Develop (through research and functional modelling that incorporates feedback from discussions with key and wider community stakeholders) conceptual ideas that communicate feasible outcomes that are justifiable in terms of the brief, and the physical and social environment in which the outcome is to be developed and finally situated Justify the suitability of materials to enable the development and of outcome appropriate to the physical and social environment in which it will be developed and placed Develop an outcome and justify key decisions through: • informed functional modelling (based on developing knowledge and skills) that test, evaluate and refine their evolving outcome • prototyping to trial and evaluate their outcome within the physical and social environment in which it will be placed Evaluate their developing and final outcome's fitness for purpose against the brief, using key and wider community stakeholder feedback to justify its suitability to address the issue

Components of Technological Practice: Indicators of Progression — LEVEL EIGHT

SUPPORTING LEARNING ENVIRONMENT – THE TEACHER:

- establishes an environment that encourages and supports student innovation
- supports students as they undertake initial research to establish an appropriate context and issue
- supports student learning as they structure and plan activities as required to enable them to undertake their technological practice to develop an appropriate outcome
- supports students in accessing resources
- provides opportunities for students to access key and wider community stakeholders in a safe and appropriate manner

Brief Development	Planning for Practice	Outcome Development & Evaluation
ACHIEVEMENT OBJECTIVE 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** Achievement ObjectiveCritically 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** 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.
INDICATORS OF PROGRESSION Critically evaluate a range of contexts and associated issues to establish a feasible context and issue suitable for technological practice. Explore the established issue to identify a need or opportunity that can be justified in terms of the physical and social environment of the context. Develop a brief that: • clearly communicates an outcome that allows for the resolution or realisation of the need or opportunity and justifies this in terms of the wider context in which the issue sits • reflects the opportunities and constraints on both the outcome and the practice to be undertaken. Undertake brief refinement and/or modification as based on their developing skills and knowledge, including understandings of physical and social environment and feedback from key and wider community stakeholders. Develop specifications that allow them, their teacher, and key and wider community stakeholders to evaluate the fitness for purpose of their outcome in its broadest sense.	**INDICATORS OF PROGRESSION** Develop an initial plan that allows for extensive exploratory work to establish a suitable context and issue, and subsequent need or opportunity to be determined and evaluated. Carry out ongoing critical analyses and evaluation of their own and others' past and current planning, and self and team management practices . Make informed projections about future activities that are supported by use of dynamic planning tools developed to manage, document and justify planning decisions in terms of the physical and social environment in which their brief is embedded. Organise and evaluate learning experiences to gain new knowledge and skills identified in planning as being needed to develop their outcome. Critically evaluate the management of learning activities, opportunities and/or constraints resulting from specific practices undertaken, and the management of resources in an ongoing manner through-out technological practice, and justify these in terms of the physical and social environment, in which their practice is occurring to address the context and issue.	**INDICATORS OF PROGRESSION** Carry out ongoing critical analyses of their own and others' outcomes, with particular regard to each outcome's fitness for purpose in the broadest sense, to inform their outcome's development. Develop (through research and functional modelling justified by key, wider community stakeholders' feedback and historical and contemporary issues related to the context) conceptual ideas that communicate outcomes that are justifiable in terms of its fitness for purpose in the broadest sense. Justify the suitability of materials to enable the development and production of an outcome appropriate to the physical and social environment in which it will be developed and placed, and clearly explaining the contribution selected resources make to their outcome's fitness for purpose (in the broadest sense). Develop an outcome and justify key decisions through: • informed functional modelling (based on developing knowledge and skills) that test, evaluate and refine their evolving outcome • prototyping to trial and evaluate their outcome within the physical and social environment in which it will be placed. Critically evaluate their developing and final outcome's fitness for purpose against the brief, issue and context, using key and wider community stakeholder feedback to justify its fitness for purpose in the broadest sense.

Components of Nature of Technology: Draft Indicators of Progression — EMERGENT

SUPPORTING LEARNING ENVIRONMENT

Teacher to provide opportunities throughout learning experiences for the students' ideas to be shared as a group and challenged, to ensure they are guided towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop technological knowledge – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should select examples of technologies/technological development that allow for the meeting of AOs and are reflective of student interests.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE No AO for emergent	**ACHIEVEMENT OBJECTIVE** No AO for emergent
INDICATORS OF PROGRESSION Yet to be developed.	**INDICATORS OF PROGRESSION** Identify the obvious physical attributes of technological outcomes; for example, shape, size, colour, component interconnections, etc. Identify the obvious functional attributes of technological outcomes; for example, what the object does/can do.

Components of Nature of Technology: Draft Indicators of Progression — LEVEL ONE

SUPPORTING LEARNING ENVIRONMENT

Teacher to provide opportunities throughout learning experiences for the students' ideas to be shared as a group and challenged, to ensure they are guided towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop technological knowledge – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should select examples of technologies/technological development that allow for the meeting of AOs and are reflective of student interests.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand that technology is purposeful intervention through design.	**ACHIEVEMENT OBJECTIVE** Understand that technological outcomes are products or systems developed by people and have a physical nature and a functional nature.
INDICATORS OF PROGRESSION Understand the purpose of technology is to meet people's needs and or desires in ways which intervene in the world. Understand the nature of this intervention is to 'improve' life by addressing people's needs or providing new opportunities, while also understanding that what may improve one person's, or group of people's, life may negatively impact on others. Understand the intentional nature of technology where technological outcomes are designed through planned and purposeful practices.	**INDICATORS OF PROGRESSION** Explain that technological outcomes are things that are designed and made by people and therefore are different to other material things that exist in the world. Describe technological outcomes in terms of their physical attributes; for example, shape, size, colour, material composition, component interconnections, etc.. Describe technological outcomes in terms of their functional attributes; for example, what the outcome can do and/or provides, or cannot do and/or provide.

Components of Nature of Technology: Draft Indicators of Progression — LEVEL TWO

SUPPORTING LEARNING ENVIRONMENT

Teacher to provide opportunities throughout learning experiences for the students' ideas to be shared as a group and challenged to ensure they are guided towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop technological knowledge – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should negotiate the selection of examples of technologies/technological development with the students to allow for the meeting of AOs.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand that technology both reflects and changes society and the environment and increases people's capability.	**ACHIEVEMENT OBJECTIVE** Understand that technological outcomes are developed through technological practice and have related physical and functional natures.
INDICATORS OF PROGRESSION Understand that technology reflects society, with people in differing societies and/or global locations developing technologies according to varying needs and desires. Understand that technologies of the past and present impact on people at an individual and collective level, and both constrain and enable what future technologies can be developed. Uunderstand that technology can enable and/or enhance people's abilities/possibilities. That is, it can enhance their capability to manipulate, store, transport, and control things. Understand that informed creativity and critical reflection are required by technologists, in order to design technological outcomes within boundaries and constraints of the context of their development and/or place of function.	**INDICATORS OF PROGRESSION** Explain that technological outcomes exist because people have undertaken technological practice to determine what is needed/wanted, explored ways in which solutions/resolutions may be arrived at, and proceeded to create outcomes as deemed appropriate. Describe technological outcomes as technological products or systems. Describe the interrelationship between the physical attributes of a technological outcome and its functional attributes. Describe how technological outcomes both enhance and limit (often at the same time) our ability to 'see' things, and can result in fundamentally different ways of viewing and/or thinking about the world and ourselves.

Components of Nature of Technology: Draft Indicators of Progression LEVEL THREE

SUPPORTING LEARNING ENVIRONMENT

Teacher to encourage students to create opportunities throughout learning experiences to share and challenge ideas with others. Teacher should focus formative interactions on encouraging students to be self reflective and critical to ensure they move towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop technological knowledge – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should guide students in selecting examples of technologies/technological development to ensure opportunity for the meeting of AOs.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE 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** Understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures.
INDICATORS OF PROGRESSION Understand how historical contexts and environmental locations have impacted on technological development. Understand how social influences have impacted on technological development. Understand how technological developments have impacted on people and social and physical environments, in the past and present. Understand that technological knowledge is judged to be useful knowledge if it allows for a technological outcome to function as intended.	**INDICATORS OF PROGRESSION** Explain that the level of fitness for purpose of a technological outcome is determined by the success (or otherwise) of the relationship between its physical and functional nature, and the context in which it is situated. Explain that the nature of this relationship is complex and rarely 1-1; that is, for any function there may be a range of physical attributes that are suitable, and that physical attributes may support a range of different functions. Explain that technological products and systems are not always exclusive categories but often relate to the way in which we view the technological outcome itself.

Components of Nature of Technology: Draft Indicators of Progression LEVEL FOUR

SUPPORTING LEARNING ENVIRONMENT

Teacher to encourage students to create opportunities throughout learning experiences to share and challenge ideas with others. Teacher should focus formative interactions on encouraging students to be self reflective and critical to ensure they move towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop technological knowledge – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should require students to explain their selection of examples of technologies/technological development as providing opportunity for meeting task requirements, and provide input as necessary.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand how technological development expands human possibilities and how technology draws on knowledge from a wide range of disciplines.	**ACHIEVEMENT OBJECTIVE** 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.
INDICATORS OF PROGRESSION Understand how technology transforms, transports, controls and/or stores energy, material and/or information in order to expand human capability Understand that expanding human capability results in new possibilities (both positive and negative) for humanity, and this brings with it complex and often unanticipated social and environmental impacts Understand the range of knowledge underpinning technological developments, and how the context of the development determines what knowledge is given most value Understand the increasingly multidisciplinary basis of contemporary technology, and the role and value of tacit knowledge gained from past practices/experiences in translating new knowledge into informed and technological practice	**INDICATORS OF PROGRESSION** Understand how the physical nature of technological outcomes provides clues to interpret their possible purpose, function, and target user Understand that the term 'proper function' refers to the function for which the technological outcome was designed Understand that technological outcomes may be used successfully by end-users for purposes other than what they were originally designed

Components of Nature of Technology: Draft Indicators of Progression — LEVEL FIVE

SUPPORTING LEARNING ENVIRONMENT

Teacher to support students to create informal and formal opportunities throughout learning experiences to share and challenge ideas with others. Teacher should focus formative interactions on encouraging students to be self reflective and critical to ensure they move towards deeper more sophisticated understandings. Teacher encourages students to make links to past experiences and consider the implications for their future learning in technology. Teacher should challenge students to justify their selection of examples of technologies/technological development as providing opportunity for meeting task requirements.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand how people's perceptions and acceptance of technology impact on technological developments and how and why technological knowledge becomes codified.	**ACHIEVEMENT OBJECTIVE** 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.
INDICATORS OF PROGRESSION Understand how context influences people's perception and acceptance of technological developments (both in terms of practice and technological outcomes) and how this in turn impacts on future developments; for example, past 'solutions' often become future 'problems'. Understand why and how technological knowledge can be coded (for example, codes of practice, codes of ethics, codes of standards, reference tolerances, etc.) For others, to ensure consistency, accuracy and efficiency. Understand how codified knowledge exists to remind technologists of their responsibilities, including procedures they must follow to fulfill constructional, ethical and/or legal compliance requirements. Understand how new materials/tools/techniques and processes, and social/political/environmental shifts challenge past codes, and the role and social responsibility technologists have in ensuring these are continually reviewed and updated as appropriate.	**INDICATORS OF PROGRESSION** Understand that the fitness for purpose of technological outcomes is judged according to its appropriateness (or not) in time and context. Understand the idea of malfunction (single event failure) of technological outcomes, and how this differs to reduced functioning of technological outcomes due to use and levels of outcome reliability, efficiency, durability, etc.. Understand the concept of risk as it relates to reducing instances of mal-functioning technological outcomes, and/or increasing levels of outcome robustness. Understand that 'failures' provide opportunity for deep insights that can greatly benefit future developments and deepen technological knowledge.

Components of Nature of Technology: Draft Indicators of Progression — LEVEL SIX

SUPPORTING LEARNING ENVIRONMENT

Teacher to support students to create informal and formal opportunities throughout learning experiences to share and challenge ideas with a range of others inside and outside of the school environment. Teacher should focus formative interactions on encouraging students to be self reflective and critical to ensure they move towards deeper more sophisticated understandings. Teacher supports students as they make links to past experiences and consider the implications for their future learning in technology. Teacher should challenge students to justify their selection of examples of technologies/technological development as providing opportunity for meeting task requirements, and encourage links between other related curriculum areas to support deeper understandings.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand the interdisciplinary nature of technology and the implications of this for maximising possibilities through collaborative practice.	**ACHIEVEMENT OBJECTIVE** 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.
INDICATORS OF PROGRESSION Understand the reasons for the interdisciplinary nature of knowledge underpinning technology – both within and across technology/other disciplines. Understand the implications of the interdisciplinary base of technology for establishing collaborative practice, which can capitalise on difference to support innovative and increasingly sustainable technological developments. Understand intellectual property in the context of technological development and how this is worked through, (or not), in collaborative ventures to enhance or stifle technological development.	**INDICATORS OF PROGRESSION** Understand the interconnectedness of some technological products and systems and the often fluid boundaries between them. Understand that no technological outcome operates in isolation from other technologies and/or aspects of society, and developing an understanding of how things interconnect allows the development of a holistic rather than reductionist view of the world. Understand the implications of previous technological outcomes on technology and society, for example, public perception and acceptance of linked or perceived-to-be similar technological outcomes.

Components of Nature of Technology: Draft Indicators of Progression LEVEL SEVEN

SUPPORTING LEARNING ENVIRONMENT

Teacher to support students to create informal and formal opportunities throughout learning experiences to share and challenge ideas with a range of others inside and outside of the school environment. Teacher should focus formative interactions on encouraging students to be self reflective and critical to ensure they move towards deeper more sophisticated understandings. Teacher challenges students as they make links to past experiences and as they critically consider the implications for their future learning in technology. Teacher should challenge students to justify their selection of examples of technologies/ technological development as providing opportunity for meeting task requirements and ensure student's choice of other learning during the year will allow them to achieve in technology at this level For example, specific sciences and arts subjects are chosen as relevant to their technology programme focus.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand the implications of ongoing contestation and competing priorities for complex and innovative decision making in technological development.	**ACHIEVEMENT OBJECTIVE** Understand that technological outcomes are a resolution of form and function priorities and that malfunction affects how people view and accept outcomes.
INDICATORS OF PROGRESSION Understand technology as a field of on-going contestation and competing priorities, that require resolution through complex decision making and balancing of resources. Understand the effects of critical evaluation, informed creativity and boundary pushing on innovation and 'alternative' technological developments.	**INDICATORS OF PROGRESSION** Understand technological outcomes are the result of design prioritisation decisions, as based on what is deemed of most value and/or perceived to be acceptable for the target market; these priorities are enacted through embedding them in the brief specifications that drive the development. Understand that many contemporary design decisions are 'hidden' from users and therefore difficult to establish without an informed and critical analysis. Understand the implications of malfunctioning technological outcomes on technology and society (for example, public perception and acceptance of linked, perceived-to-be similar, or innovative technological outcomes and how these impact on perceptions of risk).

Components of Nature of Technology: Draft Indicators of Progression — LEVEL EIGHT

SUPPORTING LEARNING ENVIRONMENT

Teacher to challenge students to ensure they access diverse and critical feedback throughout their learning experiences. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Teacher challenges students as they critically critique their past experiences and as they critically consider the implications for their future learning in ways which support increasingly innovative practices. Teacher should challenge students to justify their selection of examples of technologies/technological development as providing opportunity to surpass and/or extend the requirements of the set task, and ensure students' choice of other learning during the year will allow them to achieve in technology at this level. For example, specific sciences and arts subjects are chosen as relevant to their technology programme focus.

Characteristics of Technology	Characteristics of Technological Outcomes
ACHIEVEMENT OBJECTIVE Understand the implications of technology as intervention by design and how interventions have consequences, known and unknown, intended and unintended.	**ACHIEVEMENT OBJECTIVE** Understand how technological outcomes can be interpreted and justified as fit for purpose in their historical, cultural, social, and geographical locations.
INDICATORS OF PROGRESSION Understand how technological outcomes can 'challenge' people's views of what it is to be 'human'; for example, the current challenges of artificial intelligence developments. Understand the consequences on society of unknown and unintended consequences of technological developments, and how this relates to risk mitigation and risk management. Understand technological knowledge as a social construct with a functional epistemology.	**INDICATORS OF PROGRESSION** Understand technological outcomes as socio-cultural artefacts; that is, entities reflective of a specific time, place and social location. Understand how technological outcomes can be interpreted and justified, and/or critiqued, in terms of their historical, cultural, social, and geographical location. Understand the implications for technological outcomes of probable and possible futures.

Components of Technological Knowledge: Draft Indicators of Progression — EMERGENT

SUPPORTING LEARNING ENVIRONMENT

Teacher to provide opportunities throughout learning experiences for the students' ideas to be shared as a group and challenged, to ensure they are guided towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop understandings of the nature of technology – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should select examples of technologies/ technological development that allow for the meeting of AOs and are reflective of student interests.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE No AO for emergent.	**ACHIEVEMENT OBJECTIVE** No AO for emergent.	**ACHIEVEMENT OBJECTIVE** No AO for emergent.
INDICATORS OF PROGRESSION Yet to be developed.	**INDICATORS OF PROGRESSION** Identify the main materials from which simple products are made.	**INDICATORS OF PROGRESSION** Yet to be developed.

Components of Technological Knowledge: Draft Indicators of Progression — LEVEL ONE

SUPPORTING LEARNING ENVIRONMENT

Teacher to provide opportunities throughout learning experiences for the students' ideas to be shared as a group and challenged, to ensure they are guided towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop understandings of the nature of technology – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should select examples of technologies/ technological development that allow for the meeting of AOs and are reflective of student interests.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Understand that functional models are used to represent reality and test design concepts, and that prototypes are used to test technological outcomes.	**ACHIEVEMENT OBJECTIVE** Understand that technological products are made from materials that have performance properties.	**ACHIEVEMENT OBJECTIVE** Understand that technological systems have inputs, controlled transformations, and outputs.
INDICATORS OF PROGRESSION Understand the difference between 'reality' and representations of reality. Understand models as representations of reality. Understand the purpose of functional modelling in terms of testing design concepts. Understand the purpose of prototyping in terms of testing technological outcomes.	**INDICATORS OF PROGRESSION** Identify the materials from which simple products are made. Identify the performance requirements of materials used in simple products.	**INDICATORS OF PROGRESSION** Understand technological systems as distinct from the steps people carry out in everyday life. Understand components of simple systems (eg, inputs, outputs and transformation processes) and the connections between them. Understand the purpose of simple systems.

Components of Technological Knowledge: Draft Indicators of Progression LEVEL TWO

SUPPORTING LEARNING ENVIRONMENT

Teacher to provide opportunities throughout learning experiences for the students' ideas to be shared as a group and challenged, to ensure they are guided towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop understandings of the nature of technology – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should negotiate the selection of examples of technologies/technological development with the students to allow for the meeting of AOs.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE 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** Understand that there is a relationship between a material used and its performance properties in a technological product.	**ACHIEVEMENT OBJECTIVE** Understand that there are relationships between the inputs, controlled transformations, and outputs occurring within simple technological systems.
INDICATORS OF PROGRESSION Understand the limitations of using models as representations of 'part' or the 'whole' of reality. Understand that functional modelling is used to explore possible and probable implications of design concepts if they were to become technological outcomes. Understand how functional models can be used to gather evidence for and against design concepts. Understand that prototyping is used to gather evidence of a technological outcome's fitness for purpose. Understand how prototyping can be used to enhance the fitness for purpose through further development of technological outcomes.	**INDICATORS OF PROGRESSION** Describe the properties of the materials from which simple products are made. Explain that the materials in simple product are used because of specific performance properties.	**INDICATORS OF PROGRESSION** Understand the nature of the inputs within simple technological systems. Understand how the inputs and the nature of the transformation process enables the creation of the desired outputs.

Components of Technological Knowledge: Draft Indicators of Progression LEVEL THREE

SUPPORTING LEARNING ENVIRONMENT

Teacher to encourage students to create opportunities throughout learning experiences to share and challenge ideas with others. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop understandings of the nature of technology – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should guide students in selecting examples of technologies/technological development to ensure opportunity for the meeting of AOs.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE 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** Understand the relationship between the materials used and their performance properties in technological products.	**ACHIEVEMENT OBJECTIVE** Understand that technological systems are represented by symbolic language tools and understand the role played by the 'black box' in technological systems.
INDICATORS OF PROGRESSION Understand different forms that functional modelling can take; for example, thinking, talking, drawing, simulations, physical mock-ups, etc. Understand that different media used in modelling provide different types of evidence. Understand what evidence is required to evaluate fitness for purpose and how prototyping can best ensure evaluations are robust.	**INDICATORS OF PROGRESSION** Explain how the properties of materials used in products relate to the performance requirements of the product. Suggest possible performance properties as based on the materials used in a product. Suggest possible materials suitable for use in a product as based on proposed performance requirements.	**INDICATORS OF PROGRESSION** Understand representations of simple systems that use appropriate language tools. Understand a 'black box' as a means of representation that makes visible the inputs and outputs of a system, without showing any of that system's inner workings. Understand the role of black boxes in systems, and advantages and disadvantages associated with their use.

Components of Technological Knowledge: Draft Indicators of Progression LEVEL FOUR

SUPPORTING LEARNING ENVIRONMENT

Teacher to encourage students to create opportunities throughout learning experiences to share and challenge ideas with others. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Links should also be made to student opportunities to undertake technological practice and develop understandings of the nature of technology – both those in the past and future opportunities. That is, the understandings being developed should be used to reflect on past experiences and consider the implications for their future learning in technology. Teacher should require students to explain their selection of examples of technologies/ technological development as providing opportunity for meeting task requirements, and provide input as necessary.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE 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** Understand that materials can be formed, manipulated, and/or transformed to enhance the fitness for purpose of a technological product.	**ACHIEVEMENT OBJECTIVE** Understand how technological systems employ control to allow for the transformation of inputs to outputs.
INDICATORS OF PROGRESSION Understand the role of functional modelling in making informed predictions. Understand that it is necessary to consider both what 'can' be done, and what 'should' be done, when undertaking functional modelling to justify decision making. Understand how prototyping can be used to justify the refinement of technological outcomes.	**INDICATORS OF PROGRESSION** Understand that materials can be formed, manipulated and transformed in varying ways, as dependent on their properties. Understand how a product's fitness for purpose can be enhanced by material selection, refinement and/or development.	**INDICATORS OF PROGRESSION** Understand control mechanisms and explain how these increase in sophistication as systems become more self-regulatory. Understand the role of feedback in allowing the successful transformation of input to output in complex systems.

Components of Technological Knowledge: Draft Indicators of Progression — LEVEL FIVE

SUPPORTING LEARNING ENVIRONMENT

Teacher to support students to create informal and formal opportunities throughout learning experiences to share and challenge ideas with others. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Teacher encourages students to make links to past experiences and consider the implications for their future learning in technology. Teacher should challenge students to justify their selection of examples of technologies/technological development as providing opportunity for meeting task requirements.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE 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** Understand how materials are selected, based on desired performance criteria.	**ACHIEVEMENT OBJECTIVE** Understand the properties of subsystems within technological systems.
INDICATORS OF PROGRESSION Understand the role of evidence in justifying decisions made from functional modelling. Understand decision making strategies that employ reasoning, focused on whether outcomes can be realized, alongside whether they should be realised. Understand how prototyping can be used to justify on-going refinement/optimization of technological outcomes	**INDICATORS OF PROGRESSION** Understand how materials are evaluated against performance criteria in order to select possible resources for product development. Understand how materials change in processing and production and how this impacts on selection criteria. Understand the concept of minimal engineering and how this informs material selection and the design of products.	**INDICATORS OF PROGRESSION** Understand the generic and specialized properties of sub-systems as they serve to function within more complex technological systems. Understand how sub-systems allow for the protection of system malfunction or the damage of parts, through such things as back up subsystems or shutdown options.

Components of Technological Knowledge: Draft Indicators of Progression — LEVEL SIX

SUPPORTING LEARNING ENVIRONMENT

Teacher to support students to create informal and formal opportunities throughout learning experiences to share and challenge ideas with a range of others inside and outside of the school environment. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Teacher supports students as they make links to past experiences and consider the implications for their future learning in technology. Teacher should challenge students to justify their selection of examples of technologies/technological development as providing opportunity for meeting task requirements, and encourage links between other related curriculum areas to support deeper understandings.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE Understand the role and nature of evidence and reasoning when managing risk through technological modelling.	**ACHIEVEMENT OBJECTIVE** 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** Understand the implications of subsystems for the design, development, and maintenance of technological systems.
INDICATORS OF PROGRESSION Understand different forms of reasoning and how these provide for an understanding of risk. Understand the difference between possibility and probability, and their role in risk exploration and management. Understand the strengths and weaknesses of more and less accurate model representations, in terms of accuracy of prediction, error propagation, and robustness across contexts. Understand the limitations imposed on modelling from resources – particularly time and money.	**INDICATORS OF PROGRESSION** Understand the implications of new material formulation possibilities, such as nanotechnologies, on future technological products. Understand how materials are manipulated and transformed to increase suitability for use in particular contexts. Understand how potential materials are evaluated to determine suitability for a products development.	**INDICATORS OF PROGRESSION** Understand the purpose of sub-systems in the development and communication of complex systems. Understand the advantages and disadvantages of sub-system use in system design, development and maintenance.

Components of Technological Knowledge: Draft Indicators of Progression LEVEL SEVEN

SUPPORTING LEARNING ENVIRONMENT

Teacher to support students to create informal and formal opportunities throughout learning experiences to share and challenge ideas with a range of others inside and outside of the school environment. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Teacher challenges students as they make links to past experiences and as they critically consider the implications for their future learning in technology. Teacher should challenge students to justify their selection of examples of technologies/ technological development as providing opportunity for meeting task requirements, and ensure students' choice of other learning during the year will allow them to achieve in technology at this level; for example, specific sciences and arts subjects are chosen as relevant to their technology programme focus.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE 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** 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** Understand the concepts of redundancy and reliability and their implications for the design, development, and maintenance of technological systems.
INDICATORS OF PROGRESSION Understand why it is necessary to critically explore what 'can' be done and what 'should ' be done, when making justifiable decisions. Understand that different communities accept different types of evidence as dependent on a range of factors (such as ethics, purpose, perceived authority of people involved in evidence presentation, etc.) And why this must be taken into account in constructive argumentation about 'should' and 'could' decisions. Understand how different risks can be ascertained prior to their realization, and what strategies can be employed to mitigate these.	**INDICATORS OF PROGRESSION** Understand key concepts and processes that underpin material evaluation, such as chemical standards to compare physical properties, to identify methods of detection and evaluation. Understand how these concepts and processes interact in the design, development, maintenance and disposal of technological products.	**INDICATORS OF PROGRESSION** Understand the concept of reliability and the implications for the design, development and maintenance of technological systems. Understand the concept of redundancy and the implications for the design, development, and maintenance of technological systems.

Components of Technological Knowledge: Draft Indicators of Progression LEVEL EIGHT

SUPPORTING LEARNING ENVIRONMENT

Teacher to challenge students to ensure they access diverse and critical feedback throughout their learning experiences. Teacher should focus formative interactions on encouraging students to be self reflective and critical, to ensure they move towards deeper more sophisticated understandings. Teacher challenges students as they critically critique their past experiences and as they critically consider the implications for their future learning in ways which support increasingly innovative practices. Teacher should challenge students to justify their selection of examples of technologies/technological development as providing opportunity to surpass and/or extend the requirements of the set task, and ensure students' choice of other learning during the year will allow them to achieve in technology at this level. For example, specific sciences and arts subjects are chosen as relevant to their technology programme focus.

Technological Modelling	Technological Products	Technological Systems
ACHIEVEMENT OBJECTIVE 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** 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** Understand operational parameters and their role in the design, development, and maintenance of technological systems.
INDICATORS OF PROGRESSION Understand the critical role of technological modelling in making informed, responsive and defensible decisions about technological developments. Understand how different tools are used in ascertaining and mitigating risk, as based on a deep understanding of historical antecedents and the interactions between often competing and contestable factors (for example, factors arising from differing moral, ethical, cultural, and/or political views; the way in which people adhere to and understand issues such as sustainability, globalisation, democracy, global warming, etc.).	**INDICATORS OF PROGRESSION** Understand key concepts and processes that underpin material development, (such as chemical stability and fitness for purpose; means of matter generation, means of separation and purification, comparison of alternative production for economic advantage). Understand how these concepts and processes interact in the design, development, maintenance and ultimate disposal of technological products.	**INDICATORS OF PROGRESSION** Understand key concepts and processes that underpin the operational parameters of technological systems, (such as energy efficiency, fail-safe, back up, redundancy, and performance tolerances). Understand the complex interactions leading to the development of safe and reliable operational parameters for the design and development of systems. Understand how ongoing maintenance interacts with and supports the operational parameters of technological systems.

TECHNOLOGY PROGRAMME DESIGN

Discussion ideas for future programme development

Abstract

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

Introduction

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

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

SECTION ONE

Programme Focus and Duration

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

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

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

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

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

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

Achievement Objectives and Reporting

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

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

SECTION TWO

Learning Intentions

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

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

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

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

Pedagogical Strategies

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

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

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

SECTION THREE

Examples of programme change

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

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

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

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

Figure 1: Example of a Year 3-4 Programme

CONTEXT 1	CONTEXT 2	CONTEXT 3	CONTEXT 4
New to Here	*Playtime*	*The Aquarium*	*Celebration*
(See below)	(See below)	(See below)	(See below)

Figure 1a: Current Programme

COMPONENT-RELATED LEARNING INTENTIONS

Outcome Development & Evaluation	Planning for Practice	Brief Development	Brief Development	Brief Development	Outcome Development & Evaluation	Planning for Practice	Planning for Practice
Skill: Use of digital cameras	**Skill**: Developing a storyboard	**Skill**: Written and oral presentation	**Skill**: 2D & 3D sketching techniques to communicate concept ideas		**Skill**: Setting up trials to evaluate ideas	**Skill**: Adapting recipes to suit ingredients	**Skill**: Constructing display stands
Knowledge: Ways that information is communicated	**Knowledge**: Needs of new students	**Historical Knowledge:** Games in other cultures	**Knowledge**: Rules of selected game	**Knowledge**: About different fish species	**Knowledge**: Environments that sustain healthy fish	**Knowledge**: Foods for celebration	**Knowledge**: Roles within organisations

Figure 1b: Transition – Introduction of additional strands

COMPONENT-RELATED LEARNING INTENTIONS

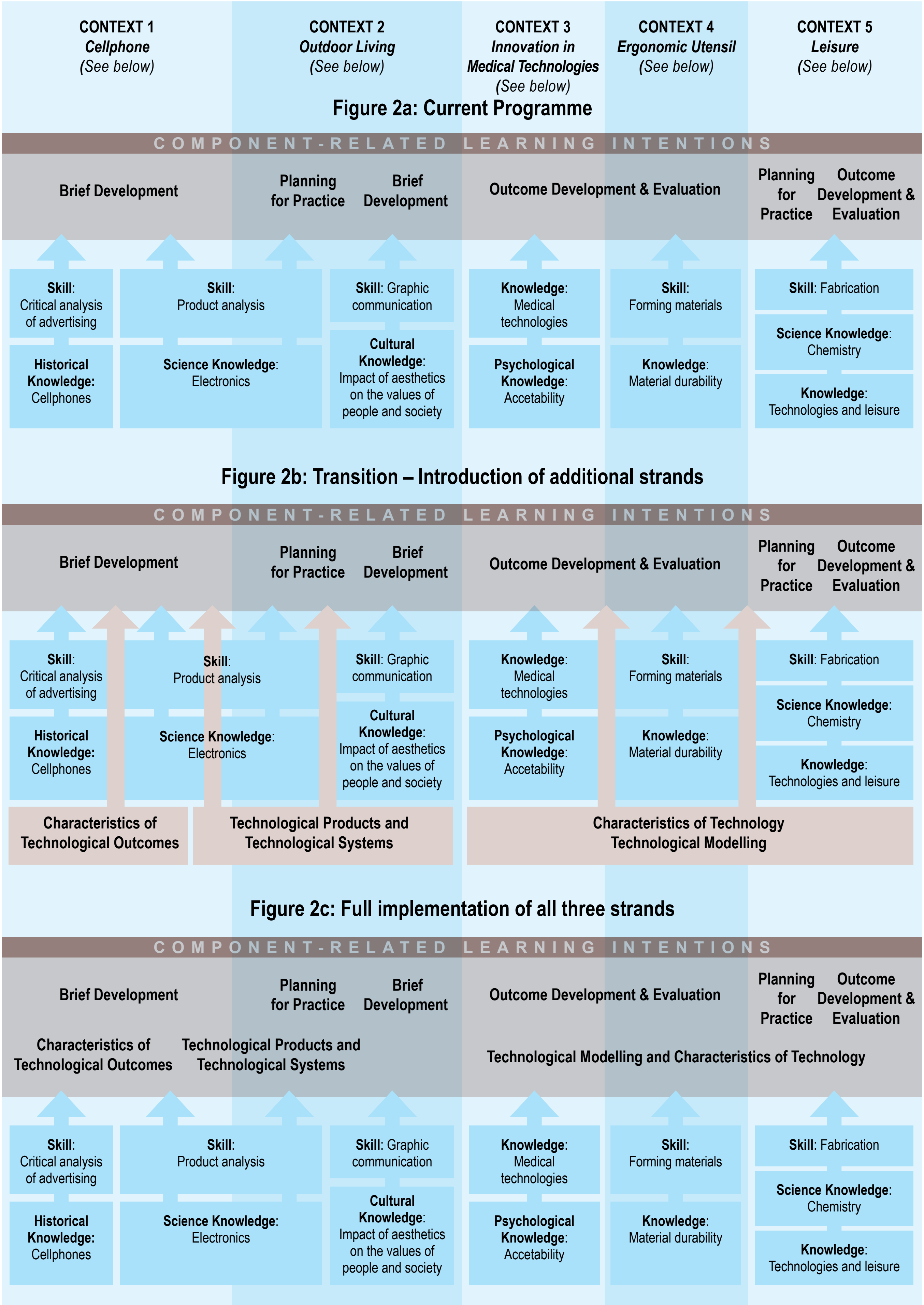
Outcome Development & Evaluation	Planning for Practice	Brief Development	Brief Development	Brief Development	Outcome Development & Evaluation	Planning for Practice	Planning for Practice
Skill: Use of digital cameras	**Skill**: Developing a storyboard	**Skill**: Written and oral presentation	**Skill**: 2D & 3D sketching techniques to communicate concept ideas		**Skill**: Setting up trials to evaluate ideas	**Skill**: Adapting recipes to suit ingredients	**Skill**: Constructing display stands
Knowledge: Ways that information is communicated	**Knowledge**: Needs of new students	**Historical Knowledge:** Games in other cultures	**Knowledge**: Rules of selected game	**Knowledge**: About different fish species	**Knowledge**: Environments that sustain healthy fish	**Knowledge**: Foods for celebration	**Knowledge**: Roles within organisations
Characteristics of Technology		Technological Systems and Technological Modelling		Characteristics of Technological Outcomes		Technological Products	

Figure 1c: Full implementation of all three strands

COMPONENT-RELATED LEARNING INTENTIONS

Outcome Development & Evaluation	Planning for Practice	Brief Development	Brief Development	Brief Development	Outcome Development & Evaluation	Planning for Practice	Planning for Practice
Characteristics of Technology		Technological Systems and Technological Modelling		Characteristics of Technological Outcomes		Technological Products	
Skill: Use of digital cameras	**Skill**: Developing a storyboard	**Skill**: Written and oral presentation	**Skill**: 2D & 3D sketching techniques to communicate concept ideas		**Skill**: Setting up trials to evaluate ideas	**Skill**: Adapting recipes to suit ingredients	**Skill**: Constructing display stands
Knowledge: Ways that information is communicated	**Knowledge**: Needs of new students	**Historical Knowledge:** Games in other cultures	**Knowledge**: Rules of selected game	**Knowledge**: About different fish species	**Knowledge**: Environments that sustain healthy fish	**Knowledge**: Foods for celebration	**Knowledge**: Roles within organisations

Figure 2: Example of a Year 9-10 Programme



Contexts for Figures 1 and 2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TECHNOLOGY AND VALUES:

Initial discussion of the relationship

Abstract

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

Values Education in New Zealand

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

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

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

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

Learning about values refers to students learning about:

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

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

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

The Relationship between Technology and Values Education

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

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

The Components within the Technological Practice strand

Brief Development

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

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

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

Planning for Practice

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

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

Outcome Development and Evaluation

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

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

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

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

The Components within the Nature of Technology strand

Characteristics of Technology

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

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

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

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

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

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

Characteristics of Technological Outcomes

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

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

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

The Components within the Technological Knowledge strand

Technological Modelling

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

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

Technological Products

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

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

Technological Systems

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

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

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

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

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

TECHNOLOGY AND KEY COMPETENCIES:

Initial discussion of the relationship

Abstract

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

Key Competencies in New Zealand

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

The curriculum identifies five key competencies. These are:

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

The Relationship between Technology and the Key Competencies

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

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

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

Thinking

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

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

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

- undertaking technological practice within innovative problem solving situations
- understanding the nature of technology through exploring examples of existing technological outcomes or

developments, debating contentious issues, or projecting into alternative scenarios
- developing key technological knowledge that is then used to evaluate within technological modelling, or to explain how and why products and/or systems work

Using Language, Symbols, and Texts

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

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

Managing Self

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

Relating to Others and Participating and Contributing

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

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