The importance of technological activity and designing and making activity, a historical perspective

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Abstract

Whilst tool use is by no means an exclusive human trait, the "ability to deliberately manipulate" is central to our development, and it is our ability to "create complex artefacts" (Wolpert, 2003) that sets us apart. Recent archaeological and neuroscience advances have suggested that the activity of designing and making of tools, such as the handaxe, played a crucial role in the development of language. This paper will argue that the technological mindset is a preeminent paradigm in human development.

The paper will work within an interpretive and constructivist paradigm. The standpoint of the author is that of a technologist and literature is used to build and argument for the historic relevance of technological achievement, the trustworthiness of the research will be addressed through critical and reflective review of literature. The conclusion ends with polemic and rhetorical questions, based on the discussion, aimed a generating further debate both within the subject and the wider educational communities.

In the context of curriculum change in the English education system, the aim of this paper is to re-examine the role of designing and making activity and technology education. The findings will be literature from contemporary neuroscience, and revisit the original nature of design and technology and current challenges (Ofsted, 2011), highlighting the historical and social importance of the designing and making activity.

A central assertion of this paper is that core subjects, such as science, in the contemporary English curriculum owe their origins to technological innovation, in terms of solving human needs through design and making. As such, they argue for the case for continued inclusion within a broad curriculum, in whatever form it may take, from a cultural rather than purely a technical or economic perspective.

Introduction

> *"… the evolution of causal thinking was essential for the development of tool use, as it is not possible to make a complex tool without understanding cause and effect. This was a great evolutionary adaptive advantage. The evolution of language may have been linked to the same process.* ***It has been technology that resulted from causal beliefs, not social interaction, that has driven human evolution."*** (Wolpert, 2003, emphasis mine)

Technology, as defined by biologist Lewis Wolpert (2003: 1709), is "the ability to deliberately manipulate the environment", describing the action and intention of human activity (such as making a product), as opposed to the manifestation of technology as artefact (the product itself). In a recent consultation event run by the Design and Technology Association, chief executive Richard Green echoed this concept of technology, describing the intent of D&T to create "thinking manipulators" (DATA, 2012). Wolpert goes on to state that technological activity predates science, which began to influence culture and society in 18^{th} Century as a formal discipline. According to Wolpert, trial and error approaches, which typify early technological activity giving rise to causal belief, which in turn give rise to the development of language and communication (McCormack, Hoerl, and Butterfill, 2011; Csibra and Gergely, 2006; Baber, 2003). In the context of this paper, design and making activity (whether as discrete or as holistic learning experiences) are viewed as functions of technological activity.

In this paper the term technology is used to refer to the human activities related to interaction with and shaping of the material world for human intentions, as opposed to the products of designing and making. Designing and making are considered to be essential functions of this intentionality in the realisation of technological solutions to human needs (and wants).

Over the past twenty years, as Design and Technology (D&T) has developed with the school curriculum in England and Wales, there has been a terminological transition from describing the outcomes of designing and making activity from "artefacts" (NCC, 1990) to "products and systems" (QCA, 2007). This can be viewed as a positive move to clarify and communicate the nature of learning outcomes and delineate between artefacts derived from artistic endeavour as opposed to technological. In this case, one might crudely define the differences in terms of the functionality and use of the created object. A *product* or *system* is recognisable outcome, which might be understood by learners and teachers alike. However, this reduction focusing on outcomes might have some negative effects on the concept of designing and making as a cultural and historical endeavour (NCC, 1990: 23; DfE, 1995, 10; DfEE, 1999: 8, 23-4; QCA, 2004: 10, 25-6; QCA, 2007: 52).

The positioning of the *cultural* statements in design and technology have shifted somewhat in the National Curriculum programme of study. This paper suggests that designing and making activity is essentially a cultural endeavour. Kimbell, Stables and Green (1996: 45-7) locate cultural technology within Key Stage 1 (ages 5-7), reflecting the first programme of study for Technology (NCC, 1990: 23). This emphasis shifts to Key Stage 4 (age 14-16) in the programme of study beginning in 2000 (DfEE, 1999:23-4), although it is also included across the curriculum (pp. 8) and by 2008 (QCA, 2007:52) is specifically mentioned in Key Stage 3 (ages 11-14). However, the role of culture as expressed in the programmes of study relates to the influence of culture *on* designing and making activities, rather than the contribution of design and making *to* culture: influencing, and creating, cultural artefacts. From a perspective that human culture is derived from social and technological activity (Bruner, 2009; de Vries, 2007:20-33), a broadening of the role of cultural learning in the curriculum could be viewed as a positive, though possibly underdeveloped, aspect of D&T. This view of the socio-technological origins of culture has been discussed by biologists (Wolpert, 2003), cultural psychologists (Cole, 1996; Cole and Derry, 2005) and sociologists (Sennett, 2008). However, this view of culture as being mediated by artefacts (Cole, 1996: 116-45) is not universally held. Clifford Geertz quotes Ward Goodenough view that "culture [is located] in the minds and hearts of men" (Geertz, 1973: 10) as contemporary and influential "theoretical muddlement" which he believed was a misconceived dualism between *subjective* and *objective*, or *idealist* and *materialist*. Similarly, Richard Sennett (2008: 124) discusses "the supposed superiority of the head over the hand", where ideas are conceived as "more sustainable than decomposing material": a view that is deep rooted in Western civilization. Although the briefest reading of the history philosophical thought would question the immutability of ideas.

This paper discusses how literature and research in the fields of neuroscience, cultural psychology and sociology inform our understanding of the role and importance of technological activity, as expressed in design and making (i.e. realising products and systems), as aspects of formal learning. The theoretical position adopted views culture and learning as distributed between social and material concerns (Fenwick et al, 2011: 2-6).

Methodology

As an interpretive study, within a broadly constructivist paradigm (Lincoln, Lynham and Guba, 2011: 98-116), this paper seeks to explore the nature of human development in relation to technological activity. In relation to the interaction between mind and body in design and making activity, ontological assumptions are relativist, recognising the multiple realities of individuals in society interpreting technological activity (Guba, 1981: 77). The standpoint adopted in this paper is that of a "situated" technologist and educator (Olesen 2011:130; Lave, 2009). Situated in the context of a standpoint epistemology, not in terms of being the member of an oppressed group, but rather of a contemporaneously misunderstood subject, whose place in the curriculum is under scrutiny (DEF, 2011a: 24; Miller, 2011). Similarly, the epistemological stance adopted is to examine with relationship between technological and social activity (**Figure 1**) in relation to cultural and cognitive evolution; rather than more positivistic concerns regarding the nature of materials or processes.

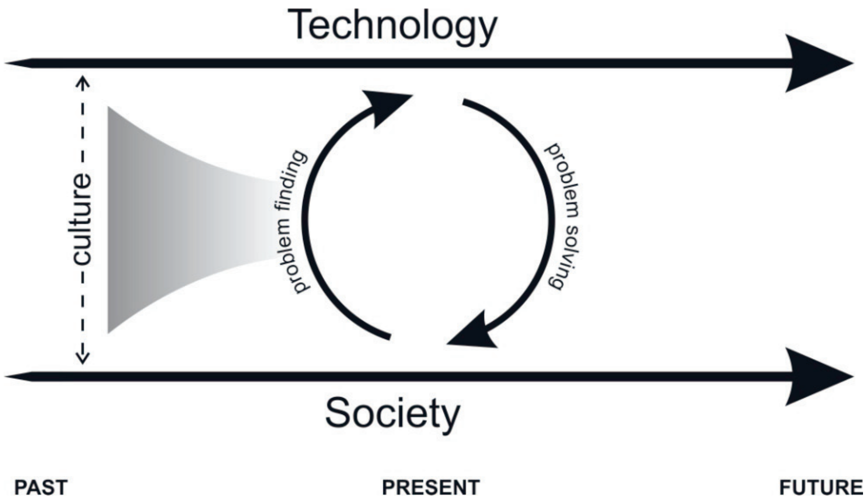

Figure 1 Socio-technological human activity

The methodological approach is to use literature from a variety of sources to discuss the complexity of the object of the study (technological activity, and in particular designing and making). Cultural-historical activity theory has influenced the dialectic analysis of the literature, which links the object of design and making activity as "cultural entities" and that in human development "object-orientedness of action" is central to understanding the mind (Engeström, 2009: 54; **Figure 2**). The nature of objects and their influence human behaviour ,and development, has also been discussed by Graham Harman (2002), who builds on Heidegger's philosophy of tool use, and Bruno Latour (2008).

To ensure a rigorous, credible and trustworthy interpretation of the central elements of this study, literature from a range of sources and disciplines is used to inform the discussion (Lincoln and Guba, 1986; Guba, 1981). However, the paper itself is a starting point, or positioning, aimed at engaging academic debate, initially within the national and international design and technology community. The aim beyond this is to engage with the wider education community, in the United Kingdom, to address the perceptions of the subject's "weaker epistemological roots" (DFE, 2011a: 24). The confirmability of the study will be tested and reviewed through peer review and further discussion. As such, this paper does not purport to stand alone, but rather to contribute to wider discussions in the context of current developments in education policy.

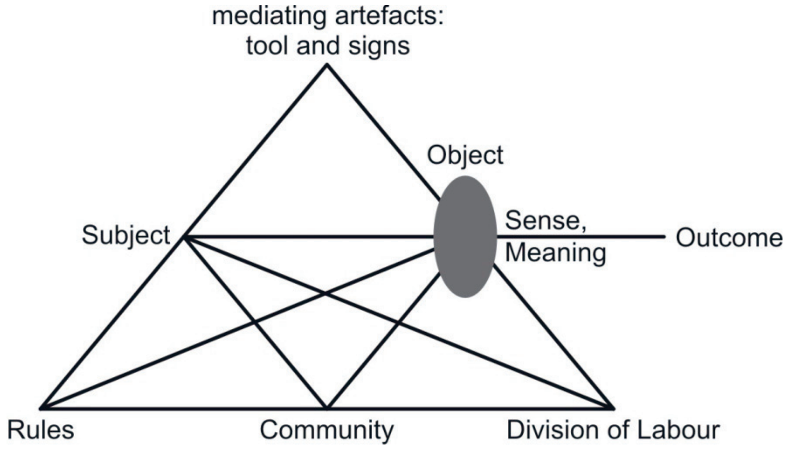

Figure 2 The structure of a human activity system (Engeström, 1987:78)

Literature Review

Three themes emerge from the literature reviewed for this study: aspects of *socio-technological activity*; *cultural learning and evolution*; and the *impact of tool use on cognition*. These themes inform a discussion, culminating in a series of polemic statements intended to trigger debate over the role of design and technology education.

Socio-technological activity: In recent years there has been an increased interesting craft, as described by Richard Sennett (2008) in 'The Craftsman' and Matthew Crawford in 'The case for working with your hands' (2009). Sennett outlines the development of craft skills from ancient times to European guilds, as self-contained units of designing and making, albeit designing and developing over long periods of time. During the Enlightenment of the eighteenth century, science emerges out of the mystical and heuristic practices of alchemy as a force for change. This change, whilst amplifying productivity was accompanied by a division of labour and in turn lead to the role of designer (or engineer) and maker being separated during the industrial revolution. One of Sennett's aims in his book is to "explore what happens when hand and head, technique and science, art and craft are separated" (Sennett, 2008: 20). Sennett discusses the nature of problem finding as a prerequisite to problem-solving, where the craftsman experiences an inner-outer dialogue between practicalities and thinking; reminiscent of Habermas' "everyday praxis". **Figure 1** attempts to interpret Sennett's finding-solving paradigm in relation to socio-technological activity.

> *"... the evolution of the hominid mind is linked to the development of a way of life where reality is represented by a symbolism shared by members of a cultural community in which a technical-social way of life is both organized and construed in terms of that symbolism."*
> (Bruner, 2009)

Cultural learning and evolution: Socially constructivist theories of learning tend to emphasis the multifaceted nature of culture and the relationship between mind and body. The concept of Cartesian Dualism, critiqued as "ghost in the machine" by Gilbert Ryle (1949), which views the mind and body as separate entities, places cognition in authority over the body. However, both seventeenth century contemporary criticism of Descartes (Huet, 2003 cited in Bakker, 2005: 78) and modern scientific investigation of the brain (Greif, 2011: 39; Johnson-Frey, 2004; Greenfield, 1991) challenge this view. Bruner's concept of the "technical-social way of life" centres on embodiment and culture, where body and mind are actively involved cultural and cognitive evolution (Barrett, Henzi and Lusseau, 2011).

Level	Description	Example
Primary	"artefacts… used in the direct production"	Tools (as technological artefacts) and language (as social artefacts).
	"artefacts… used in the preservation and transmission of the acquired skills or modes of action or praxis by which the production is carried out."	Knowledge (knowing that) and skills (knowing how)
Tertiary	"constitute a domain in which there is a free construction in the imagination of rules and operations different from those adopted for ordinary, this worldly praxis."	Creativity and imagination

Table 1 Wartofsky's levels of artefact (1979: 202)

In social constructivism, human cognitive evolution as a product of technological and social drivers, is mediated by artefacts as "objectifications of human needs and intentions" (Daniels, Cole and Wertsch, 2007: 255; Wartofsky, 1979; Vygotsky, 1978). Returning to the earlier discussion of the problematic nature of the term 'artefact' in early D&T, the Wartofsky (1979: 202) describes three levels of artefact (**Table 1**) that place the technological (tools) alongside the social (language) as primary artefacts. This reinforces the assertion that technological and social activities are primary drivers in human development.

The impact of tool use on cognition: The links between intelligence, as expressed in language use and tool use, are explored by John Campbell (2011: 169-182) who identifies common features in both. In fact the term *tools* in constructivist theory can refer to cognitive, or psychological, tools (Vygotsky, 1978). Campbell describes the use of tools as "an extension of the body" (pp.170), although he dismisses a simplistic analogue as not "immediately helpful". Michael Cole (1996: 136) cites an example of a blind man using a stick, asking where the sensation begins – in the hand or in the stick? The effect of technology as a cognitive amplifier are discussed by Raymond Nickerson (2005: 6) "either by facilitating reasoning directly or by reducing the demand that the solution of a problem makes on one's cognitive resources, thereby freeing those resources up for other uses." In other words technology enables human beings to outsource, or distribute, elements of cognitive capacity. For example, the development of written language and methods of recording enabled knowledge to be stored, and the invention of the printing press in Europe in the mid-fifteenth century facilitated the distribution and democratisation of that knowledge, technological advances developing hand-in-hand with social human activity (not to mention the telegraph, telephone, internet and so on). Melvin Bragg, in "the Adventure of English" (2004:238) highlights the link between language and technology in recent times, linking the effect of the industrial revolution on language. This emphasises the symbiotic relationship between language and technology. Rather than technology being the servant of language, or vice versa, they have an integral and cyclic relationship. These technological advances would not have been possible without the facilitation of designing and making activity.

Returning to Campbell's analysis of the similarities between language use and tool use, intelligent application is more than mere demonstration of use, but rather the "sense in which you understand why it works as it does" (2005: 171) and the ability to transfer that understanding into different contexts. Intelligent use implies a "focal awareness" of the target (that which the tool is acting on – i.e. object) with a subsidiary awareness of the tool itself, balancing both the variable properties and standing properties of the target and the tool. An every day example of this might be driving a car, where the learner initial focuses on the front of the vehicle (i.e. the tool), consciously steering it without being able to focus on the road ahead (i.e. the target). Similarly, when using tools in design and technological activity (be it physical/making or cognitive/design – or indeed a combination), the intelligent use of the tool is virtually invisible to the user.

The value of practical learning:

> *"When education, under the influence of a scholastic conception of knowledge which ignores everything but scientifically formulated facts and truths, fails to recognize that primary or initial subject matter always exists as matter of an active doing, involving the use of the body and the handling of material, the subject matter of instruction is isolated from the needs and purposes of the learner, and so becomes just a something to be memorized and reproduced upon demand. Recognition of the natural course of development, on the contrary, always sets out with situations which involve learning by doing."* (Dewey, 1916, 2001: 192)

The value of practical learning (including technological activity – and designing and making) is not confined to economic drivers. Influential linguistic theorist Noam Chomsky quotes John Dewey as stating that the "ultimate aim of production is not production of goods, but the production of free human beings associated with one another on terms of equality" (Chomsky, 2003). Dewey, in common with Vygotsky, attack attempts to reductionist or dualistic divisions within education, adopting a "dynamic holism" (Russell, 1993:173-174) in opposition to influential contemporary philosophy. A, possibly, unconscious expression of this is evident in the popular taxonomy of educational objectives presented by Bloom et al (Bloom, 1956; Krathwohl, Bloom and Masia, 1956) and revised by Andersen and Krathwohl (2001). Bloom had identified three domains of educational objective: *cognitive*, *affective* and *psychomotor*. The most familiar, *cognitive* domain (Bloom, 1956), and *affective* (Krathwohl, Bloom and Masia, 1956) domain were developed first, with the intention to develop the psychomotor domain. However, this division of functions was not without its critique (Marranzo and Kendell, 2007: 17-18) as it "isolates aspects of the same objective". In fact, one of the subsequent texts addressing the psychomotor domain, Elizabeth Simpson, quotes Bloom (1956: 7-8) as having found "so little done about [the psychomotor domain]" and that they "[did] not believe the development of a classification of these objectives would be very useful at present" (1966: 2). Simpson, as principle investigator, drew from expertise in practical subjects at the time (Industrial Arts, Agriculture, Home Economics, Music, Physical Education and Art), and emphasised the link between cognitive and motor control.

In common with other practical subjects, design and making activity can engage the whole person, cognitive, affective and psychomotor domains. However, the focus of this paper is to challenge conceptions of a dualistic self, and the importance of design and making as cultural activities engaging body and mind in socio-technological activity. The body is not merely a vehicle to transport the head to meetings, as Ken Robinson quips (Robinson, 2006), but an integral part of our being. Rather than the body serving the mind, the brain evolved to control movement, with causal belief, tool use and language as by-products (Wolpert, 2003: 1710-11)

Conclusions

Jürgen Habermas (1981: 3-14) echoes some of the sentiments of constructivist 'dynamic holism' and challenges the tendency of post-enlightenment, modernist, thinking to view spheres of culture (science, morality and art) as distinct and separable. This division created by the professionalization of culture helped create the role of the designer as distinct from the craftsman, and Habermas does not denounce the intentions of the Enlightenment, but called for "unconstrained interaction" (p.11). A similar philosophy was envisaged in the beginnings of D&T, where knowledge was conceived as a "resource to be used" (DES and WO, 1988:29) in contrast to the curriculum being comprised of "essential knowledge [and] fundamental operations" (DFE, 2011a: 6). Wolpert discusses the relationship between science and technology, where "reliable scientific knowledge is value-free" and the moral decisions occur when science is applied as technology in the production of products (Wolpert, 2002). Technological activity, as a Habermasian "moral-practical" culture, plays a key role in the *three spheres* (**Figure 3**), which begs the questions: Do we accept and try to fit in with the new order? Or do we challenge the foundations that our definitions of education as a cultural activity?

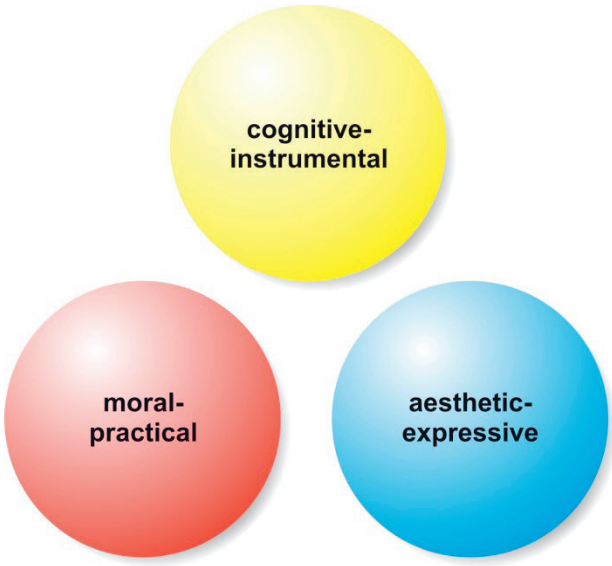

Figure 3 Representation of Habermas' cultural spheres

The literature reviewed for this paper builds an argument for technological activity, from a range of disciplines being viewed as within a constructivist paradigm, as a facet of overarching human activity. Design and making, as discrete elements or functions of technology (and, historically, central to D&T), plays a key role both historically and contemporaneously in cognitive and cultural evolution. It is apparent that the nature of culture is interpreted in different ways, exemplified by the highly cognitive "minds and hearts" of Goodenough (Geertz, 1973: 10), which builds on a dualist tradition in Western philosophy. Contemporary sociological commentator, Richard Sennett (2011) describes the tensions between head and hand, outlining three manifest aspects of practical activity: the interaction between *inner and outer life*, which encourages an iterative interaction reminiscent of the "APU model of the interaction between mind and hand" (Kimbell et al, 1991:20); the concept of *resistance*, in searching for limits and reflexive "use of minimal force": and dealing with *ambiguity*, which characterises Engestrom's activity system (**Figure 2**). All forms of practical learning contribute to either fine motor skills (Art and Design, Design and Technology and Music) or gross motor skills (Physical Education).

So what therefore is the case for Design and Technology, if this kind of learning can be found elsewhere in the curriculum? Part of an answer lies in returning to the concept of cultural artefacts as physical objects. Both Art and Design and Design and Technology have a shared, though underdeveloped, interest in design and craft skills (Ofsted, 2009; de Vries, 2007: 23-27). Where D&T differs is in the focus on combining "practical and technological skills with creative thinking to design and make products and systems that meet human needs" (QCA, 2007:51). The rationale for retaining design and making activities in the curriculum is cultural, rather than economic. Much has been made, in recent times, of the importance of the Science, Technology, Engineering and Mathematics (STEM) agenda, which are valuable expressions of learning in D&T. However, design and making as technological acts (or functions) has more to offer, including a vehicle for cultural awareness and evolution. It is the interaction between social and technological drivers that generate the 'wake' of cultural artefacts (**Figure 1**), be they physical (tools, products, systems or environments) or psychological (language or cognition). In a world where knowledge is prolific and accessible through computers and mobile devices (Internet), and products and building can be design in virtual environments (Sennett, 2008: 39-45), the ability to interact and create with real materials is essential (Dewey, 1916, 2001: 192).

To conclude, I would like to pose a number of polemic and rhetorical questions to challenge the status of technological activity. Each question has convincing arguments both for and against, but the aim is to generate discussion. Whether or not design and technology activity, and designing and making, is weak epistemologically (DFE, 2011a), it is ontologically active.

Questions

If technological activity predates scientific method, why is science perceived as more important?

If language came about as a result of our ancestors' creation and use of tools, why is there an imbalance in society and education between practical and cognitive skill?

How do we measure the social aspects of history or geography, if not through the mediation of technological development?

Can a painter paint without a brush, or a sculptor sculpt without hammer and chisel?

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