EXPLANATORY PAPER

The Nature of Technology Strand: Characteristics of Technology

ABSTRACT

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

COMPONENT DESCRIPTOR

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

KEY IDEAS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

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

New Zealand is different: Chemical milestones in New Zealand history, edited by Denis Hogan and Bryce Williamson, provides a series of historical examples of the inter-relationship between technology and society. In particular, it describes some of the chemistry and technology that has contributed to the development of New Zealand’s current economic, research, and development base. This book also forms the basis for a website called *An history of technological innovation in New Zealand*, which can be found at http://www.techhistory.co.nz/. Examples provide illustrative accounts of how technology is embedded in society and the resulting benefits, losses and unforeseen consequences associated with this.

POSSIBLE LEARNING EXPERIENCES

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

Junior Primary (NE-Year 4)

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

Students achieving at level 1 could be expected to:

- identify things around them that belong to the made world and suggest why they may have been developed; and
- identify the types of things a technologist would have had to take into account when developing a technological outcome.

Students achieving at level 2 could be expected to:

- identify the year their selected technological outcome was made and discuss what factors might have impacted on its development at this time;
- identify how their outcome changed how people do things and discuss any positive and/or negative impacts it has had on society and/or the environment; and
- make suggestions as to how the technological outcome may change in the future and describe how this may impact on the made, social, and natural world.

Senior Primary/Intermediate (Years 5-8)

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

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

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

Students achieving at level 2 could be expected to:

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

Students achieving at level 3 could be expected to:

- explain why their selected technological development has changed over time;
- describe how their selected technological development has impacted on the social world over time;
- describe how their selected technological development has impacted on the natural world over time; and
- describe what technological knowledge is.

Students achieving at level 4 could be expected to:

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

Junior secondary (Years 9-10)

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

Students achieving at level 3 could be expected to:

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

Students achieving at level 4 could be expected to:

- explain how their selected technological issue has stimulated creative and critical thinking;
- explain how their issue has led to changes in how people perceive or do things; and
- identify the knowledge used to support different perspectives within a selected issue.

Students achieving at level 5 could be expected to:

- describe a personal position regarding the acceptance of a particular technological development related to the selected technological issue and explain this in terms of their own experiences and developing views; and
- explain why the codes of practice relevant to their issue were developed and the impact these have had on related technological developments to date and the possible influence on future developments.

Senior Secondary (Years 11-13)

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

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

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

Students achieving at level 4 could be expected to:

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

Students achieving at level 5 could be expected to:

- discuss the role of creative and critical thinking in the technologist’s practice;
- explain how the past experiences, attitudes, and knowledge of the technologist impacts on how they undertake their work;
- identify codified technological knowledge important to the technologist and explain how it impacts on their practice; and
- explain how and why the identified technological knowledge became codified.

Students achieving at level 6 could be expected to:

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

Students achieving at level 7 could be expected to:

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

Students achieving at level 8 could be expected to:

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