Cultural and historical roots for design and technology education: why technology makes us human

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In the continuing context of curriculum change within English education, this paper explores the cultural and 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 and outside of the discipline. The authors revisit the original intention of design and technology as a national curriculum subject and within the contemporary challenges, highlight the historical and social 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 tend to focus on practical and potentially mundane concerns. This paper asserts that technological human activity is rooted in technological innovation and determinism. The aim is to add to the literature and 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 socio-technological perspective; recognising the value of the subject as cultural rather than a merely technical or as an economic imperative.

Key Words: culture, design and technology education, philosophy of technology, socio-technological human activity.

1. INTRODUCTION

This paper as a thinking piece, presenting the 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 (Black and Harrison, 1985), design (Williams and Wellbourne-Wood, 2006), and within the context of the Science Technology Engineering Mathematics (STEM) agenda (Bell, 2016; Harrison, 2011). In this paper, we present a cultural and historical perspective on technology, 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).

This paper explores design and technology, as subject in the school curriculum (NCC, 1990: 23; DfE, 1995, 10; DfE, 2011b), focusing on cultural and historical factors relating to technological activity as a fundamental human trait, inextricably linked to the evolution of our species and societies. With this paper, we will not attempt to provide the historical context of the subject. Excellent historical accounts of the origins of design and technology education already exist, for example 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

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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 Paechter (1995).

After design and technology's rise to prominence as the first subject to be defined by the National Curriculum in England (NCC, 1990; DES and WO, 1988) towards the end of the last millennium, two decades on the subject came under scrutiny of government advisors (DfE, 2011a) and outside commentators (Miller, 2011; McGimpsey, 2011). More recently, through the introduction of the English Baccalaureate (EBacc) and proposals to extend the "school day to include a wider range of activities, such as sport, arts and debating" (DFE, 2016: 21), 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) resulting in current challenges outlined by the Design and Technology Association (D&TA) for "teacher recruitment, reducing curriculum time, decreasing GCSE entries, access to professional development" (D&TA, 2018).

2. PROBLEM FINDING AND PROBLEM SOLVING

In the contemporary educational context, design and technology faces several currently 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, 2011a: 24) than other curriculum subjects, such as mathematics, where the bodies of knowledge are clearly defined. In his work, Bernstein (1990) explores the nature of subjects, and their disciplinary boundaries, supporting 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 them through a sketch. In this typically design and technology scenario, both imagination and sketching are not the sole domain of the subject.

Taking a step back from education, technology is a complex phenomenon and term and "does not mean exactly the same thing in all contexts" (Mitcham, 1994: 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 would be similarly challenged. Reviewing philosophical discourse, Mitcham sought "to identify the stance and distinctions proper to thinking about technology philosophically" (p.267), presenting "set of quasi-empirical categories for speaking about technology" (p.269): technology as object, as knowledge, as activity and as volition.

The following discussion will elaborate on the challenges in defining design and technology using Bernstein's classification and framing and Mitcham's modes of the manifestation of technology, scoping out the subjects epistemological problem. The agreement will be developed proposing an historical and cultural rationale for the inclusion of design and technology in a board and balance curriculum, as a focal point for socio-technologic human activity, drawing on thinking from social constructivism, cultural psychology and neuroscience to challenge the academic hegemony.

3. THEORETICAL FRAMEWORK

This paper explores literature from a variety of disciplines to discuss technological activity, within a social constructivism framework in the educational traditions of Dewey and Vygotsky. Our analysis considers technology, including tools and artefacts, as "cultural entities" and is informed by an "object-orientedness of action" view of the mind (Engeström, 2009: 54). Latour (2008) and Harman (2002), building on Heidegger's philosophy of tool use, discuss the nature of objects and the influence they weld on human behaviour and development. 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).

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 (Table 1) 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).

Table 1. Wartofsky's taxonomy of artefacts

Level	Description
Primary:	Technological (e.g. a hammer) and social (e.g. words) tools.
Secondary:	Includes the preservation and transmission of skills or modes of action.
Tertiary:	Creativity, imagination and transfer beyond the immediate context.

According to Bell et al. (2017) as a single subject, in part because of its interdisciplinary nature, design and technology, struggles to surrender its axioms, which is a contributory factor in the subject's failure to establish itself as a single discipline (Bell, Morrison-Love, Wooff and McLain, 2017). In the following sections we explore the 'problem' on the basis of an assumed ontological richness, if a not yet defined epistemological as one; as an artefact mediated discipline that not only uses artefacts and tools, but one that designs, makes and evaluates them.

4. BERNSTEIN'S CLASSIFICATION AND FRAMING OF EDUCATIONAL KNOWLEDGE

In this section we will explore design and technology through the lens of Bernstein's classification and framing of educational knowledge (1971).

In his work, British Sociologist Basil Bernstein explores 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 help 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.

In earlier work, Bernstein (1971) codified subjects 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. The collection code is characterised by subjects that have distinct external boundaries, well insulated from other disciplines. Within these are subject's knowledge is deemed to be 'sacred' and as such are subjects that reside within this category are deemed to be 'strong'. In contrast within the 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.

Brought about by the 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 and skills 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, in direct contrast to its STEM counterparts of science and mathematics, which are classified as subjects with strong external boundaries (Bernstein 2000, 1971), those working to deliver the subject have to constantly justify design and technology's place as a subject of worth within a hierarchy of well-established curriculum subject disciplines. When presented as a single subject, with nomadic characteristics, and weak external boundaries that are difficult to define, design and technology manifests as a soft, applied subject (Bernstein, 2000, 1971), and as such, within the hierarchy of its academic counterparts 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 (Morrison-Love, 2017; McLain, 2012) of the subject is overlooked. The following discussion will explore the cultural and historical expression of technology.

5. 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.

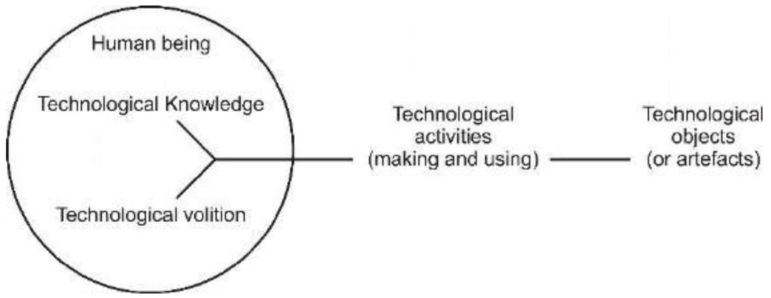

Figure 1. Mitcham's Modes of the manifestation of technology

The 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**, as defined by Mumford (1934, in Mitcham, 1994: 162) includes: 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 that learners design and make in design and technology classrooms.

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 theories (involving real world application of theory and/or operation of humans and technology). Mitcham draws parallels with 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.

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 list typical behaviours in technological activity loosely as actions (crafting, inventing, and designing) and processes (manufacturing, working, operating, and maintaining). 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. In technology as activity, it becomes clear that design and technology cannot lay sole claim on the domain of technology. Therefore the subject must articulate the unique perspectives and pedagogies that it lends to a broad and balanced curriculum and what dispositions it engenders; such as design "as a method of practical action" (Mitcham, 1994: 228-229) that underlies all practical activity (including business, education, law and politics).

In technology as **volition**, Mitcham moves the discourse towards philosophy and 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 the actor.

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 skills, as knowing how. In design & technology, technological volition and activity 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 in designing an appropriate curricular experience for the classroom.

6. SOCIO-TECHNOLOGICAL HUMAN ACTIVITY

The social constructivist 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: 255; Wartofsky, 1979; Vygotsky, 1978), akin to Mitcham's aforementioned technological volition. Design and technology takes a holistic mind-body stance, as described by Kimbell, Stables and Green's (1996) in their model of the dynamic interaction between head (thinking) and hand (acting) during designing and making activity. The dualistic worldview of Descartes that considers the mind and body as separate entities, privileging the mind over the body, has been challenged by Ryle (1949), Vygotsky and Dewey (Russell, 1993). Dewey and Vygotsky challenged reductionism and dualistic divisions within education and beyond, "denying all absolutes to assert a dynamic holism" (Russell, 1993: 173-174). Furthermore, Brunner (2009) builds on the cultural aspect of this holistic view of the "technical-social way of life" (p. 160) in human evolution.

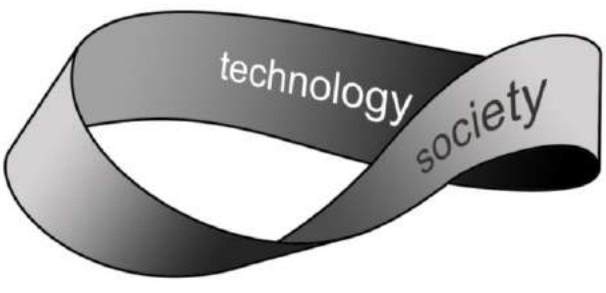

Figure 2. Mobius, representation of the dynamic interaction between technology and society

The 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. 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 artistic expression and the evolution of styles.

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 extends 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 people use technology "to outsource, or distribute, elements of cognitive capacity" (McLain, 2012: 334).

7. CONCLUSION

Through this paper we have explored the value of technology within society, how technological developments have helped to shape our evolution and society. We have also sought to locate the problem of design and technology as a subject in the curriculum with an undefined epistemological basis. 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 explains the difficulty in defining technology. In this paper we begin to argue for design and technology education at the heart of the modern democratic curriculum as a cultural.

8. REFERENCES

Allsop, T. and Woolnough, B. (1990). The relationship of technology to science in English schools, Journal of Curriculum Studies, 22(2), p.127-136. doi.org/10.1080/0022027900220202

Atkinson, S. (1990). Design and Technology in the United Kingdom, Journal of Technology Education, 2(1). Available at https://scholar.lib.vt.edu/ejournals/JTE/v2n1/html/atkinson.html [Last Accessed 05 April 2018]

Bell, D. (2016). The reality of STEM education, design and technology teachers' perceptions: a phenomenographic study. International Journal of Technology and Design Education, 27(1), pp.61-79. DOI: 10.1007/s10798-015-9300-9

BACC for the Future (2018). What is the EBacc? Why does this matter? [online]. Available at https://www.baccforthefuture.com/ [last accessed 05 April 2018]

Bakhurst, D. (2007). Vygotsky's Demons. In H Daniels, M. Cole, and J.V. Wertsch (Eds). The Cambridge Companion to Vygotsky. Cambridge, UK: Cambridge University Press

Bell, D., Morrison-Love, D., Wooff, D. and McLain, M. (2017). Analysing design and technology as an educational construct: an investigation into its curriculum position and pedagogical identity, The Curriculum Journal, 28(4), p.539-558. DOI: 10.1080/09585176.2017.1286995

Bernstein, B. (1971). On the classification and framing of educational knowledge, in Young M.F.D.(Ed). Knowledge and Control: New directions for the sociology of education. London: Collier MacMillan, 47-69.

Bernstein, B. (1990). The structuring of pedagogic discourse: Class codes and control (Vol. IV). London: Routledge.

Bernstein, B. (2000). Pedagogy, Symbolic Control and Identity: Theory, research, critique (revised edition), New York: Rowman and Little

Black, P. and Harrison, G. (1985). In place of confusion: technology and science in the school curriculum. London: Nuffield-Chelsea Curriculum Trust.

Campbell, J. (2011). Why do language use and tool use both count as manifestations of intelligence? In T. McCormack, C. Hoerl and S. Butterfill, (eds). Tool Use and Causal Cognition. Oxford: Oxford University Press. p. 169-182

Chand, I. and Runco, M.A. (1993). Problem finding skills as components of the creative process. Personality and Individual Differences, 14(1), pp.155-162.

Cole, M. (2007). Cultural Psychology. In Y. Engeström, R. Miettinen and R-L. Punamäki. Perspectives on Activity Theory. Cambridge: Cambridge University Press.

Cole, M. (1996). Cultural Psychology: a once and future discipline. London: Harvard University Press.

Cole, M. and Gajdamaschko, N. (2007). Vygotsky and Culture. In H. Daniels, M. Cole, and J.V. Wertsch (Eds). The Cambridge Companion to Vygotsky. Cambridge, UK: Cambridge University Press.

Csikszentmihalyi, M. (1988). Motivation and Creativity: Towards a Synthesis of Structural and Energetic Approaches to Cognition. New Ideas in Psychology, 6(2), pp.159-176

Daniels, H., Cole, M. and Wertsch, J.V. (Eds) (2007). The Cambridge Companion to Vygotsky. Cambridge, UK: Cambridge University Press.

DfE (2016). Educational Excellence Everywhere [electronic document]. Retrieved from https://www.gov.uk/government/publications/educational-excellence-everywhere

DfE (2013). National curriculum in England: framework document [online]. Available at:
https://www.gov.uk/government/collections/national-curriculum [last accessed 05 April 2018]

DfE (2011a). The Framework for the National Curriculum: A report by the Expert Panel for the National Curriculum review. London: Department for Education.

DfE (1995). Design and Technology in the National Curriculum. London: Department for Education.

D&TA (2018. Designed and Made in Britain...? [online]. Available at https://www.data.org.uk/campaign/ [last accessed 05 April 2018]

Dewey, J. (1916). Democracy and Education: an introduction to the philosophy of education. New York: The Macmillan Company.

Dreyfus, H.L. and Dreyfus, S. (1986). Mind over machine: the power of human intuition and expertise in the era of the computer. New York: Free Press.

Engeström, Y. (2009). Expansive learning: towards an activity-theoretical reconceptualisation. In K. Illeris, K. (2009). Contemporary Theories of Learning: Learning Theorists ... In Their Own Words. Oxon, UK: Routledge.

Feenberg, A. (1999). Questioning technology. London: Routledge.

Ferré, F. (1988). Philosophy of technology. Englewood Cliffs, USA: Prentice-Hall.

Florman, S. (1968). Engineering and the liberal arts: at technologist's guide to history, literature, art and music. New York: McGraw-Hill.

Greenfield, P.M. (1991). Language, tools and brain: The ontogeny and phylogeny of hierarchically organized sequential behavior. Behavioral and Brain Sciences, 14(4), pp. 531-551. DOI: 10.1017/S0140525X00071235

Harrison, M. (2011). Supporting the T and the E in STEM: 2004-2010. Design and Technology Education: an International Journal, 16(1). Available at https://ojs.lboro.ac.uk/DATE/article/view/1591 [Last accessed 06 April 2018]

Hickman, L.A. (2001). Philosophical tools for technological culture: putting pragmatism to work. Bloominton, USA: Indiana University Press.

Johnson-Frey, S., H. (2004). The neural bases of complex tool use in humans. Trends in Cognitive Sciences, 8(2), pp.71-18. DOI: 10.1016/j.tics.2003.12.002

Kimbell, R., Stables, K. and Green, R. (1996). Understanding practice in design and technology. Buckingham, UK: Open University Press.

Latour, B. (2008). A Cautious Prometheus? A Few Steps Toward a Philosophy of Design (with Special Attention to Peter Sloterdijk). [Keynote lecture] Networks of Design meeting of the Design History Society Falmouth, Cornwall, 3rd September 2008. Available at: http://www.bruno-latour.fr/sites/default/files/112-DESIGN-CORNWALL-GB.pdf [last accessed 05 April 2018]

McCormick, R. (1997). Conceptual and Procedural Knowledge. International Journal of Technology and Design Education, 7(1-2), pp.141-159. DOI: 10.1023/A:1008819912213

McGimpsey, I. (2011). Summary of a review of the academic literature on Design and Technology in the National Curriculum [Online]. London: RSA. Available at: https://www.thersa.org/globalassets/pdfs/blogs/rsa_dt-lit_review_final.pdf [last accessed 05 April 2018]

McGinn, R. (1978). What is Technology?, Research in Philosophy and Technology, 1, pp.179-197

McLain, M. (2012). The importance of technological activity and designing and making activity, a historical perspective. PATT 26 Conference, Technology Education in the 21st Century. Royal Institute of Technology, Stockholm, Sweden. In T. Ginner, J. Hallström & M. Hultén (Eds.). (pp. 330-340). Linköping, Sweden: Linköping University Electronic Press, Linköpings universitet.

Miller, J. (2011). What's wrong with DT? [Online]. London: RSA. Available at: https://www.thersa.org/globalassets/pdfs/blogs/rsa_whats-wrong-with-dt.pdf [last accessed 05 April 2018]

Mitcham, C. (1994). Thinking through technology: a path between engineering and philosophy. Chicago: The University of Chicago Press.

Morrison-Love, D. (2017). Towards a Transformative Epistemology of Technology Education. Journal of Philosophy of Education, 51(1), p.23–37. doi:10.1111/1467-9752.12226

NCC (1990). Technology in the National Curriculum. London: Department for Education and Science and the Welsh Office.

Nickerson, R.S. (2005). Technology and cognition amplification. In R.J. Sternberg and D.D. Preiss (eds). Intelligence and technology: the impact of tools on the nature and development of human abilities. London: Lawrence Erlbaum Associated Publishers.

Penfold, J. (1987). From Handicraft to Craft Design and Technology, Studies in Design Education Craft and Technology, 20(1), p.34-48.
Roe Smith, M. (1994). Technological determinism is American culture. In M. Roe Smith and L. Marx (eds). Does technology drive history? The dilemma of technological determinism. Cambridge, USA: The MIT Press.
Roe Smith, M. and Marx, L. (1994). Does technology drive history? The dilemma of technological determinism. Cambridge, USA: The MIT Press.
Russell, D. R. (1993). Vygotsky, Dewey, and Externalism: Beyond the Student/Discipline Dichotomy. Journal of Advanced Composition, 13(1) p173-197. http://www.jstor.org/stable/20865898
Ryle, G. (1949, 1990). The concept of mind. London: Penguin Books Ltd.
Sternberg, R.J. and Preiss, D.D. (eds) (2005). Intelligence and technology: the impact of tools on the nature and development of human abilities. London: Lawrence Erlbaum Associated Publishers.
Tallis, R. (2003). The hand: a philosophical inquiry into the human being. Edinburgh: Edinburgh University Press.
Tappan, M.B. (1997). Language, Culture, and Moral Development: A Vygotskian Perspective. Developmental Review, 17(1), p78–100 [online]. Available at: http://dx.doi.org/10.1006/drev.1996.0422 [last accessed 06 April 2018]
Vygotsky, L.S. (1978). Mind in Society: Development of Higher Psychological Processes. Cambridge, USA: Harvard University Press
Wartofsky, M.W. (1979). Models: representation and the scientific understanding. Dordrecht, Holland: D. Reidel. Publishing Company.
Williams, P.J., Wellbourne-Wood, S. (2006). Design for experience: a new rationale. Design and Technology Education: an International Journal, 11(2). Available at https://ojs.lboro.ac.uk/DATE/article/view/Journal_11.2_RES1 [Last accessed 06 April 2018]
Williams, P.J. and Stables, K. (eds) (2017). Critique in Design and Technology Education. Singapore: Springer Nature.
Wolpert, L. (2003) Causal belief and the origins of technology. Philosophical Transfers of the Royal Society London 2003 361, 1709-1719.