Transformation by Design

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Abstract

This paper will argue that design capability is one of the most significant capacities of the human mind and is therefore essential for young people's education. Underlying this assertion is the belief that design capability distinguishes technology from technicity (procedural knowledge in a technical context).

Extrapolating Ryle's (1949) ontology to technology education, the author has previously asserted that

Know that)
Know relevance))-----→ Strategy knowledge
Know how)

inserting *know relevance* into Ryle's two-fold distinction.

Additionally, the role of the inner eye is central to design: *seeing in* (Wollheim, 1987) and *seeing as* (Wittgenstein, 1989). The recognition of the use of extrapolation, simile, metonym and metaphor transforms Ryle's distinction between declarative and procedural knowledge into something much more powerful for thinking about design processes. In a technological context, it represents the transformation of an initial perception of possibility into an innovative product, process or system.

This theoretical understanding grew from the author's doctoral research into young children's use of drawing as a tool for designing, part of which involved a 2-year longitudinal study in which the purpose of using drawing for designing was explained to a class of 6-7 year olds using the dual metaphor of drawing as both a container and a journey. This metaphor enabled them to understand the potential and purpose of using drawing to support the generation and development of design ideas. Not only were these young children able to use drawing in a much more powerful way than previously observed in children of this age, but the products and design solutions that they produced were more creative and effective.

Within education, as in the real world, the ability to transfer and apply knowledge from one area to another is highly valued. Within technological design, an effective solution frequently requires the ability to extrapolate, to use metonyms and metaphors from other realms of experience and expertise. The success of the container / journey metaphor depended on this capacity.

The transformational capability of the human mind, to see things from multiple perspectives and to take leaps of imagination stems, this author believes, from our love of story. Essentially, I told the children a good story. To apply narrative to the use of science to engineer a solution is, I believe, a uniquely human capability and empowering children to do so may be imperative for all our futures.

Knowing What is Relevant to the Problem

At the heart of what a designer / producer is trying to do is transformation: the changing of something into something else which, in some specific circumstance(s), is (hopefully) going to be useful.

In contrast to the scientific quest for a "one-size-fits-all" theory of everything, technological knowledge is heuristic, specific, opportunistic and pragmatic. The strategies employed to solve a problem may be practical, theoretical, imaginative; involving analogy or metaphor, prior knowledge and / or experience, social awareness, empathy, cultural traditions, religious or ethical beliefs. There is also the "real world" of what the materials and components will actually *do*, what someone might do with them, and the consequences of success or failure in the attempt, which can all be on an personal, community and / or global scale. Designing technology is complex as are the strategies employed.

Designing is messy; intellectually that is, not just the dust and glue and bits all over the floor when making the product. It comes under Rittel and Weber's (1974) classification of "wicked problems", or as Buchanan (1995) calls them, indeterminate, in which no answers are true / false only better / worse. Every situation is unique and designers are continually required to flip mentally between the general and the particular, which sheds a different light on Ryle's neat division of knowledge into "what" and "how". If every design situation is new, then how can rules about what counts as knowledge within this messy field be decided? Not only do designers have to think about the materials, procedures, economics and so on, but also the needs and desires of a client or potential user, and perhaps also about the shelf-life and disposal of the product once obsolete or broken. Plus the product may need some aesthetic appeal in order to be taken off the shelf in the first place.

Middleton (2000) provided a model (Fig 1) for designing in which his "search and construction space" is replete with backtracking, diversions, cul-de-sacs, and end-points. The "satisficing zone" may not be the only idea, not even the best there is, since it may be refined later or new technology may affect its efficacy, but as the idea or solution of the moment, it is sufficient.

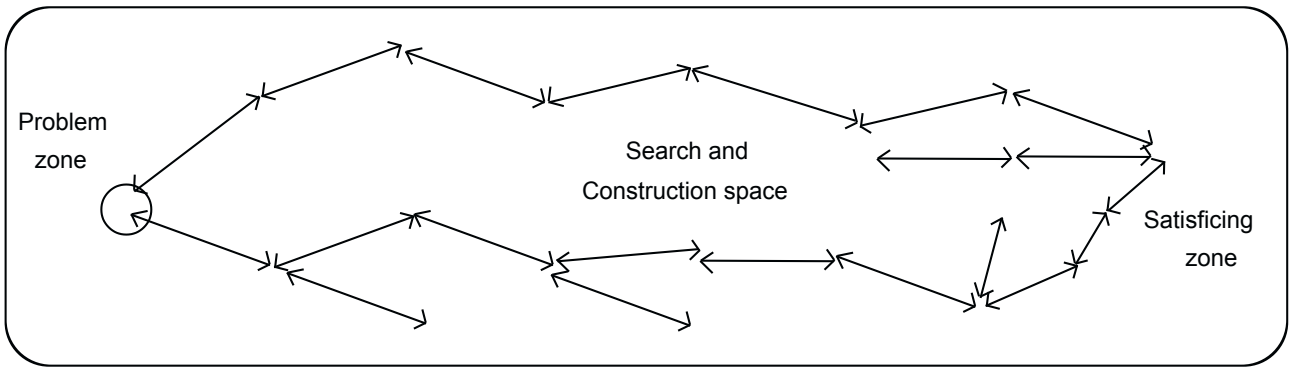


Fig.1; from Middleton (2000)

A useful analogy here is that of the key in the lock, provided by Von Glasenfeld (1987):

> "Knowledge can never be interpreted as a picture or representation of [the] real world, but only as a key that unlocks possible pathways for us." (p.194)

Von Glasenfeld rejected the view that knowledge should *match* reality (like paint matching some already on the wall), asserting that if we say that it *fits* in sense of a key fitting a lock then a totally different relation exists between solution and problem / idea and opportunity. The fit describes the key, not the lock and many keys fit same lock.

Deciding which strategy to follow can be seen as an expansion and development of Ryle's (1949) division of knowledge into *knowing how* and *knowing that* to include the lateral thinking often employed by designers as well as their skill, experience and understanding in judging which of these flights of fancy are most apposite to the design opportunity or to solve the problem in hand (Fig 2)

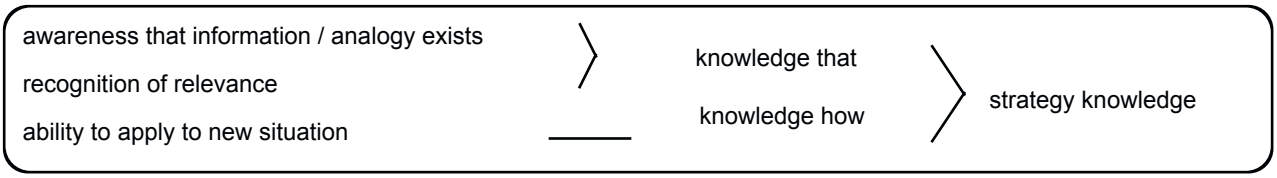


Fig. 2: know that / know how / know relevance

"Strategy knowledge" is defined here as underpinning the choice of procedure to follow in a specific circumstance, a combination of *know how* and *know that* which has power when linked to *knowledge of relevance* to the problem or opportunity. This informs the way in which a new project is approached and carried through. Once a strategy has been mastered and internalised, it then becomes part of the *know that* and *know how* which makes solving the next similar problem so much easier. This creates a cognitive network of strategies, linked by simile and analogy, which enable life-long building of learning to deal with both the familiar, the new and the totally novel, leading to the ability to create new ideas that will work in the real world.

In this model, *know that* is a combination of knowing of the existence of particular information and of its relevance to the current design situation. The designer does not need to know all the details; they can search the internet, consult an in-house expert or be able to work it out in practice. *Knowledge of relevance*, therefore, is more pertinent to design opportunities, than knowing all the facts. Knowing how to use the relevant information, or knowing someone else who can, may lead to design success. The way forward, *strategy knowledge* in a design context ("What we could do is…"), is parallel to the breakthroughs of science or the finding of a new melody or the use of a striking metaphor in a poem. The choice of appropriate strategy in any design situation depends on the depth and salience of this three-fold knowledge base: *know that*, *know how* and *know relevance*.

The understanding of relevance is key to children's developing design capabilities. Donaldson (1992) found that 6 year olds had difficulty in solving adult-defined problems because they could not solve "this problem and this problem only"; they wanted to re-invent the rules of the game:

> "They did not have a clear conception of this problem - this one and no other - which they could hold on to and use in deciding when the problem had been successfully dealt with, so that thinking about it should cease. Such a conception is the very foundation of relevance. And there can be no intellectual power where a sense of relevance is lacking."(p.135)

Choosing to conduct my research with 6-7 year olds, therefore, was risky, but a risk worth taking. This age group was purposely chosen because they were on the cusp of this perceived understanding of what is relevant to solving a design problem.

Extrapolation, Analogy and Metaphor

Lurking behind *know relevance* is to "see analogy" or "perceive metaphor". The relevance of prior knowledge or new perception may be realised through a flight of fancy, a side-ways jump of the imagination or a new way of seeing old knowledge.

This may be through:

- Realising that the situation has similar but not identical features to one encountered previously (extrapolation)
- Seeing the new situation as if it were an example of one taken from a different field of experience (analogy)
- Applying thinking, concepts and vocabulary from a different conceptual system to enlighten thinking within the present situation (metaphor)
- Using a symbolic system (e.g. drawing) as a way of supporting thinking about a solution that will be realised in different materials or systems (metonym).

Although they are specifically discussing language, Lakoff and Johnson's (1980) *Metaphors We Live By* demonstrates how knowledge is built across many different fields, including designing. Concepts come with attachments (entailments) and when these encounter each other, then new ways of seeing will arise. Veale's (1999) term "conceptual scaffolding" which (also discussing language) he describes as "an architectural guide, or blueprint, for the assembly process, but may not constitute an element in the final edifice. That is to say, conceptual scaffolding possesses a transient existence to serve as a temporary representational purpose" (http:/www.compappdcu.ie/~tonyv/papers/CogSci.ps,gz).

In the context of design development, drawing, mock-ups, maquettes and prototypes would all fit under the umbrella of Veale's conceptual mapping. Roberts' (1994) helpful distinction between "modelling of" and "modelling for" extends and defines the way in which designers use these design tools for imaging the future and putting the ideas in the mind's eye into the public world, available for evaluation, scrutiny and improvement. Likewise, Baynes (1994) definition of modelling as the *language of design* also is helpful in opening up the ways forward in accessing the literature on language theory and applying them to our field. The way in which language works, by constantly reapplying a set of words and rules in new situations and in novel ways in order to communicate, project ideas and influence the social world, is parallel to the way in which people use materials, components and systems to create new products or use existing products in new ways.

Gentner (1982) saw models as "structure mappings" from one domain to another since it was often the overall structure of a problem that was transferred analogically from one domain to the other, rather than a specific feature or characteristic, and this too can be seen within designing. A design drawing or model is both metonymic and metaphorical, as defined by Miall (1982), a transaction between contexts, enabling the construction in one symbol system a pattern for construction in another, whether through drawing, a 3D mock-up or cutting up old newspaper. A design drawing can be seen as a metaphor, or perhaps more strictly speaking a metonym, since it stands *instead of* rather than *parallel but in a different plane to* the idea in the mind's eye and the product to be created. Creating a parallel system in which to think about and plan a product to be made in something else falls within Wittgenstein's (1969) phrase "*seeing as*". In using drawing to design, the drawing is *seen as* if it were the product; putting ideas on paper enables these to be viewed and evaluated, changes made and practical problems of construction thought through. Design drawing is "*place holder*", an external memory system that allows the examination of thoughts and ideas, allowing the brain to get on with the higher order functions of evaluation and improvement without being cluttered with having to remember what the potential product might look like.

A Metaphor to Teach By

This final section of this paper describes the research context from which the preceding theoretical perspective emanated. From boldly claiming that "drawing is a metaphor", I quickly side-stepped into something that could be empirically proved in a classroom: that a good metaphor is a good teaching tool. I was also building on Egan's (1996) insight that children did not understand the purpose of using drawing to support designing.

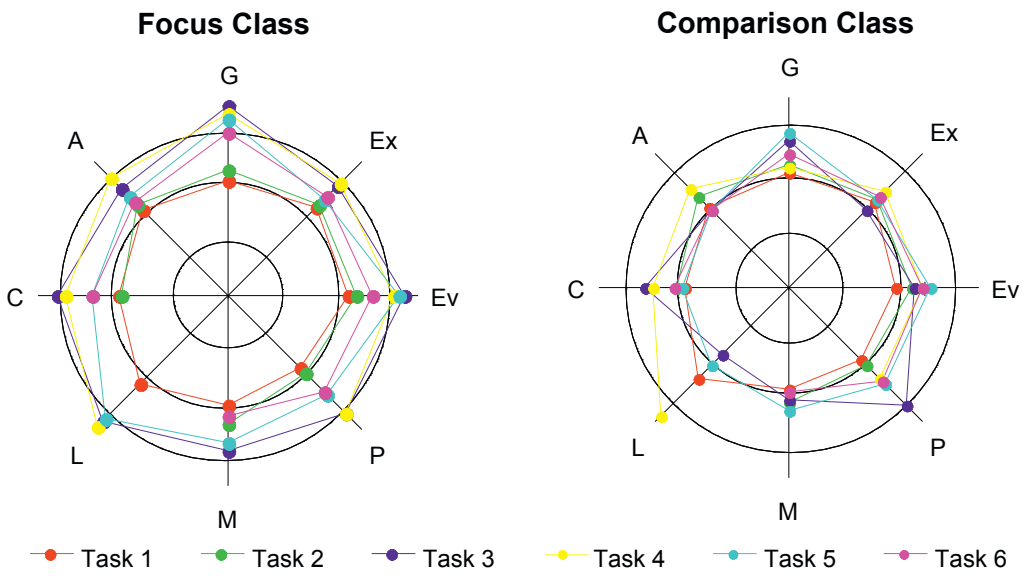
The dual metaphor that I used with a class of Year 2 (age 6-7 years) children to explain the purpose of drawing for design was the *container* and a *journey* from Lakoff & Johnson (1980). Across a 2 year longitudinal study, I taught design & technology to one class (the Focus Class), while an experienced colleague taught the Comparison Class. The only difference was the *purpose of design drawing* was explained to the Focus Class using the metaphor. They were not taught any specific drawing techniques, nor were they told to spend more time drawing than were their peers. This, however, came to be so by the end of the study as a by-product of their understanding the way in which drawing could help develop their thoughts and ideas.

The purpose of using drawing to support design development was explained to the Focus Class children by means of a narrative involving this container/journey metaphor. They were shown two sets of drawings done by Year 4 children, one of which were design drawings and the other not, and were asked what kinds of drawings they thought the two sets were. "Planning drawings" were one child's immediate response to the design drawings, which enabled the introduction of the metaphor. I explained that the drawings both *contained* ideas but that those ideas were on a *journey* that ended, not on the page, but in the product that was finally made. It was stressed that only part of the journey might be contained in the drawing and that this might be a different part on different occasions; that different people might use different kinds or numbers of drawings; or that some people might want to draw a lot and others not much. What was emphasised to the children was that the purpose of the drawing was to help them design; what kind of drawing they did was up to them. The drawing was part of the journey, not part of the destination – like the carrier bag that contained your picnic when you went on a day out but might get to contain daisies or pebbles during the day, which would be played with when you got home, but was itself only the container used on the journey.

Between the assessment tasks, both classes experienced similar design activities, largely dictated by the long-term plans that were in place in the school, with permitted variations. For instance, the Focus Class made sandals while the Comparison Class made hand puppets when the long-term plans indicated mastering skills of using templates based on personal body measurement. As they moved into Year 3, both classes were set a design problem by the school catering manager: designing a packed lunch. Not all the projects involved drawing; transferability of the metaphor to other designing media was seen as important for deep understanding. For instance, a marble run was designed through making mock-ups in mouldable material, card and small recycled components. Care was taken to ensure that the Focus Class were not asked to do more drawing than the Comparison Class and thus benefit simply from practice effects. The pedagogical difference was in the way the purpose of design drawing was conveyed to the children. To ensure the difference here, the teacher of the Comparison Class was not made privy to the *container/journey* metaphor used with the Focus Class.

At regular intervals, both classes took part in an assessed design task. Fig 3 shows the profile of both classes across these activities during the two year period of the study. Appendix A contains the assessment criteria to which the quantification of the evaluation of the different aspects of the children's drawings refers.

Fig. 3: Comparison across Assessment Tasks



Key

G = Generating and Developing Ideas
Ex = Exploring the Possibilities of the Task
Ev = Evaluating Whilst Planning
P = Planning Construction
M = Basis for Making the Product
L = Planning the Look of the Product
C = Communicating Ideas
A = Addressing Tasks Constraints

Task 1: Design a Pizza
Task 2: Problem-solving - getting Frosty the Snowman across the lake
Task 3: Design an Easter Egg Holder
Task 4: Design a Greetings card
Task 5: Design a travel bag for the class mascot
Task 6: Problem-solving - helping Theseus escape from the Minotaur

The immediate success of the *container/journey* explanation can be seen in Fig.4. Tasks 1 and 2 preceded the explanation, since it was necessary to firmly establish that there was no initial difference in the children's capabilities through conducting two different design tasks: a problem-solving task and a product design task. Assessment Task 3 was conducted 4 weeks after the *container/journey* explanation and its immediate effect can be seen.

As can be seen from Fig 4, there is a sense of the Focus Class' design capability expanding after the *container/journey* metaphor was introduced. The Comparison Class' profile swings about wildly but does not significantly expand. The aspect on which they do well in each task tends to be the area of designing on which the task centred. For instance, in making a greetings card (Task 4), they did well on thinking about how the product will look; on making the Easter Egg holder (Task 3), they did well on planning construction. The Focus Class' profile not only expands but it does so in a balanced way; their overall design capability had improved.

Wittgenstein (1969) referred to systems of thought as "language games". Being able to think the thoughts requires knowledge of the rules and ciphers of the language game (e.g. philosophy, mathematics). In school, children are expected to pick up quickly on the language games being played by the teacher. By using the *container/ journey* metaphor, I had provided a story-line that enabled the children to understand the purpose of using drawing for designing. In accepting my story-line, couched in the *container/journey* metaphor, and learning to use it as a framework for their design activity, the Focus Class children learnt the rules of the design game. The constraints imposed by role-taking, learnt as part of children's normal play activities, are essential for developing problem-solving skills. Learning to accept *"these rules and these rules only"* (Donaldson, 1992) as

part of social play powers the development of design capability. Learning to accept constraints, not just on actions but also on what is allowed to be imagined within a given context, is dependent on the acceptance of a situation-as-defined, of socially mediated thought and action.

In Conclusion

In this paper, I have argued for a design ontology that goes beyond Ryle's *know how* and *know that* to include *know relevance,* but, as importantly, to recognise analogies and metaphors within the sphere of knowledge and its exploitation. The key skill of a designer is frequently more than just know what will work but to think laterally and to see the apparently irrelevant as essential. Being able to apply reversals and inversals may be the greatest design skill.

This metaphorical thought within designing has been illustrated by reference to the research that I conducted with young children. Their understanding of narrative and their willingness to play the design game my way was, I believe, a key factor to the success of my teaching. This lead, finally, into the assertion that the role-taking and accepting of socially-mediated game rules within children's play contributes considerably to their ability to take on the role of designer, to accept the constraints of a design challenge to produce a novel and pleasing solution that works.

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APPENDIX A : Assessment Criteria

Generating and Developing Design Ideas

1	2	3	4	5
Drawing a picture, not designing a product	Simple sketch, showing object to be made	Design ideas generated but not developed	Progression of ideas across or within drawings	Uses drawings reflectively to generate new ideas

Exploring the Possibilities of the Task

1	2	3	4	5
Design possibilities are not addressed in the drawing	Stereotypical response, showing little creative thought	Recording possible creative solution(s) to the task	Using drawing to develop novel design solution(s)	Combining novel solutions to produce innovative design

Addressing the Constraints of the Task

1	2	3	4	5
Minimal understanding of task / user needs	Drawing shows some understanding of task constraints	Records way to address task &/or client needs/ wants	Task constraints considered as the design proceeds	Task constraints treated as part of iterative process

Planning the Look of the Product

1	2	3	4	5
Appearance of a product is not considered	Little consideration of final appearance of product	Overall decorative scheme considered	Ideas about finishes are added to design whilst drawing	Ideas about finishes develop within overall designing

Communicating Design Ideas

1	2	3	4	5
Use of narrative or other drawing genre	Simple unlabelled sketch(es); relying on shared meanings	Conveys some sense of the object to be made; e.g. indicates materials	Conveys sense of object to be made; e.g. working diagram	Clear enough for someone else to make the product

Planning Construction

1	2	3	4	5
Not planning to make the object as drawn	Minimal consideration of construction whilst drawing	Drawing indicates some consideration of construction	Drawing demonstrates consideration of construction	Constructional issues considered en route to final design

Evaluating whilst Drawing

1	2	3	4	5
Yet to define the design task	Minimal evaluation at drawing phase	Considered and rejected a range of ideas	Decisions made about product whilst drawing	Changes made as result of considering design drawings

A Basis for Making

1	2	3	4	5
Making an object is seen as separate new activity	Product relates to ideas recorded in the drawing	Object is one of the ideas drawn	Clear development path through drawing into making	Using drawing as resource during making