EXPLANATORY PAPER

The Technological Knowledge Strand: Technological Products

ABSTRACT

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

COMPONENT DESCRIPTOR

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

KEY IDEAS

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

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

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

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

Material selection is based on matching the desired performance criteria of a technological product with the performance properties of the materials available to ensure the material selected will be adequate for use in the product. Material evaluation plays a critical role in material selection decisions that can be justified in terms of the material not only being adequate, but being the *optimal* material for use when all factors are considered. In order to effectively evaluate a material's suitability, specific knowledge of material composition is critical, as are understandings of what techniques and/or procedures are accepted within particular communities of practice. To support the processing or construction of products, technologists often use specialised language and symbols to communicate material-related details. Material-related details include such things as what materials would be feasible for use and how they would need to be formed, manipulated, and/or transformed.

Material development refers to the development work that makes available different and/or innovative performance properties through the formulation of new materials. The contemporary field of material development is crossing many traditional disciplines and showing increasingly diverse and exciting possibilities for material performance properties, and, therefore, the types of functions that a technological product may have. The development of new materials relies on understanding such things as existing materials including their advantages and limitations; new material composition and structure possibilities; formulation procedures; future requirements, needs, and desires; and an awareness that new evaluative procedures may need to be developed to determine the suitability of new materials.

The development of "smart" materials in a range of areas allows for the exploration of the relationship between material performance properties and what types of products can be designed. The defining characteristic of a "smart" material is its ability to change or adapt in response to an external stimuli which may be technological or environmental in nature or from human input. The external trigger causes a transformation resulting in a change to the properties of the material itself. Examples of products developed from smart materials include heat regulating clothing, light-responsive sunglasses, artificial muscles, self-cleaning textiles, self-adjusting optical lenses, colour-changing shirts, self-healing paint, etc. An example of smart material development can be seen at www.techlink.org.nz/Case-studies/Technological-practice/Materials/smart-fibres.

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

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY[4]

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

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

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

POSSIBLE LEARNING EXPERIENCES

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

Junior Primary (NE-Year 4)

In small groups, students could explore a range of technological products developed for similar functions and identify what is different about them and why this might be. For example, one group could explore a range of different brushes (toothbrushes, wire brushes, paint brushes, etc.) and establish why different materials were used for the handles and bristles to carry out different specific purposes. The students could also discuss what they think may have been done to the material in the making of the product.

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

Students achieving at level 1 could be expected to:

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

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

Students achieving at level 2 could be expected to:

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

Senior Primary/Intermediate (Years 5-8)

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

When exploring the use of materials involving living organisms, students could develop understandings of how properties can be measured – including objective and subjective measurement techniques.

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

Students achieving at level 2 could be expected to:

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

Students achieving at level 3 could be expected to:

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

Students achieving at level 4 could be expected to:

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

Junior secondary (Years 9-10)

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

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

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

Students achieving at level 3 could be expected to:

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

Students achieving at level 4 could be expected to:

- explain how a musical instrument was enhanced through the way materials were manipulated;
- explain how the fitness for purpose of a musical instrument was enhanced through the formulation of a new material; and
- explain how the cleaning and ongoing care of a musical instrument has been enhanced by the use of a finishing technique that transformed a material.

Students achieving at level 5 could be expected to:

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

Senior Secondary (Years 11-13)

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

They could then investigate lighting products that have become available due to the development of new materials. They could explore the knowledge and techniques required for the development of these materials, including new evaluation procedures to ensure product designs were both technically feasible and socially acceptable. The product could be critiqued in terms of wider social and environmental considerations regarding the availability, production, modification, usage, and disposal of the materials used in the products. The students could then use these understandings to inform their own conceptual design of a lighting product for an identified client. They could present their design effectively through the use of specialised language and drawings to clearly communicate how materials would need to be selected and manipulated to ensure they upheld the design's feasibility and acceptability.

Students achieving at level 4 could be expected to:

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

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

Students achieving at level 5 could be expected to:

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

Students achieving at level 6 could be expected to:

- explain the composition and structure of the materials used in lighting products;
- explain how existing materials have been manipulated and/or transformed to increase their suitability for lighting products in particular contexts and/or for specialised functions; and
- describe how the evaluation of different materials has informed their own conceptual design.

Students achieving at level 7 could be expected to:

- explain the concepts and processes involved in the objective and subjective evaluation procedures used to determine the suitability of different materials for a range of reliable and safe lighting products;
- explain how material evaluations influenced the initial design ideas and life cycle decisions, ongoing development, maintenance guidelines, and disposal of lighting products; and
- critique the selection of materials for a range of lighting products on the grounds of material sustainability, user-friendliness, and disposal.

Students achieving at level 8 could be expected to:

- explain the concepts and processes involved in the development of a new material that provided an opportunity for an increase in the type and nature of lighting functions;
- explain how new materials were evaluated to ensure they would met feasibility and acceptability related specifications; and
- discuss how new materials have influenced the development of new lighting products in terms of expanding initial design ideas, influencing life-cycle decisions, enhancing ongoing development and evaluation, ensuring effective maintenance, and acknowledging issues associated with the ultimate disposal of products.