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Beyond knowing how to make it work: the conceptual foundations of designing.

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Abstract

Gilbert Ryle (1949) divided knowledge into "know that" and "know how", which is neatly appealing to many Design & Technology educators, and like many writers on developing the curriculum, Kahney (1993) made a distinction between declarative knowledge:

"verbal knowledge, that is, the kind you get from books, instructions and being told what to do."

and procedural knowledge:

"In order to achieve skilled performance you need to be able to translate declarative knowledge into actions. A new form of representation, known as procedural knowledge must be established."

(p.91)

However, a curriculum that consists simply of information and techniques not only fails to reflect the original intentions of the members of the working party for the creation of the National Curriculum for Design & Technology (1988) but also misses the mark in terms of developing creative and inventive minds. Evidence from cognitive archaeology (e.g. Renfrew, 1994) also suggests that the symbiotic relationship between mind and hand that typifies technological action and innovation was a primary driver within human evolution. Thus designing technology is one of the defining characteristics of our species. Technology education, therefore, should not be seen simply from an instrumentalist viewpoint as a preparation for the world of work but as a preparation for full functionality in human society.

The contention within this paper is that if we fill up our curriculum with declarative and procedural knowledge, without acknowledging and encouraging the unique response or the innovative idea, then we will have designed a curriculum that, however hard we try, we will never really succeed in "making it work" for many of our most creative pupils.

Introduction

The background for this paper is my doctoral research into young children's use of drawing for designing, involving analysis of some 500 drawings by about 400 children aged 4-9 years, followed by a more intensive longitudinal study of 2 parallel Year 2 classes (Focus Class and Comparison Class, 25 children in each), which lasted approximately 15 months (average age 6.5 years at start).

As Table 1 demonstrates, the Comparison Class began Year 2 saturated with my teaching style, whereas the Focus Class and I were almost strangers. This was ideal, since I was exploring the effectiveness of a specific way of explaining the purpose of drawing for designing and it was vital to eliminate any effects of my teaching style. This also eased the ethical issues surrounding such comparisons. Claire, who taught the Comparison Class, knew I was trying a new method and that I was not, therefore, comparing my teaching skill with her teaching skill. We had worked together for about 5 years and her classes had been part of the first phase of my research activities and I had discussed this with her freely. However, I purposely told no one in school, including Claire, of the central metaphor of the longitudinal programme (Fig.2) in order to ensure there would be no contamination of the data, since it was the effectiveness of this metaphor that I was testing.

This paper builds on the underlying ideas emerging and developing out of this research into young children's design capabilities, which have been documented in papers at both Design and Technology Association and Centre for Research into Primary Technology (CRIPT) conferences across the last few years. Part of my on-going attempt to unpick the bigger picture issues that underpin what it means to be a creative, design-capable human has led to a tentative taxonomy of the features of conceptual learning within technological action, which underpins children's learning within Design and Technology.

	In Year 1	In Year 2
Focus Class	Not taught by me at all	Taught by new colleague with no knowledge of my research
	D&T taught by teaching assistants, because class teacher had little enthusiasm for practical activities	D&T taught by me 1 afternoon per week; Assessment Activities conducted termly, same content and format as Comparison Class
		Taught purpose of drawing for designing using metaphor shown in Fig.1
Comparisson Class	My class (full time teaching)	Taught by colleague who worked previously with me in Year 1 who knew a lot about my research interests and activities.
	D&T taught by me as part of overall curriculum delivery; design drawings collected as part of first stage of research	D&T taught by class teacher; Assessment Activities conducted termly by me, same content and format as Focus Class
		Not taught purpose of drawing for designing using metaphor shown in Fig.1

Table 1: Experience of D&T by classes participating in longitudinal study

Knowing and Doing

The questions began early in my personal research journey. In 2000, at the DATA Millennium Conference, I put forward my take on Gilbert Ryle's *know how / know that dualism* (Fig. 1, from Hope, 2000).
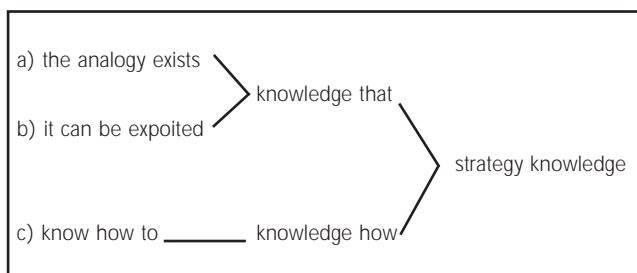

Fig. 1 Strategy Knowledge (Hope, 2000)

Where does strategy knowledge come from? How do we know which bits of our store of knowledge (whether know how or know that) is relevant in any given situation, especially in complex situations such as designing? At the time, all I had for evidence of this synthesis and extension of Ryle's duality were my observations of children's approaches to designing and a rather large pile of Flat Stanley puppets made by about 300 children aged between ages 5 and 9 years old.

My central contention was two-fold. Firstly, that for practical activities, however much factual knowledge a child (or adult) might have about a topic, this would not impact on their approach to a practical design task unless they saw the relevance of that knowledge to the task. Children as young as 5 years old could draw what they wanted to make but only by age 8 years were they using their drawing as a basis for action. Knowing the parameters of the task and knowing how to draw their ideas was not enough.

In parallel to my research, Egan (1999) identified that children did not understand the function of the drawing in the design process. In my study, some of the youngest children asked "Why are we drawing this twice?" (i.e. once on the paper and again on the card) Since they were working in pairs, some solved the dilemma by one child decorating the drawing whilst the other made the puppet.

Metaphor and Paracosm

A sort of epiphany in my research process happened in 2001, when I saw design drawing as being a metaphor, to which Richard Kimbell said "I'm sure you're right. All you need to do now is prove it."

But how?

Is it a provable hypothesis?

It became a working hypothesis such that, if I could find a metaphor that would explain design drawing to children so that

their capability to use drawing for designing showed some measurable improvement, I would have achieved a successful research outcome. The metaphor I found (extrapolated from Lakoff and Johnson, 1980) was that design drawing is simultaneously a Container for ideas and a Journey of ideas across the page and off the page into the prototype and/or product (Fig. 2, Hope, 2003b). This is the metaphor by which I explained the purpose of drawing for designing to the Focus Class and it worked, (Hope 2003a). However, despite this success, I was acutely aware that I had neatly side-stepped the central issue of whether or not design drawing was a metaphor by finding a metaphor for design drawing that produced success in a classroom.
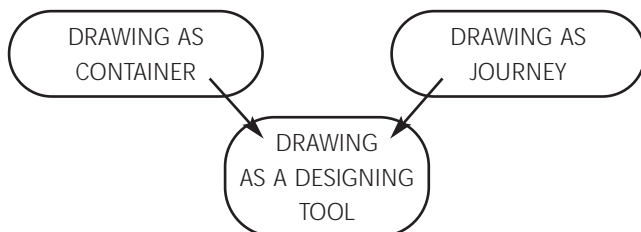

Fig. 2 Container and Journey Metaphor of Design Drawing (Hope, 2003b)

The term "metaphor" is more commonly applied in literature, especially in poetry. Was it the right word for drawing? Strictly speaking, I think design drawing is a metonym, not a metaphor. However, most people are less familiar with that term (which makes it less useful) and also because metonyms are further from other usefully related terms such as analogy and extrapolation. In the past twelve months I have come to believe that design capability is second cousin to paracosm.

A paracosm is a complete, internally logical, fantasy world. Some people create a complete world which they draw, invent maps and devise communities with a history and on-going adventure (Tolkein's Middle Earth is probably the best publicly known paracosm). But everyone fantasises and tells themselves stories, it is just the degree of complexity that varies. Computer simulations such as Second Life demonstrate the ease with which ordinary people create alternative worlds. This paracosmic capacity, I would contend, is fundamental to design, creativity and invention. Designing requires the ability to create paracosms, to think in a system or context that has its own internal logic, that obeys the laws of the system as perceived, observed or created. As such, design and paracosm are parallel universes. The same cognitive capacities are common to both and they lie, I believe, close to the foundations of what it is to be human.

Cognitive Archaeology

Paralleling the philosophy of Ryle, but with no reference to him (probably quite unaware of his contribution to English-speaking epistemology) the French cognitive archaeologist Pelegrin (1991) identified connaissance and savoire-faire as the two main characteristics of stone knapping hominid's cognitive capabilities. Connaissance equates roughly to "knowledge with understanding" in English; savoire-faire equals "know-how". Producing a stone chopping tool, say Pelegrin (1991), required an inner mental model of the final shape, an understanding of the properties of stone and the know-how with which to combine the two. Handling examples of such tools from half a million years ago inspires a sense of connectedness with the tool-makers who created these beautiful tear-shaped symmetrical artefacts. Yet these tool-makers were not homo sapiens, nor even homo anything. The tools were created by pre-homo primates. Know-that and know-how are not enough to define humanity's capabilities. Whatever it is to be human does not reside there.

The British archaeologist Steven Mithen (1996) claims that a cognitive re-shuffle happened at the birth of homo sapiens. Whereas other previous and contemporaneous homo species (including the Neanderthals) were knowledgeable about their environment, had well-developed social skills and tool-making capacities, there were no real connections between their separate spheres of thought. When that occurred (the Great Leap Forward of about 40,000 years ago) then creativity began, of which we have evidence in a sudden flowering of tool types, including tools to make tools, decoration, statuary and art. After which all other homo species became extinct.

This joined-up thinking of which homo sapiens (humans) are capable, transforms know-that / know-how into the most powerful thinking strategy on the planet. It enables us to design technology. No other creature on earth does this. Other creatures have technical fixes that enable them to survive (birds have their nests, chimpanzees have termite fishing sticks) but no other creature actively and purposefully designs the technology that they use in the way that humans do. The ability to see something "as if", which Craft (1997) called "possibility thinking" or Wittgenstein (1969) describes as "seeing as", is close to the heart of design capability. However, paracosm goes one stage deeper. The ability to reason, imagine and think within a complete created system, the author's skill, is also the designer's skill. The ability to create and understand the world as stories and metaphors ("Contes et Metaphores" Fèvre, 2004) underpins the creation of the design narrative, and is first cousin to the dialogue between the inner and outer reality that Winnicott (1971) identified within play.

Like play, paracosms have internal logic. However crazy to others the tale might seem, the idea of an island populated by tiny people, on which a normal sized man is shipwrecked, falls asleep and wakes to find himself tied down by hundreds of tiny threads, has its own internal logic. The contradictions were ironed out in Defoe's head. In the same way, the laws of relativity were visually modelled in Einstein's; or the mechanics of Babbage's difference engine were worked out in dialogue between hand and brain. Really powerful paracosms create paradigm shifts and major technological breakthroughs.

Conceptual Foundations

The human cognitive design architecture is:

• Agentic

Subsumed under the term "agentic" are concepts such as sentience, self-awareness and evaluative capabilities; the relatives of meta-cognition. The ability to classify and reflect on the success of one's own and other peoples' thoughts, ideas and designs depends on the awareness of one's self as a subject, an agent who can plan, decide and effect changes in the environment, whether physical, social or cognitive.

Agency assumes "I can do", empowerment and action. Atman (1992) used the word "conation" to imply a similar concept. "Enaction" is a similarly related term:

> "… all technical artefacts, from stone tools to cars to computers, are "enactive interfaces" that mediate the structural coupling between human beings and the world they live in, and hence bring forth a particular world of lived experience"
>
> (Khatchatourov et al. 2008)

In Example 1, Carl, aged 7 years, has drawn a pencil alongside his design idea. "That's me drawing" he explained, in assertion of agency and self-reference.

Craig
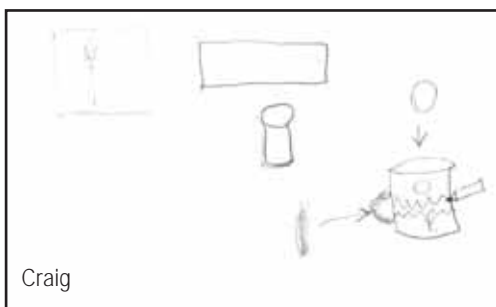
Tomasello (1999) claimed that this leads to a theory of mind that perceives others as showing intentionality of action such that learning is possible both through imitation of techniques

and direct instruction. Furthermore, this enables humans to take the perspective of another and design something that will be useful for someone else, even if we have no need of the artefact ourselves, which, in turn, enables us to evaluate existing and possible solutions to design questions without having to actually make the product.

• Symbolic

Language, both spoken and written is uniquely human symbolic reference system that enables us to think, imagine and design. "Man is a symbolic animal" (Fèvre, 2004) and this enables us to make sense of the world through the creation of narrative and to communicate our ideas to others.

For example, by Year 3 (aged 7-8 years) the Focus Class in my research confidently used their drawings as discussion documents. The parallel Comparison Class drew their design ideas individually and without discussion. Not only were there far more children whose products did not satisfy the design brief but the range of ideas across the Comparison Class were more limited. Discussion not only helped the Focus Class children to remain centred on the design question, but also enabled them to spark ideas off each other.

Drawings, the making of prototypes and other models that can be examined and discussed as if they were the real thing also serve a symbolic function. Example 2 not only shows 7-year old Maria's use of numerical standardised measuring units, but also her ability to use a diagram that records just the relevant part of the drawing for her purpose. She does not need to re-draw the whole travel bag for the toy Panda, she simply draws the two sides to remind herself of the dimensions.
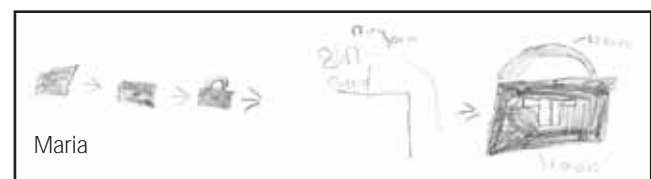
Maria

Example 2: Maria's use of symbolism

• Systematic

During one lesson, Maria and I had conducted a conversation at cross-purposes because I thought each sketch on her paper represented a different idea. Later, I saw she had added the arrows and I understood that she wanted me to know that she had been using drawing to think through the process of making the product (Example 3: Maria's Easter Egg Holder).

Maria
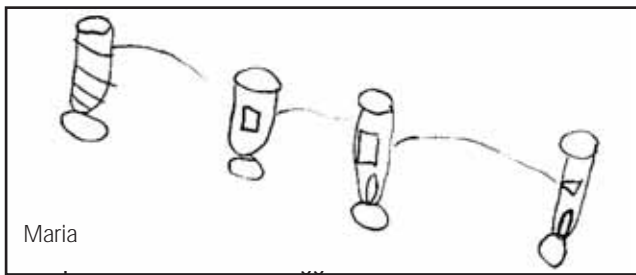
Human technological activity involves awareness of the teleology of the design task and the systematic fore-thought and planning of the processes and techniques needed to bring it into being, including gathering together all the required materials and, possibly, involving others in the plan. Integral to this are both analysis and synthesis, the ability to mentally take things apart and re-construct something new.

• Rational

Like paracosms, designs must make sense in order to work. Our rational faculties enable us to see what will work and what will not, whether by deduction or induction (of which extrapolation is the extension which starts to border with analogy and metaphor). We compare what we see to what we know from past experience and can judge whether or not the idea holds an internal logic. This faculty develops with age. For instance, adults see the joke within Professor Brainstorm's inventions whereas small children just stare at them without perceiving the illogical and impossible. The age at which children's humour develops to the point where they start to tell linguistic jokes (about age 6-7) is also, interestingly, the age at which they can begin to use drawing effectively for designing. However much Piaget's experimental technique has been maligned for its validity (for example, Donaldson, 1979), he did appear to have come to valid overall conclusions. There is a shift in the way in which children of this age reason about the world.

• Creative

Koestler (1974) began his book "The Act of Creation" with a consideration of humour. In his view, the ability to see the mis-match between two things as funny is fundamental to creativity. His term "bisociation" includes analogy, metaphors, trophes and other linguistic and poetic devices, as well as design.

Paralleling Lakoff and Johnson (1980 "Metaphors We Live By"), Fèvres (2004 "Contes et Metaphores" (Stories and Metaphors) claims that all knowledge is built through narrative. Bruner (1962) distinguished between paradigmatic (mathematical and scientific) ways of thinking and narrative ways, and believed that there was no possible dialogue between the two.

However, I would now contend both conclusions. I think that true creativity comes through the bisociation of the rational and the divergent. It is the application of reason to possibility that turns divergency into creativity, the crazy idea into a plausible design.

Some children in the research caused me so much angst over whether a solution is creative if it is beyond the constraints of the design brief (Hope, 2004, 2007). My current thinking is that a successful design solution must also follow from the rational as well as the narrative. One girl, Shannon, was so good at narrative that she even constructed "Episode 2" for one of my design tasks (Hope, 2004). Although this solution followed logically from the parameters of the design question, it did so only as narrative. It was not, therefore, a creative design solution to the question she was asked to address. Leaps of the imagination are fine, as long as they land somewhere within the zone of possible answers (Middleton's (2000) "satisficing zone"). Playing with ideas only moves from being a paracosm to being a design solution if the answer conforms to the internal logic of the design question.

The "So What?" Factor

How does all this relate to our teaching and to research into children's learning in Design & Technology?

Firstly, the teaching of techniques is not enough. The National Curriculum for Design & Technology for England & Wales (1999) defines its Breadth of Study as covering three areas:
  • Investigating familiar products
  • Focused practical tasks
  • Design and make assignments

However, too often in schools, children seem to be doing a series of focused practical tasks in which they learn a series of techniques rather than being given a design and make assignment in which they can make real choices and experience real freedom in design.

What I have tried to do in this paper is to begin to unpick what going beyond "how to make it work" might look like. My research demonstrated that simply teaching children techniques of drawing is not enough (Hope, 2003a). They need to understand the purpose of the activity for deep learning and application to take place. It seems to me that, if homo neandertahlensis had know-that and know-how, and passed these on from generation to generation and yet went extinct, we need to do something a bit better for young homo sapiens in the interests of the future of our species. This paper is another step along my journey of exploration into what that might be and why.

References

Atman, K. (1992) Goal Accomplishment Style and the Design Process in Conference Proceedings, *International Conference on Design Education* (INCOTE92); Weimar, Germany

Bruner, J. (1962) On Knowing; Cambridge, MA: Harvard University Press

Craft, A. (1997) *Can you teach Creativity?* Nottingham; Education Now

DfEE/QCA (1999) *National Curriculum for Key Stages 1 and 2 in England & Wales*; London; DfEE/ QCA

Donaldson, M (1979) *Children's Minds*; Glasgow; Fontana

Egan, B. (1999) Children talking about designing: a comparison of Year1 & Year 6 children's perceptions of the purposes/uses of drawing as part of the design process in Conference Proceedings, *International Design and Technology Education Research* (IDATER 99); Loughborough University of Technology, Department of Design & Technology.

Fèvre, L. (2004) *Contes et Métaphores*; Lyon, France; Chronique Sociale

Hope, G. (2000) *Beyond "Draw one & Make it"* in Conference *Proceedings*, Design and Technology International Millennium Conference; Wellesbourne; The Design & Technology Association

Hope, G. (2003a) *A Holistic View of Assessing Young Children's Designing*; The Third International Primary Design and Technology Conference (CRIPT); Birmingham

Hope, G. (2003b) *Taking Ideas on a Journey : a model to support young children's thinking processes*; British Educational Research Association (BERA) Conference; Exeter

Hope, G. (2004) *"Little c" creativity and "Big I" innovation within the context of Design and Technology Education*; in Conference Proceedings International Design and Technology Association 2004; Wellesbourne; Design & Technology Association

Hope, G. (2007) *Unpacking a Research Activity: What was hidden in the Panda's Suitcase?* in Conference Proceedings International Design and Technology Association (IDATA 2007); Wellesbourne; Design & Technology Association

Kahney, H. (1993) *Problem Solving - Current Issues*; Milton Keynes, Buckinghamshire; Open University Press

Khatchatourov , A., Lenay, C. and Stewart, J (accessed 2008) Enaction and Engineering; http://www.interdisciplines.org/enaction/papers/7

Koestler, A (1974) *The Act of Creation*; London; Hutchinson

Lakoff, G. and Johnson, M (1980) *Metaphors We Live By*; Chicago; University of Chicago Press

Middleton, H. (2000) *Design & Technology: What's the Problem?* in Conference Proceedings, The Design and Technology Millennium Conference, London; Wellesbourne; D&T Association

Mithen, S. (1996) *The Prehistory of the Mind*; London; Pheonix (Thames & Hudson Ltd)

National Curriculum Design and Technology Working Group (1988) *Interim Report*; London; HMSO Publications

Pelegrin (1991) in Renfrew, C. & Zubrow, E.B.W. (1994) *The Ancient Mind: Elements of Cognitive Archaeology*; Cambridge; Cambridge University Press

Renfrew, C. (1994) Towards a Cognitive Archaeology of the Ancient Mind in Renfrew, C. & Zubrow, E.B.W. (1994) *The Ancient Mind: Elements of Cognitive Archaeology*; Cambridge; Cambridge University Press

Ryle, G. (1949) *The Concept of Mind*; London; Huchinson

Winnicott, D.V. (1971) Playing and Reality; London; The Tavistock Press

Wittgenstein, L (1969) *Philosophical Investigations; the Blue Book*; The Brown Book; Oxford, Basil Blackford