How technology makes us human: cultural historical roots for design and technology education

Abstract

In the context of curriculum change within English education, and beyond, this paper explores the cultural historical roots of design and technology as an educational construct, distinct from design or engineering, which exist as career paths outside of the school curriculum. It is a position piece, drawing on literature from a wide range of sources from writing, largely, outside of the discipline.

The authors revisit the original intentions of design and technology as a National Curriculum subject and, within the contemporary challenges, discuss the importance of technology, including designing and making, as an essentially human and humanising activity. The aim being to contribute to the theorisation and philosophy of the subject, where typically practitioners focus on practical and potentially mundane concerns.

This paper asserts that technological human activity is rooted in technological innovation and determinism, inextricably linked to social human activity. The aim is to add to the literature and provoke debate around the place and value of design and technology. The argument for retention of the subject, as part of a broad and balanced curriculum, is presented from a social and technological perspective; recognising the value of the subject as cultural rather than a merely technical or economic imperative.

Keywords: culture; design and technology; philosophy of technology; pragmatism; technology and society.

Introduction

This paper is a position piece, presenting a rationale for design and technology education as a discipline within the curriculum, at the local (school), national (statutory) and international (research and scholarship) level. Defences of the subject have been presented based on capability (e.g., Black and Harrison, 1985), design (e.g., Williams and Wellbourne-Wood, 2006) and within the context of the Science Technology Engineering Mathematics (STEM) agenda (e.g., Harrison, 2011). In this paper, we present a cultural historical perspective on technology, and technology education, positioning it as a fundamentally human activity (McLain, 2012; Bakhurst, 2007; Florman, 1987, in Mitcham, 1994) academically and culturally comparable with science, art, religion and sport (McGinn, 1978, in Mitcham, 1994).

> "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, p. 217)

Practical education has been promoted by various educational theorists (Claxton, Lucas and Webster, 2010; Dewey, 1916; Froebel, 1908), and in particular Dewey challenged the traditional tendency to favour abstract knowledge over concrete (Hickman 2001). In fact, Hickman goes as far as to suggest that Dewey viewed knowledge itself as a “technologically produced artefact” (p. 47). Design and technology wrestles with varying (albeit not incompatible) facets of practical or vocational verses academic, creative verses technical, to identify but a few (O'Sullivan, 2013). As a school subject, it offers more than the opportunity to develop what Sternberg (2005) calls 'practical intelligence', as valuable in itself, but also opportunity to develop creative and analytical intelligence. Whilst the subject might have its critics in terms of a definable knowledge base and curricular coherence (Hardy, 2017; DfE, 2011; McGimpsey, 2011; Miller, 2011; Pavlova, 2005), a theme to be discussed and problematised below, it seeks to promote what Sternberg describes as 'fluid ability' (thinking flexibly and creatively). This within the context of a shift towards a so-called knowledge-based curriculum in the United Kingdom and other Western nations (Gibb, 2017; Young, 2008).

White (2018) comments on the alluring and emotive nature of Young's notion of 'powerful' knowledge, which is predicated on bodies of knowledge and unique "systems of interrelated concepts" and are the "province of distinct specialized groups" (p.326). This becomes problematic when applied to a pre-existing, subject-led curriculum, constrained by the availability of teachers capable of delivering specialist knowledge (Reiss and White, 2013) - a challenge that design and technology faced as it coalesced from separate, gendered, craft disciplines with different material foci (Paetcher, 1995). The attractiveness of defining theoretical knowledge belies the complexity of curriculum design, particularly as enacted at a national level.

This paper focuses on cultural and historical factors relating to technological activity, as a fundamental human trait, inextricably linked to the evolution of our species and societies. However, we do not attempt to narrate the history of the subject, nor do we draw extensively on the rich pedagogic literature on design. Excellent historic accounts already exist, such as Atkinson (1990) who explores its evolution and transformation from handicraft through to design and technology, as we know it today and Allsop and Woolnough (1990), who also investigated the contentious relationship between science and technology in the wake of the subject's emergence in the English curriculum. Precursors to design and technology have also been well documented; for example, Penfold (1987), who narrates the struggles of educators in the gradual emergence of a more designerly curriculum in pre-national curriculum England, the resistance to change, a theme described as subcultural retreat by Paetcher (1995). We acknowledge that our choice to ignore much of the excellent work on design pedagogy may frustrate some readers. This choice was not made lightly and our decision to focus our argument largely on literature outside of the discipline was to speak into the current political context, where practical and creative subjects are perceived to be under values and under threat.

Design and Technology Education

After design and technology's rise to prominence as the first subject to be defined by the National Curriculum in England (NCC, 1990; DES/WO, 1988) towards the end of the last millennium, two decades on the subject came under scrutiny of government advisors (DfE, 2011) and outside commentators (Miller, 2011; McGimpsey, 2011). More recently, through the introduction of the English Baccalaureate (EBacc) (DfE, 2016), the status of traditional academic subject has been elevated, leaving "little room, if any, for creative, artistic and technical subjects" (BACC for the Future, 2018). Furthermore, the Design and Technology Association (D&TA) has outlined current challenges for "teacher recruitment, reducing curriculum time, decreasing GCSE entries, access to professional development" (D&TA, 2018).

Pedagogical literature has debated the role and nature of design and technology since its pre-National Curriculum days in England (DES/WO, 1988). Concluding statements from such texts include preparation for active participation in society and discovery of the ideas of oneself and others (Eggleston, 1996, p. 36); and the unique concrete language of graphics and models enabling learners to visuals their developing ideas in response to a task (Kimbell, Stables and Green, 1996, p. 35). Typically, design and technology curricula refer to activities relating to designing, making and critiquing in relation to technical knowledge and context, in addition to links with other disciplines and future careers (e.g., DfE, 2015, 2013). Furthermore, Morrison-Love (2017) explores the transformational aspect of design and technology pedagogy, compared to the proof in mathematics and interpretation in science; and Gumbo (2017) the diverse and contextually unique cultural value, affected by indigenous experience and worldviews, rather than design and technology education as a merely technical or economic imperative, promoting global or Western values.

Since the design and technology's emergence from the 'crafts' in the National Curriculum for England (DfE, 1995; NCC, 1990; DES/WO, 1988) in the 1980s, paralleled in the international proliferation of the subject, , the importance of technology and society have been part of the rationale for its inclusion in the curriculum. The current purpose statement makes the bold claim that pupils learn how to become "capable citizens" and that "design and technology education makes an essential contribution to the creativity, culture, wealth and well-being of the nation" (DfE, 2013). Similar statements from international design and technology curricula include:

- Australia: the "…important role in transforming, restoring and sustaining societies" (ACARA, 2014)

- New Zealand: the development of "…knowledge, practices and dispositions that will equip them to participate in society as informed citizens…" (MoE, 2017)

When developing a theoretical basis for developing the technology education in Finland, Rasinen (2003) studied six countries curricula: Australia, England, France, the Netherlands, Sweden and the United States. Through systematic analysis common educational objectives emerged for students, schools and society. The shared societal objectives included the notion that technology and society are integral.

In this paper, we explore the relationship between technology and society, although it is important to acknowledge that the design and technology curriculum does not 'own' technology. In fact, we propose that because technology is a fundamental human activity, the role of design and technology provides learners with a unique way of knowing, distinct from other subjects closely related to technology, such as computing and science. The location of 'design' in design and technology is an important signifier of the subject's purpose and intent. Cross, having examined 'designerly' ways of knowing (2006; 2001) as differing from so-called scientific approaches, discussed design thinking as complex, personal and contextual (2011). This approach to technology underpins and distinguishes design and technology education around the world, focusing on action and expression, which "pushes ideas forward" (Kimbell, 2018, p.185). In other words, design is the driver, rather than content knowledge about materials or component, and a crucial question is: "What do children need to know in order to engage with design?" The response from Kimbell, being knowledge on how to act, including where there is contextual ambiguity and multiple potential outcomes.

According to Bell et al. (2017), in part because of its complex and interdisciplinary nature, design and technology struggles to reveal its nature as a subject. A contributory factor in the subject's failure to establish itself as a single discipline. In the following sections we explore the 'problem' from the position of an a priori assumption as to the ontological richness of design and technology activity (acknowledging perceptions of epistemological weakness), as an artefact mediated discipline that not only uses artefacts and tools, but one that also designs, makes and evaluates them.

As authors, we are also conscious of the pragmatic nature of design and technology teachers, who tend to focus on practical and potentially mundane concerns (de Vries, 2005). This paper aims to contribute to the theorisation and philosophy of the subject, to challenge perceptions of the subject, both within and outside of the communities of practice; and promote debate on the role, nature and value of design and technology in the curriculum.

Theoretical Position

This paper explores literature from a variety of disciplines to discuss technological activity, from the position of pragmatism in the educational tradition of Dewey (Biesta, 2014; Biesta and Burbules, 2003). We adopt this stance in the context of educational 'extremism', where the dominating voices on curriculum in England being those adopting a realist stance; where the pendulum swing of policy favours content knowledge. This is, to some degree, in reaction to a perceived over emphasis on process and soft skills, such as so-called 21st Century Skills. Biesta (2014) argues that, rather than being at the opposite end of an objectivist / relativist continuum, pragmatism "operates beyond [this] age-old opposition" (p.30). We seek to reframe the argument about the value of design and technology education from knowledge (centred in the mind) to interaction and experience. Dewey's transactional theory of knowing side steps the 'impossible question' of knowing what is real and true, a fixation derived from assumptions that the mind and world are separate; and thus knowing what is true becomes significant. Rather it focuses on interaction and experience, acknowledging ambiguity. This view of 'intelligent action' has resonance with the model of interaction between head and hand (thinking and action) when designing and making, presented by Kimbell et al. (1996). We identify with the notion that "it is the combination of reflection and action which leads to knowledge" (Biesta, 2014) in design and technology. From this perspective, beginning with the question 'what is the core content knowledge in design and technology?' is the wrong starting point in curriculum design. Therefore, to adopt knowledge-based assumptions automatically privileges some subjects and demotes others.

Problem Finding and Problem Solving

In the contemporary educational context, design and technology faces several currently and seemingly insurmountable problems. Adopting a suitably designedly approach; let us engage with problem finding (McLain, 2012; Chand and Runco, 1993; Csikszentmihalyi, 1988). Design and technology has been identified as having "weaker epistemological roots" (DfE, 2011, p. 24) than other curriculum subjects, such as mathematics, where the bodies of knowledge are more clearly defined. Bernstein (1990) and Biglan (1973a, 1973b) explore the nature of subjects, and their disciplinary boundaries, explaining the aforementioned concern regarding design and technology's epistemological basis. Bernstein's framework classifies subjects as having strong or weak boundaries, depending on how clearly bodies of knowledge can be defined.

Utilizing mathematics as an example, whilst aspects of mathematical knowledge are included within other subjects, the knowledge is largely readily identifiable as belonging to the subject. For example, in design and technology a pupil may use knowledge of geometry when designing a prototype, but the knowledge is clearly mathematical. Whereas, again in design and technology, the same pupil may employ her imagination and communicate it through a sketch. In this typically design and technology scenario, both imagination and sketching are not the sole domain of the subject; although engagement in designing and making artefacts "that solve real and relevant problems, considering their own and others' needs, wants and values" (DfE, 2015, p. 3) could arguably be considered such. As Morrison-Love (2017) proposes, the unique pedagogy for design and technology is transformation – ideation through to realisation, synthesising contexts, solutions and resources to meet the aforementioned needs and wants. Therefore, the unique knowledge is in relation to this activity must be knowledge for action (knowing *how* as opposed to knowing *that*).

Taking a step back from education, technology is itself a complex phenomenon and term, and "does not mean exactly the same thing in all contexts" (Mitcham, 1994, p. 152). If it is true that technology eludes a single universal definition by philosophers, it should not come as a surprise that any school subject directly related to technology (including computing, design and technology and information communication technology) would be similarly challenged. Reviewing philosophical discourse, Mitcham sought "to identify the stance and distinctions proper to thinking about technology philosophically" (p. 267), presenting a "set of quasi-empirical categories for speaking about technology" (p. 269): technology as object, as knowledge, as activity and as volition.

> "*Technology as object* can be distinguished according to types of objects (utilities, tools, machines), *technology as knowledge* according to types of knowledge (maxims, rules, theories), *technology as activity* according to types of activity (making, designing, maintaining, using) and *technology as volition* according to types of volition (active will, perceptive will)." (p. 268, emphasis ours)

Mitcham speaks of the former epistemic challenge (DfE, 2011), stating that as "science is an abstraction from technology, knowledge for its own sake [often cited by well-meaning educators as an end in itself] as abstraction from practical knowledge" (Mitcham, 1994, p. 256). In other words, abstract knowledge ultimately emerges from practical knowledge through experience and the mind's desire for intelligent and informed action. Separation of thought (abstract) and action (concrete) in Western thought ranges back to Aristotle's identification and classification of Technē (craft knowledge) and Epistēmē (scientific knowledge) (Sharff and Dusek, 2003, Chapter 2), although in the opinion of Hickman (2001), "the Greeks failed to develop technology in the sense of a deliberate and systematic study" (p.11). We would note that whilst technē shares similar features to modern definitions of technology, they are not interchangeable terms or concepts. An over extension of the similarity could lead to virtually any human activity being defined as a technology. We do not propose a line of argument that leads to, for example, categorising religious practices as technology of the soul!

The influence of the classical thinking about knowledge and the separation of knowing that and knowing how can be observed in schooling systems over recent centuries in the United Kingdom and across the globe. In England, there has been a recent resurgence of the idea of the academically selective Grammar school (Jeffreys, 2017), following moves to open vocational establishments as University Technical

Colleges (Welham, 2015) and Studio Schools (Harrison, 2013), linked to technical and creative industries, respectively, for children between the ages of 14 and 19.

The following discussion will elaborate on the challenges in defining design and technology using Bernstein's classification and framing (1990, 1971) and Mitcham's modes of the manifestation of technology (1994), with an exploration of theories on technology and society in human development, scoping out the subject's epistemological problem. The lenses of Bernstein and Mitcham are used to focus on the problem of knowledge and curriculum in design and technology, rather than its pedagogy; the rationale for, rather than the methods of, the subject. The argument explores a cultural historical rationale for the inclusion of design and technology in a broad and balance curriculum, to challenge the current curricular hegemony. In choosing to foreground 'technology', it is not our intention to ignore 'design'. Design and technology was originally envisaged as a name to be "spoken in one breath" (DES/WO, 1988, p.2), with both aspects intimately connected with one another. We consider technology a complex and paradigm shifting human activity, with design integral, as an expression of human beings' unwillingness to "accept the environment, but to change it" (Bronowski, 2011, p.20).

Bernstein's Classification and Framing of Educational Knowledge

In this section, we will explore this through the lens of Bernstein's classification and framing of educational knowledge (1971). British Sociologist Basil Bernstein investigated social class, performance at school and how education reproduces inequality. Through analysis of language, Bernstein (1990) sought to understand why children in lower social class do less well in school. In his early work he sought to distinguish between school (elaborate) and everyday (restricted) language in order to analyse how children access and subsequently make sense of what is going on at school, in order to understand how children access and apply knowledge. He contended that the language used to teach a subject either enables, or prevents, access and found that children from working class backgrounds are less likely to achieve academically; because of their limited understanding of the language used in school. Consequently, they are less able to access information received and subsequently communicate their own thoughts and ideas.

Bernstein explores the distinction between different types of curriculum, how knowledge is organised hierarchically, and the power relationships between what is taught (classification) and control over how knowledge is learnt (framing):

> "…how a society selects, classifies, distributes, transmits and evaluates … educational knowledge … reflects both the distribution of power and the principles of social control" (Bernstein, 1971, p. 47)

Classification refers not to what is being classified (a school subject), but to the boundary strength between what is being classified (bodies knowledge and curricula), whereas framing refers to the pedagogical approach by which knowledge and skills are transmitted. From this perspective subjects are not bodies of knowledge, but are organisational frameworks that maintain class divisions within schools. Therefore, to promote some subjects as more academic and desirable than so-called practical or vocational subjects, could perpetuate social inequity during children's formative years in school.

In his work, Bernstein (1971) uses the notion of alternative codes to define the distinction between different types of curriculum and illustrate the power (classification) relationships between what is taught, and the control (framing) of how knowledge is learnt. According to Bernstein the first known as a 'collection code' is characterised by subjects that have distinct external boundaries, well insulated from other disciplines; within which knowledge is deemed to be 'sacred' and subjects in this category are considered to be 'strong'. In contrast, the second, known as an 'integrated code' there is little insulation between subject boundaries. This may reflect thematic based work or homogenous teaching approaches and hence these subjects are classified as 'weak'. Within the integrated code the teacher needs to be able to handle uncertainty, there is a balance of power between the teacher and the student.

Framing refers to how knowledge and skills are transmitted, and received. At the micro level, framing relates to the amount of pedagogical control the teacher employs during the process of knowledge transmission (Bernstein, 1975). If framing is deemed to be strong, knowledge dissemination is authoritarian, dominated by a teacher-led methodology. Where the pedagogical approach to knowledge delivery is determined between the student and the teacher, or the teacher seeks to design delivery to meet the interests of the student, framing is classified as being 'weak'.

In the code, where both classification and framing is deemed to be 'strong', the teacher is in control, and subject content pre-determined, being framed explicitly within clear boundaries (Neumann Parry and Becher, 2002). In the integration code, classification is weak and subject boundaries are considered less well defined and blurred. Where framing is also 'weak', the pedagogical approach enables an open form of control, and in application this leads to a negotiated approach between student and teacher.

Bernstein maintains that the hierarchical status of a subject within the school curriculum results from a well-defined, often long-established body of knowledge which remains consistent over time, and that the school curriculum has been dominated by subjects adhering to these principals. This domination is reflected in contemporary education policy (Abrams, 2012; cf. BACC for the Future and D&TA, 2018), and within this theoretical framework the characteristics of the currently privileged set of subjects, represented in the so-called English Baccalaureate (EBacc), which includes both science and mathematics. The EBacc (DfE, 2019) being more akin to an accountability measure for schools in England, than a qualification for students. These align strongly within the collection classification code, and typically the pedagogical approaches adopted means that framing is also strong. In stark contrast, in part due to design and technology's need to consistently embrace, adapt and accommodate change, the subject's physiognomies are distinctly different to subjects, such as mathematics and science, where arguably curriculum content has remained relatively unchanged over time. This results in the assignment of a classification for design and technology that is perceived as being loosely classified or 'weak'. It is unsurprising therefore that utilising Bernstein's theoretical lens (2000), when compared directly with strongly framed subjects, such as mathematics and science, design and technology finds itself at a distinct disadvantage (McGarr and Lynch, 2015).

Brought about by this need to consistently embrace and adapt to change in order to meet curriculum demands and reflect a world with ever progressing technological advancement, design and technology is characterised by perpetually shifting curriculum content; and a fluctuating knowledge base that manifests and perpetuates subject instability and in doing so, it presents itself as a subject with 'weak' external boundaries.

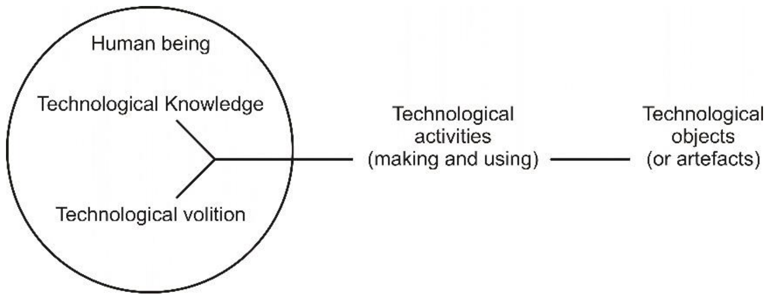
As a result, design and technology is a subject misunderstood, perceived to be lower in status than its well-established counterparts. In practice, this means that those working to deliver the subject have to constantly justify the place of the subject within a hierarchy of well-established curriculum subject disciplines. This is in direct contrast to its STEM counterparts of science and mathematics; which are classified as subjects with 'strong' external boundaries (Bernstein 2000, 1971) or 'hard', 'pure' disciplines (Biglan 1973a, 1973b; Becher 1994), when presented as a single subject, with its nomadic vocational characteristics design and technology manifests as a 'soft', applied subject with 'weak', flexible external boundaries. Boundaries that are difficult to define, and as such within the hierarchy of its academic STEM counterparts, design and technology finds itself in an uncomfortable and often isolated place.

Bernstein provides a way to understand the difficulty that design and technology faces in justifying its place in the curriculum on epistemological grounds. Where the prevailing bias in education and education policy is towards definable knowledge, the relative ontological strength (McLain, 2012) of the subject is overlooked. The following discussion will explore the cultural and historical expression of technology, and the implications for design and technology.

Mitcham's Modes of the Manifestation of Technology

Acknowledging the complexity of technology, Mitcham (1994) presents an analysis of the issues in the philosophy of technology, which encompasses a breadth of philosophical perspectives; from both inside (engineering) and outside (humanities) technology. Figure 1 (p. 160) illustrates the developing framework, exploring the broad and interrelated categories of technology as *object*, technology as *knowledge*, technology as *activity*, and technology as *volition*. Design is inherent to Mitcham's analysis of technology, through each of the modes, but particularly within the processes of ideation and realisation in technological *activities* (designing and making) and *objects* (prototypes, products and systems). Furthermore, the designer applies both will to change (volition) and know-how (knowledge) to these ends. Whilst this section does not directly address the ‘D’ in design and technology, it should not be overlooked or viewed as a separate activity that is removed or remote from technology.

Figure 1: Mitcham's (1994) Modes of the manifestation of technology



Mitcham’s framework encompasses views as diverse as technological determinism, where technology is considered as influencing or controlling human activity (Roe Smith, 1994), to human freedom, where human will and creativity directs technology (Hickman, 2001; Feenberg, 1999). Further, it is open to viewing knowledge from both reductionist and transcendent perspectives.

Technology viewed as **object**, is familiar to design and technology pedagogy and practice, and is defined by Mumford (1934, in Mitcham, 1994, p. 162) as including:

- *clothing* (“…utilitarian and decorative”),
- *utensils* (“… storage containers and instruments of the… home”),
- *structures* (“houses and other stationery artefacts”),
- *apparatus* (“…containers for some physical or chemical process…”),
- *utilities* (“… roads, reservoirs, electric power networks”),
- *tools* (“instruments operated manually… to move or transform the material world…”),
- *machines* (“tools that do not require human energy input…”) and

- *automata* ("… machines that require neither human energy input nor immediate human direction")

These categories, with the possible exception of apparatus and utilities, are resonant with artefacts (typically prototypes of products and/or systems) that learners design and make in design and technology classrooms. Furthermore, learners in design and technology use tools (such as hammers, needles, and knives), machines (such as drilling, sewing and mixing machines) and automata (such as computer aided manufacture and computer numerical control devices) when realising (designing and making) artefacts.

Mitcham begins with an epistemological analysis of technology as **knowledge** with a taxonomy of increasingly conceptual distinctions: *sensorimotor skills* (acquired through heuristic or mimicry), *technical maxims* (including rules of thumb and recipes), *descriptive laws* (recognising cause and effect – if you do X then Y will happen), and *technological theorie*s (involving real world application of theory and/or operation of humans and technology). He draws parallels with Dreyfus and Dreyfus' five stages of skill development: novice, advanced beginner, competency, proficiency, and expertise (Dreyfus and Dreyfus, 1986); although he goes on to infer that 'knowing how' (procedural knowledge) is a heuristic precursor to a higher level 'knowing that' (conceptual knowledge), a notion that Ryle (1949, 1990) and McCormick (1997) challenge. There are also parallels to be noted with psychomotor domain of taxonomy of educational objectives (Harrow, 1972; Dave, 1967; Simpson, 1956), alongside the more commonly recognised cognitive (Marranzo and Kendell, 2007; Andersen and Krathwohl, 2001; Bloom, 1956) domain.

Technology as **activity** can be viewed as the factor that unites knowledge and volition resulting in the production of technological objects (artefacts). Indeed technological objects, as tools in the ideation and realisation process or the outcomes themselves, can likewise influence technological activity. Mitcham lists typical behaviours in technological activity loosely as actions (crafting, inventing, and designing) and processes (manufacturing, working, operating, and maintaining). He goes on to describe how Aristotle suggested a distinction between cultivating and constructing, as types of making. We can see here how ‘cultivating’ technological domains, such as agriculture and horticulture, are distinct from domains typically understood as design and technology education. “Cultivation involves helping nature to produce more perfectly or abundantly…” (such as medicine or farming) and construction “entails reforming or melding nature to produce things not found” in nature (such as carpentry or catering) (p.211). In light of this one might forgive the epistemic muddlement of the government advisor who proposed the revised national curriculum programme of study for design and technology in England to include flower arranging and cultivating plants (Paton, 2013). A further dimension to technology as activity is the distinction between useful (or servile) and fine (or liberal) arts, the names of which indicate the historic and cultural bias, elevating the fine (or use-less) arts. A crude explanation of the difference between the approaches to design in ‘art and design’ and ‘design and technology’ lies in the functionality and user focus of the latter. In technology as activity, it becomes clear that design and technology cannot lay sole claim on the domain of technology (nor, indeed, design). Therefore the subject must articulate the unique perspectives and pedagogies that it lends a broad and balanced curriculum and what dispositions it engenders; such as design “as a method of practical action” (Mitcham, 1994, p. 228-229) that underlies all practical activity (including business, education, law and politics) or transformation as “a core epistemic source” for design and technology (Morrison-Love, 2017, p. 34) against the proof in mathematics.

The coincidence of design 'and' technology distinguishes the curriculum intentions and pedagogical approaches from other design 'or' technology related subjects.

In technology as **volition**, Mitcham moves the discourse towards philosophy into the mind, motivation and intentionality. Interpretations of volition in technology are wide and varied, ranging from biological imperative to the competing drives for control and freedom. Mitcham quotes Ferré (1988) describing technology as "practical implementations of intelligence" (p. 30) and the incremental improvements of this "embodied in culture and perpetrated by tradition" (p. 36-37); positioning technological human activity as predating modern scientific notions and reconstructions. Mitcham describes volition as the most subjective of the modes of technology, expanding that one cannot directly know or perceive volition, relying on external action to infer the intention and character of the actor. To add complexity, volition might also be intrapersonal, interpersonal, socio-cultural or external through a prevailing hegemony. In this mode, technology and values are inextricably linked and technological objects and activities cannot be considered as neutral. In other words, humans create, and shape technology and technology reciprocates to shape humans and society.

Technological objects (such as a knife) exist in a context (such as a kitchen), influenced by a will to change or act that affect how the object and activity are perceived and enacted. The BIC Biro, for example, does not exist in isolation or in its own right; it exists as a result of a will to make marks (the technology of writing) to communicate or record (a social imperative) and made available to all as a ubiquitous modern technological artefact, in the context of the development of written language across millennia and cultures.

Mitcham acknowledges that the four modes of technology overlap and interact. In this it is helpful to ask ourselves how this relates to design and technology as curricular entity. He exemplifies the interaction of technological object and activity (without knowledge and volition) as “play with toys” (p. 269), and one could liken this to focused making activities in design and technology, which engage learners in the development of skill, as knowing how. Technological volition and activity might result, in design and technology, might result in speculative designing; to meet a perceived need or desire. Therefore, it is important to consider the breadth and complexity of technology in constructing not only a strong defence of the role of design and technology in the curriculum, but also designing an appropriate curriculum experience for the classroom. Furthermore, it is essential to challenge a narrowing of the perceived contribution and scope of the subject, both with and outside of the design and technology community.

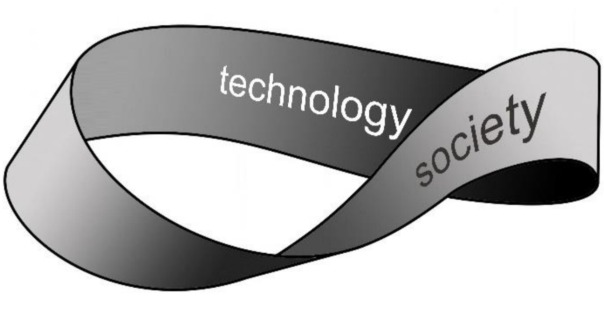
Having discussed two theoretical perspectives, potential affecting how design and technology is both valued and understood, the next section will reframe the nature of technology and society from a cultural historical perspective on human activity and development.

Technology and Society

> “…“technology and social organization, which stem from a definite stage in the development of this technology, are the basic factors in the development of primitive man” (Vygotsky & Luria, 1993, p. 92–93). This statement points us toward Vygotsky’s understanding of the common “core” of culture characteristic of all Homo Sapiens: the intertwining of their use of tools, signs, language, and the distinctive core of their technologies, with the special forms of social life that the technologies mediate.” (Cole and Gajdamaschko, 2007, p. 199)

Vygotsyy's view of human evolution and development acknowledges the intertwined nature of technology and society, and mediating artefacts as "objectifications of human needs and intentions" (Daniels, Cole and Wertsch, 2007, p. 255; Wartofsky, 1979; Vygotsky, 1978), akin to Mitcham's aforementioned technological volition. Design and technology promotes a holistic mind-body stance, as described by Kimbell, Stables and Green's (1996) model of the dynamic and iterative interaction between head (thinking) and hand (acting) during designing and making activity. As discussed above, Dewey's transaction theory of knowing provides an alternative to dualistic worldview of a "mind-world scheme" (Biesta, 2014) that considers the mind and body as separate entities; privileging the mind over the body. This worldview has also been challenged by Ryle (1949, 1990) and Vygotsky (Russell, 1993). Both Dewey and Vygotsky challenged reductionism and dualistic divisions within education and beyond, "denying all absolutes to assert a dynamic holism" (Russell, 1993, p. 173-174). Furthermore, Bruner (2009) builds on the cultural aspect of this holistic view of the "technical-social way of life" (p. 160) in human evolution.

Figure 2: Dynamic Interaction of Technological and Social Activity



A Mobius strip (Figure 2) provides an apt visual metaphor for the dynamic relationship between technology and society, avoiding the question of pre-eminence or causal nature of one over the other; promoting a flat, rather than hierarchical, ontology.

That being said, emerging evidence from the study of the brain suggest a causal effect from the tool use to the development of language (Johnson-Frey, 2004; Wolpert, 2003; Greenfield, 1991). Furthermore Tallis (2003), acknowledging the relationship between tools and language, cites fossil records as evidence of tool use predating capacity for speech and therefore a more convincing argument for the achievements of humans beyond our fellow hominids. The social achievements of modern humans, including the liberal arts, are facilitated by technology. For example, the painter does not normally paint without a brush (or other suitable implement), nor does the sculpture carve without the appropriate tools; both of which being technological artefacts, which have enabled expression and evolution of styles in the so-called fine arts.

Arthur (2009) describes how new technological domains are built on preceding domains, as reflected in historical categorisation of human eras as stone age, bronze age, iron age, et cetera. The flint axe knapped by our ancestors enabled them to cut wood, which in turn enable wood technologies, through to modern times and quantum computers. Viewed in such a manner, technology appears inextricably linked to disciplines defined as humanities! A technological continuum connects modern with historic cultures.

> "… 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 [sic] has driven human evolution." (Wolpert, 2003, p. 1709)

Campbell (2011) explores intelligence and the relationship between language use and tool use, identifying common features and the notion of a tool as an extension of the body. It may be that to talk about tools and language as different things is unhelpful, as the language extents the embodied mind to communicate with others through speech and writing. Writing as a cultural psychologist, Cole (1996) describes the example of a visual impaired person using a stick (white cane) and asks whether the sensation begins in the hand or in the stick. Nickerson (2005) discusses technology as a cognitive amplifier "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" (p. 6). In this way, human beings use technology "to outsource, or distribute, elements of cognitive capacity" (McLain, 2012, p. 334).

Our analysis considers technology, including tools and artefacts, as "cultural entities" (Engeström, 2009, p. 54). Vygotsky discussed the importance of technological activity as a key to understanding the mind, and the link between tool use and speech (Tappan, 1997; Vygotsky, 1978). Engeström (1999) added cultural and historical aspects to Vygotsky's notion of tool mediated activity to analyse systems. Applied to design and technology activity, humans use a range of tools (physical and conceptual artefacts) brought to bear on a subject, such as a problem or context, with the object of creating a product, be it a physical prototype or a system (DfE, 2015). Wartofsky (1979) states that the creation and use of artefacts, as tools, is a "distinctively human form of action" (p. 202), fundamental to our development as a species.

Cole (2007) describes Wartofsky's assertion that the "creation of artefacts, including the words of one's language" is distinctively human. Wartofsky (1979) outlines three levels of artefact, with both technological and social tools as primary artefacts used in the production of the means to perpetuate the species. Secondary artefacts incorporate primary artefacts and their application, including the transmission and preservation of technical knowledge. Tertiary artefacts enter an imaginary realm, allowing for praxis to be transferred and transformed "beyond the immediate context" (p. 91).

Discussion

Through this paper, we have explored the classification and framing of knowledge in education and the nature of technology within society, in scoping out 'the problem'. In beginning to address 'the problem', we reflected on how technological developments have helped to shape human development and societies. We sought to 'find' the problem of design and technology as a subject in the curriculum with an undefined epistemological basis; focusing on literature and ideas outside of the subject community. First, through the lens of Bernstein's classification and framing of educational knowledge, which explains the difficulty the subject has in defining what is uniquely design and technology knowledge. Second, through the lens Mitcham's modes of the manifestation of technology, which illustrates the difficulty in defining technology.

It is important to note that design and technology neither owns nor wholly represents technology education. Neither does its knowledge base encapsulate the entirety of technology, nor for that matter design. However, it draws together aspects of the interwoven technological and social drives that have been key factors in the evolution and development of the human race, in a way that other subjects do not. Furthermore, to view design and technology solely as a STEM or a vocational subject, denies the potentially powerful cultural contribution it makes to education and society. Cultural artefacts, as real and corporeal entities, are created through this dynamic interaction of socio-technological human activity (Figure 2). A unique feature of design and technology education is that technological artefacts not only mediate activity, but learners engage with artefacts to design, make and evaluate their own artefacts – variously referred to as models, prototypes, systems or products – transforming the world around them (Morrison-Love, 2017) requiring that pupils defer judgement and manage ambiguity when designing (Nicholl and McLellan, 2007). This activity differs from, superficially, similar activities in art and design, when considered from the perspective of the servile (useful) or liberal (fine) arts, describe by Mitcham. Designing activity in design and technology has a functional purpose, whereas (broadly speaking) in art and design, it is expressive in nature. Therefore, we argue for design and technology education at the heart of the modern democratic curriculum, not only due to the deterministic nature of technology as guiding society, but a cultural imperative as a liberating factor in human evolution and the development of society.

Conclusion

We believe that there is great power in design and technology, and this paper speaks into the current political context regarding the epistemological status of the subject in England (and in other jurisdictions where dominating educational ideologies favour a so-called knowledge led or rich curriculum), rather than rehashing pedagogical arguments that are neither understood nor accepted by the decision makers. This paper has explored ways in which assumptions about both knowledge, curriculum and technology affect how design and technology is potentially (de)valued and (mis)understood. In response, we challenge the design and technology communities of practice to engage with the philosophy of technology (and technology education), and to widen our notions of the subject as cultural and historical; to breakout from the "day-to-day and down-to-earth types of questions" (de Vries, 2005, p. 1) and reflect on the pedagogical power of design and technology education, beyond its technical and vocational purposes. To the education policy makers, our challenge is to espouse and enact inclusive curricula that equip children and young people to live and thrive in an increasingly technological world; eschewing narrow or limiting ideological perspective. This may result in counterarguments critique and refutation of our position, which we welcome in the pursuit of a democratic curriculum that espouses and celebrates social and technological achievement, past, present and future. Indeed, in this paper, we hope to promote and ignite discussion and debate, both inside and outside of the subject community. However, by adopting a pragmatic approach to the curriculum we also hope to dampen the relativist/realist pendulum swing in education policy towards design and technology.

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