The Technological Practice Strand: Outcome Development and Evaluation

ABSTRACT

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

COMPONENT DESCRIPTOR

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

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

KEY IDEAS

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

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

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

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

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

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

Trialling a prototype provides data for evaluating a technological outcome's fitness for purpose. Accessing feedback from stakeholders is essential to all evaluations.

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

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

• functional modelling should seek to explore the outcome's suitability with reference to both the outcome itself *and* the practices used in its development;

• prototyping should attempt to evaluate the outcome in keeping with the wider context within which the brief resides, including both physical and social environment influences and impacts, both now and in possible future scenarios.

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY

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

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

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

ILLUSTRATIVE EXAMPLES FROM TECHNOLOGY EDUCATION

Learning experiences

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

Junior Primary (NE-Year 4)

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

Students achieving at level 1 could:

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

Students achieving at level 2 could:

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

Senior Primary/Intermediate (Years 5-8)

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

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

Students achieving at level 2 could:

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

Students achieving at level 3 could:

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

Students achieving at level 4 could:

- develop logo designs for a gift pack that took into account the resources available (material and manufacturing process of the button, size and material of labels);
- communicate design ideas to recipient to gain feedback;
- explore and test different recipes for shampoo and wax and research ingredients;
- compile a summary of feedback from the recipient on suitability, in terms of hair type and personal preferences concerning fragrance and ingredients;

- evaluate logo designs and product ideas in terms of their ability to meet the attributes identified from recipient feedback and the constraints identified from research into resources available;
- undertake testing of shampoo (acidity and tensile strength) and hair wax (drop and rub), and use results to modify products based on ensuring key attributes were prioritised to best meet recipient needs;
- develop prototype samples of products for recipient testing, using their feedback to refine the products;
- develop a gift pack containing products that incorporated all key attributes identified; and
- gather recipient feedback to provide evidence of how well the final gift pack addressed the key attributes for use in an evaluation of the gift pack's fitness for purpose.

Junior Secondary (Years 9-10)

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

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

Students achieving at level 3 could:
- develop designs for labels that reflect the selected client's colour preferences;
- explore the suitability of a range of containers;
- explore and test different recipes for a range of potential products, and identify storage issues associated with the ingredients for each;
- evaluate designs and product ideas to determine suitability for the client and select one for further development;
- undertake sensory testing with the client to refine the recipe;
- develop a package of bottled ingredients, including labels for containers, that address the client's colour, taste, and 'ease of making' preferences; and
- evaluate the package against key attributes identified in the brief.

Students achieving at level 4 could:
- develop designs for labels, and select a range of containers and product outcomes that reflect the selected client's colour, taste, nutritional requirements, and requirements for making preferences, i.e., ease of use and time to make;
- develop concept diagrams to test design ideas with the client to gain feedback on what attributes are key from their perspective;
- explore and test different recipes for a range of potential products and use the outcomes as functional models to gain further feedback from the client on taste preferences (sensory testing using a hedonic scale) and nutritional concerns based on the ingredients used (discussion of recipes);
- test ingredients to identify any storage issues and explore how these may be influenced by container choice;
- evaluate labels, containers, and product ideas, and select a package design appropriate for further development, refine the package design to ensure it incorporates key attributes;
- develop a prototype of bottled ingredients for client testing, refine product in keeping with client feedback on key attributes associated with the look and user friendliness of labelling and instructions and the quality of outcome produced;
- develop a package of bottled ingredients, including labels for containers, that incorporate the key attributes as determined by the client's preferences, and address the constraints imposed by storage requirements;
- gather client feedback to provide evidence of how well it addressed the key attributes for use in an evaluation of the package's fitness for purpose.

Students achieving at level 5 could:

- experiment with a range of "ready to make" food packages and analyse how labelling and packaging requirements enable the product to be successful – or not;

- reflect on past experiences of food preparation and use the above analysis and reflection to develop a feasibility guide to inform the generation of initial ideas for developing a 'batters in a bottle' food package;

- develop designs for labels, and select a range of containers and product outcomes justified in terms of the requirements of the brief (based on client preferences and specifications associated with storage, packaging, and user friendliness);

- develop appropriate functional models (including concept diagrams, discussion prompts, photographs of container types, recipes, and photos of products);

- use the models to illustrate the range of options available and test initial design ideas as to how they may form a package;

- use the models to gain critical feedback from the client on the specifications they consider essential;

- experiment with a range of labels, recipes and storage options, and seek input from additional sources (for example, research findings, other people who may eat the food product such as family members, friends, etc.) to determine suitability of resources in terms of the specifications;

- refine package ideas, incorporating justified label designs, containers, recipes, and ingredients, and undertake further functional modelling with the client to gain critical feedback to select one for further development. Modelling includes sensory testing of food product, functionality testing of containers, and judgments on quality of label including clarity of instructions;

- develop a prototype of bottled ingredients for client trialling in the environment for which the package is being developed;

- refine the product in keeping with client feedback related to the specifications of the brief and any additional comments from others who viewed and/or used the package or ate the food product; and

- use feedback from key stakeholders, including the client and teacher, to provide evidence to support an evaluation of the fitness for purpose of the final "Batters in a Bottle" package.

Senior Secondary (Years 11-13)

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

Students achieving at level 4 could:

- develop design ideas for potential lighting products reflective of the key aesthetic attributes established from Sandwiches' "Retro Kiwiana" style;

- develop a functional model (for example, using sketches, annotated diagrams, material samples, and colour suggestions) to test design ideas with the client to gain feedback;

  - explore and test different materials for a range of potential lighting products, taking into account key attributes of cost effectiveness and safety;

  - create mock-ups to gain further feedback from the client on preferences;

  - explore possible means of production for different design ideas and evaluate these in terms of suitability for batch production;

- evaluate design ideas, and select a design appropriate for further development;

- experiment with materials and design features to ensure they incorporate key attributes and will allow for the development of a feasible outcome;

- develop a prototype lighting product, and gain product safety certification from a registered electrician prior to trialling *in situ*, for client feedback;

- refine in keeping with client feedback on key attributes associated with the look and function of the lighting product;
- present a final lighting product that incorporated the key attributes determined from the opportunity provided by the client's preferences and constraints imposed by budget, production, and safety requirements; and
- gather client feedback to provide evidence of how well it addressed their needs/desires and use this in an evaluation of the lighting system's fitness for purpose.

Students achieving at level 5 could:

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

Students achieving at level 6 could:

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

related to safety, construction processes, and associated costs as well as wider considerations of physical (resource availability) and social (symbolic associations of the design) considerations;

- refine design ideas incorporating justified features and materials, and undertake further functional modelling with the client and other stakeholders (including customers) to gain critical feedback to select one for further development;

- develop a prototype of the lighting product, and gain product safety certification from a registered electrician prior to trialling *in situ* for client, mentor, and customer feedback;

- refine in keeping with client and mentor feedback related to the specifications of the brief and in keeping with any additional comments from key stakeholders and customers that could enhance the product without compromising any specifications;

- present a final lighting product that met the specifications of the brief and was appropriate to the physical and social environment of Sandwiches; and

- use feedback from a range of stakeholders, including the client, teacher, mentor, and customers, to provide evidence to support an evaluation of the lighting product's fitness for purpose in terms of the brief and the physical and social environment of Sandwiches.

Students achieving at level 7 could:

- explore a range of contemporary and historical lighting products, including those used in Sandwiches currently and in the past, with particular emphasis on critically analysing their fitness for purpose;

- reflect on experiences from previous technological practice – including tea lantern development, critically analysing these in terms of how fit for purpose they were;

- use the above analysis and reflection to inform the generation of a range of innovative ideas that explore the potential of the opportunity provided;

- evaluate the design ideas to select those justified as appropriate in terms of the requirements of the brief (based on Sandwiches' style, client preferences, and specifications associated with safety and batch production), in terms of the physical and social environment in which the lighting system is to be placed, and in terms of the wider context of lighting public venues;

- develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, and models to illustrate potential materials and how they can be modified for different effects) to illustrate the range of options available and test initial design ideas of how they may work in the environment of Sandwiches;

- use the models to gain critical feedback from the client, mentors, a range of customers, and other identified stakeholders (for example, musicians that regularly play at Sandwiches, potential customers, neighbouring shop owners, etc.) on the specifications they consider essential and desirable;

- explore a range of resources and the implications of material selection for disposal, and critically investigate design features, including an exploration of the implications for product maintenance, seeking guidance from additional sources (for example, research findings, mentors, friends, etc.) to determine the suitability of the resources. Undertake evaluative testing procedures in line with accepted codes of practice to ensure the resources would meet the specifications related to safety, production processes, and associated costs, as well as wider considerations of physical (resource availability, sustainability/disposal) and social (symbolic associations of the light product's aesthetic) considerations;

- explore the implications of the changing use of the venue (during the day, early evening, late night) and refine design ideas accordingly, incorporating justified features and materials, and undertake further functional modelling with the client and other stakeholders to gain critical feedback to select one for further development;

- develop a prototype of the lighting product, and gain product safety certification from a registered electrician prior to trialling *in situ* for client, mentor, and customer feedback;

- refine in keeping with client and mentor feedback related to the specifications of the brief and in keeping with any additional comments from key stakeholders and customers that could enhance the system without compromising any specifications;

- present a final lighting product that met the specifications of the brief and was appropriate to physical and social environment of Sandwiches; and
- evaluate the final lighting product's fitness for purpose against the brief, using key and wider community stakeholder feedback to justify its suitability to address the issue of lighting public venues.

Students achieving at level 8 could:

- explore a range of contemporary and historical lighting products, including those used in Sandwiches currently and in the past, with particular emphasis on critically analysing the product's fitness for purpose in its broadest sense. Identify wider issues associated with the context of lighting in public venues. Reflect on experiences from previous technological practice – including tea lantern development, critically analysing these in terms of how fit for purpose they were. Use this analysis and reflection to inform the generation of a range of innovative ideas that fully exploit the potential of the opportunity provided;

- evaluate the design ideas to select those justified as appropriate in terms of the requirements of the brief (based on Sandwiches style, client preferences, and specifications associated with safety and batch production) and in terms of the physical and social environment in which the lighting system would be placed. Develop effective functional models (for example, concept diagrams, discussion prompts, photographs of other lights that include appropriate features or styles, and models to illustrate potential materials and how they can be modified and finished to create a range of effects) to justify the options available, allowing for a lighting product that would be fit for purpose in its broadest sense. Use models to gain critical feedback from the client, mentors, customers, and other identified stakeholders (for example, musicians that regularly play at Sandwiches, potential customers, neighbouring shop owners, etc.) on the specifications they considered essential and desirable;

- explore a range of resources and the implications of material selection for ultimate disposal. Critically investigate design features, including an exploration of the implications for ongoing product maintenance, seeking guidance from additional sources (for example, research findings, mentors, friends, etc.) to determine the suitability of the resources. Undertake evaluative testing procedures in line with accepted codes of practice to ensure the resources will be appropriate for use in a lighting product that will be fit for purpose;

- explore the implications of the changing use of the venue (during the day, early evening, late night) and refine design ideas accordingly, incorporating justified features and materials;

- undertake further functional modelling, with the client and other stakeholders, to gain critical feedback to select one model for further development;

- develop a prototype of the lighting product, and gain product safety certification from a registered electrician prior to trialling *in situ* for client, mentor, and customer feedback. Refine in keeping with client and mentor feedback related to the specifications of the brief and in keeping with any additional comments from key stakeholders and customers that could enhance the system without compromising any specifications;

- present a final lighting product that was fit for purpose; and

- critically evaluate the lighting product's fitness for purpose against the brief, issue, and context, using key and wider community stakeholder feedback to justify its fitness for purpose.