Analysing design and technology as an educational construct: an investigation into its curriculum position and pedagogical identity

Dawne Bell, David Wooff, Matt McLain and David Morrison-Love

ABSTRACT

The hierarchal status of academic disciplines, what defines valuable or legitimate knowledge and what should we teach our children is a topic of much debate. Amidst concerns of an academic decline, tackling the culture of low expectation and anti-intellectualism, the need to address social justice, and its by-product of cultural reproduction, is the focus of current education policy. Set within the UK, this paper presents a critical review of the literature relating to disciplinary knowledge and teaching and learning regimes, specifically seeking to explore the subcultures which exist between design and technology and its associated curricula counterparts that combine to produce science, technology, engineering and mathematics (STEM). The purpose being to proffer an explanation that is supportive in developing an understanding as to why design and technology is perceived by many to be of less value than its STEM counterparts. Situation within a functionalist approach to STEM education policy, findings are discussed in relation to design and technology, which as a subject is caught between the identities of academic and vocational exponents, and it is from this perspective that complex nature and perceived value of design and technology is explored.

KEYWORDS

STEM; subcultures; subject knowledge; pedagogic identity; curriculum development; curriculum theory; design and technology

Introduction

Drawing primarily upon the work of Biglan's (1973a, 1973b), Becher's (1994) and Bernstein's (1971a, 1971b, 1975) theoretical view of the curriculum, preparatory work by Bell (2015) sought to establish the position of design and technology as a curriculum subject of value within science, technology, engineering and mathematics (STEM) education.

As the study moves forward, theoretical framing is utilised to support an understanding as to why, as a curriculum subject integral to the development of STEM education, the seemingly persistent marginalisation of design and technology occurs.

In his controversial review of design and technology, Miller (2011), provides a piercing account of 'what' is wrong with design and technology. His work however stops short of offering an explanation that supports an understanding as to 'why' he has determined the state of design and technology to be in such a position.

Through a critical review of literature, the work presented here seeks to explore the significance of design and technology from the perspective of its own disciplinary and interdisciplinary subject subcultures. This is undertaken against a backdrop which considers its positioning within the wider context of the hierarchical relationships to its STEM subject counterparts.

Design and technology: a valid and valued subject?

In order to secure long term economic prosperity (Mitchell, 2015; Morgan, 2014a), in the United Kingdom (UK), as is the case in many other countries across the globe, a workforce equipped with 'high value' STEM skills are perceived as being crucial in maintaining a nation's competitiveness (Donelan, 2016; Heitin, 2014; Obama, 2013a, 2013b; UKCES 2015).

In line with many other countries, the UK has adopted a functionalist approach to STEM policy the focus of which is grounded in education and training (Bell, 2016). However, evidence would suggest that funding streams favour mathematics and science (Morgan, 2014a; The House of Lords Select Committee, 2012) rather than the other associated STEM disciplines of design and technology and engineering. This is replicated within university STEM funding streams (HEFCE, 2016), and within bursary funding for those embarking upon STEM subject Initial Teacher Education. In considering the latter, there is substantial variance within the identified need to recruit teachers to deliver individual subjects which fall within the definition of STEM disciplines. For those seeking to pursue careers in mathematics, physics, chemistry and computing, training bursary payments of up to £40,000 (DfE 2016a)

are available. Support for those training to teach engineering, or design and technology are less lucrative, with design and technology attracting a maximum bursary of £12,000 whilst those seeking to teach engineering find themselves unable to receive any bursary support in their endeavours.

This paper adopts the ontological premise that, created virtually overnight from a heterogeneous amalgam of hitherto individual subject disciplines, design and technology is an 'educational construct'.

Curriculum reform, along with educational policy (DES/Welsh Office, 1988, 1990), is the sole determinants responsible for the creation of design and technology as a curricular entity. Outside of the boundaries which define compulsory education, design and technology does not exist, but its constituent components which include; product design, electronic products and textiles technology do. This results in a lack of direct correlation to industry, and the world outside of education, which leads us to assert that the subject must be considered to be an educational construct; a subject which exists through an educational need, rather than one that dovetails neatly into a specialist field of further study, or a post graduate career.

Within the confines of an examination-based education system designed to measure a child's attainment upon their academic success, through its omission from the English Baccalaureate (EBacc) set of subjects (DfE, 2016b), design and technology has effectively been relegated to the confines of a subject considered to be less desirable and arguably non-academic by educational policy.

When coupled with publicly promoted rhetoric about valueless vocational subjects (Coe, 2010; Gibb, 2015; Morgan, 2014b), and the implications of university admission policy (Morrison, 2015, The Sutton Trust, 2000) which present design and technology as a subject of more limited suitability (Trinity College Cambridge, 2017), the value of design and technology as a worthwhile area of study becomes unclear.

It is from this perspective, and for this reason, that design and technology as a subject is evidently not fully appreciated or understood by those working outside of compulsory schooling, all of which contribute to its perception as it being a subject lower in status than its STEM, and EBacc, counterparts.

In seeking to undertake an exploration of design and technology, this paper is divided into three discrete sections. The first examines the complexities of design and technology, a curriculum subject positioned as being caught between academic and vocational interests. The second seeks to discuss the nature of design and technology through the lens of disciplines and interdisciplinary working practices. The third section explores conceptual and theoretical ideas around design and technology, linked to the notions of disciplinary hierarchical relationships situated

within the context of Biglan's typology of academic disciplines (Biglan, 1973a, 1973b) and knowledge territories (Becher, 1989; Becher & Trowler, 2001; Trowler, Saunders, & Bamber, 2012). Finally, the paper draws these areas together to develop conclusions.

Current education policy

Within the UK, the hierarchal status of academic disciplines, what defines valuable or legitimate knowledge, and what should we teach our children is a topic of much debate (Gibb, 2015; Morgan, 2016; Morris, 2012). Amidst concerns of an academic decline, tackling the culture of low expectation and anti-intellectualism, the need to address social justice and its by-product of cultural reproduction, is the focus of current education policy (DfE, 2016d, 2016e; Morgan, 2015).

Citing Freire (1972), Gibb (2015) is scathing of the disproportionately low number of pupils from disadvantaged backgrounds being entered for subjects which he identifies as being academic. Whilst acknowledging that vocational and technical disciplines are vital to future economic growth, referring to the Wolfe Report (2011a), he asserts that only by placing 'academic' subjects at the heart of the curriculum can we ensure a rigorous education for all:

> 'The body of academic knowledge belongs to everyone, regardless of background, circumstance or job'. Gibb (2015)

Accompanying the drive to improve academic attainment for all (Morgan, 2016), the government introduced the EBacc, and subsequently Progress 8, the former a measure designed to calculate and assess pupil performance and the latter an individual schools' effectiveness (DfE, 2016c). Introduced in 2010 (DfE 2016b; Long & Bolton, 2017), the EBacc is a school performance measure utilising grades from a group of specified individual subjects; English, mathematics, history or geography, science and a language, all curriculum subjects perceived by some to be academic (CapeUK, 2016). Further to this, the Department for Education (DfE, 2016b) made clear their intention that all pupils commencing secondary education from September 2015 are required to study the EBacc set of subjects at General Certificate of Secondary Education (GCSE) level (DfE, 2016b) as a starting point.

There has been speculation that under-performing schools have been relying on subjects of 'little academic worth' (BBC, 2012), and according to Gibb (2015) many schools encouraged pupils to pursue vocational qualifications with no, or even negative value in the labour market (ibid). Arguably this practice has been perpetuated since the introduction of school performance league tables in 1992 (HMSO, 1992). It is clear that initially there was an absence of controls to prevent schools from entering pupils into subjects which would afford them the highest

league table position, rather than necessarily being cognisant to the needs of each and every pupil.

> For a decade now we have steered hundreds of thousands of young people towards courses and qualifications which are called vocational even though employers don't rate them and which have been judged to be equivalent in league tables to one - or sometimes more – GCSEs, even though no-one really imagines they were in any way equivalent.
>
> Gove (2012)

This reaffirmed the view by policy-makers that young people were studying subjects in order to maximise the school's probability of gaining a higher position in the league tables based on undefined subject specificity, than would have occurred had the same pupils followed subjects perceived to be more academic in nature. This suggests that if pupils were able to study subjects they wished to pursue, it would lead to low standing for the school in performance tables. According to Gibb (2015), the pupils being let down are disproportionately from poorer social and economic backgrounds. As policy, perhaps to counter a necessity for all school's to commit to EBacc delivery, mechanisms including Progress 8 (DfE, 2016c), one could argue that this has been designed to restrict the continuation of this practice and prevent schools from delivering qualifications that afford them the most favourable results (Baker, 2007). However, as a consequence schools have lost their autonomy to deliver a bespoke, local curriculum designed to meet the individual needs of their pupils. The restriction of curricular freedom imposed by the EBacc seems at odds with one of the stated founding principles underpinning proposals for the mass academisation of schools throughout state education in England in Wales.

Design and technology: vocational or academic?

Supplementary to these changes there has been a subtle, yet significant shift, in the discourse around academic and vocational education. Traditionally, vocational education, within which some (Paechter, 1993) perceive the curriculum discipline of design and technology to reside, has been widely perceived as being job focussed, a route with inherent value that align to employment and a clear career trajectory. However, the linguistic associations in current use focus heavily upon those subjects perceived by the DfE as academic in nature, as being fundamental to an individual's ability to secure future economic prosperity (Gibb, 2015).

This rhetoric has led to pupils being steered and counselled against undertaking subjects which are considered to be creative and non-academic. With advice suggesting that the study of such subjects will limit their life chances (Gove, 2012, Morgan, 2014b), coupled with a warning that the study of arts based subjects at

school could ‘hold them [pupils] back for the rest of their lives’ (ibid). According to Wolf (2011b), the study of vocational courses does ‘…not do people any good’ (ibid), and she maintains that secondary age phase pupils ‘should not be making irreversible decisions’ which could result in doors being ‘slammed in their faces’ in later life (Wolf, 2012).

Following his review of vocational education, Sainsbury (2016) concluded that over 20,000 vocational courses currently in existence should be scrapped (Adams, 2016; Richardson 2016). Accepting all of Sainsbury’s recommendations in a recent speech, the right honourable Nick Boles, MP said: ‘…despite progress there are still some serious issues. Technical education remains the poor relation of academic education’ and he went on to outline plans to fully implement Sainsbury’s recommendations and scrap ‘thousands of ineffective courses’ (Boles, 2016; Department for Business, Innovation and Skills, 2016). Despite these proposed changes which would seek to improve vocational educational provision, the ‘stigma of vocational education often reduces it to a second choice to academia’ (Centre for Business and Economic Research in Coughlan, 2015).

The idea skills somehow exist independently of knowledge, and that skills and knowledge are in opposition to each other is a notion rebuffed by Reiss and Oates (2014) however the dominant discourse facilitates the continued perception that the study of vocational, skills based subjects is worthless. This is further compounded through the publication of research that would also suggest that subjects which sit outside of the EBacc are easier to attain higher grades in (Newbigin, 2015), and are, therefore, they are clearly of less value. A perception which is reinforced by the work of Coe (2010) who determined that it is easier to pass subjects perceived to be non-academic:

> Why would you do a hard subject like maths or science or a language when you could do an easier subject?.
>
> Coe (2010)

A common theme within sociological educational theory is the relationship between education, social mobility, transitions into higher education and the labour market (Bourdieu & Passeron, 1990; Giroux, 1983; Hirsch, Kett, & Trefil, 1988; Young, 1971). Historically, students from working class backgrounds have been excluded from accessing higher education, and despite over a decade of initiatives to raise aspirations and widen participation (Archer & Hutchings, 2000; Bowes et al., 2013; Lall, Morley, & Gillborn, 2003; Reay, David, & Ball, 2001; Thomas & Quinn, 2007), the number of students from this socioeconomic group transitioning into study beyond compulsory schooling remains stubbornly low (Archer, Hutchings, & Ross, 2003; Yorke & Longden, 2004).

Research has sought to explore the impact of increased diversity of qualification choice at secondary school (Van de Werfhorst, Sullivan, & Cheung, 2003), and in their work, Ball, Maguire, and Macrae (2000) document a link between the increase in diversity and the reproduction and reinforcement of class advantage (Bourdieu, 1971; Bourdieu & Passeron, 1990).

Theoretically, an increase in qualification choice at school should improve the breath of study for all pupils, and subsequently it should facilitate an improvement in the numbers of pupils accessing higher education. However, in practice, Ball et al. (2000) found that despite a significant increase in the variety of access pathways, students with higher levels of cultural capital (Bourdieu & Passeron, 1990) remain better able to navigate the diverse options available to them and successfully transition into further study.

These findings which indicate it is harder for those in a lower social class to access higher education are supported by recent work by Shields and Masardo (2015) who explored the differences in degree attainment of students entering higher education. In their work they examine the trajectories of students entering higher education with vocational qualifications and compare their achievements against those entering through more traditional A-level based routes. They determined that students entering higher education with vocational qualifications are less likely to achieve a first or an upper second class classification in comparison to their counterparts.

Whilst universities do not have direct control over the subjects taught within the secondary school age phase curriculum (Young, 1975), according to Becher and Trowler (2001), they [universities] do have a very clear 'consensus on what counts as a discipline and what does not'. Therefore, in order to enable the continuity of educational progression, it is logical to ensure that the qualifications studied at school are reflective of, and are intrinsically linked to those areas of study found within higher education. According to Which? University (2016), a number of universities actively and openly discourage students from studying what they consider to be too many practical, or vocational, subjects which they argue:

> may restrict what you can do later down the line at university, because some unis include these in lists of 'non-preferred' subjects.
>
> Which? University (2016)

Some universities go further, and classify individual subjects in a hieratical list, deeming some to be of a higher status than others, and relegating others to be considered as being less desirable. In one specific example, any A level qualification grounded within the field of design and technology is openly relegated to the status of a second-rate subject, a 'B' list qualification determined as one being of

‘more limited suitability’ (Trinity College Cambridge, 2017). Surprisingly, this direction remains continuous, even for entry to STEM related programmes of study including mathematics and science degree courses (Morrison, 2015; Which? University, 2016).

According to Paechter (1993), technology-based subjects are seen as ‘subjects which had a history of being of low status, non-academic, and mainly aimed at working-class and “less able” students’, and for those working within design and technology, this situation serves to strengthen resolve to establish the subject as being of academic worth rather than merely accept it as being vocational in nature (Morgan, Jones, & Barlex, 2013; O’Sullivan, 2013). This beseeches the question: if design and technology is not perceived to be academic and does not support entry to higher education, nor is it perceived as a qualification vital in supporting an individual to secure future employment, then what exactly is its worth and is there any intrinsic value in studying it?

Design and technology: an accessible pedagogy for the effective delivery of ‘STEM’?

Having considered the debate into the worth of the subject that is ‘design and technology’, it is important to consider if current opinion about its positioning is a consequence of how the subject has come into existence, or is it derived from opinion and anecdotal rhetoric? In order to do this, it is necessary to look at the early inception and developmental journey of the subject from its earliest routes as it is inconceivable that policy-makers envisaged the creation of a subject of less academic worth and status than others.

Individual curriculum subject disciplines (Pre 1988 DES/Welsh Office orders)	Design and technology subject disciplines (Current iteration 2016f)
Woodwork and Metalwork	Product Design
Needlework / Home craft	Textiles
Cookery / Home Economics	Food Technology
Technical / Geometric Drawing	Graphic Design
Business studies	Electronics / Systems and Control
Information technology	Engineering
	N.B. Computer Aided Design (CAD) and Computer Aided Manufacture (CAM) are integral to all areas and not discrete.

Table 1 Subject disciplines: Pre and post design and technology's inception.

Prior to 1988, in England and Wales, design and technology existed as a heterogeneous group of individual subject disciplines (Table 1). In creating a single [multi or interdisciplinary] subject, the government was clear to establish its curriculum content as a subject '… always involving science or mathematics' (DES/Welsh Office, 1988).

From this perspective, it could be argued that design and technology was created by a forward thinking government seeking to establish a vehicle through which science and mathematical principles and theories could be explored through practical application. A notion aligning with Young's (2016) concept of 'powerful knowledge' where the term curriculum (referring to subject knowledge) is context independent, and pedagogy refers to the mechanisms teachers employ to engage with the prior experiences of pupils in order to support them in gaining access to curriculum concepts.

Empowering and equipping young people with the skills necessary for knowledge transfer through the contextualisation of facts and concepts, this philosophical stance would support the effective development of an environment where children could become technologically literate, long before the concept of 'STEM' and the development of twenty-first century skills became a significant focus of global attention.

However, if this is the case, then why, with such concern over the future of development of STEM orientated literacies (Katsomitros, 2013; UKCES 2015), is design and technology's potential to contribute constantly overlooked and undervalued? Is this a lack of foresight by policy-makers to utilise a curricular vehicle at its immediate disposal, or the determination that in using design and technology in such a way is counter to their educational vision?

Since its inception (DES/Welsh Office 1988), design and technology has been increasingly marginalised within the school curriculum (Richard Green, quoted in Burns 2014), and within the context of STEM education, policy frequently focuses upon the subject disciplines of mathematics and science (Morgan, 2014a). Analysis of the recently revised design and technology curriculum (DfE, 2016f) illuminates a significant shift in the subject's position. The new curriculum orders make it clear that there is a requirement for design and technology to 'draw on disciplines' rather than to work with, or contextualise, them. Following examination of the latest curricular revisions for mathematics, science and computer science there is no similar articulation. This positions design and technology uncomfortably as a subject different to its STEM peers, seemingly without its own discreet set of knowledge and skills, which we argue lowers its standing as a discipline in its own right.

Since the amalgamation of the individual subject disciplines to create the multifaceted subject that we determine to be design and technology (DES/Welsh Office, 1988, 1990), there has been an absence of theoretical literature, and little or no effort to articulate the importance of design and technology as a subject within its own right. This deficiency in theoretical exploration has led to the failure of design and technology, as a subject, to establish a consensus which enables the categorisation of each individual subject discipline's knowledge, and subsequently, the capacity to identify a single common philosophy that transcends distinct subject divisions.

A significant part of the problem in understanding the nature of design and technology could be attributed to the pedagogy associated with its teaching. Despite operating under the umbrella of a single subject at Key Stage 3 (ages 11–14) since its inception, in practice, design and technology rarely meets this aspiration and its delivery is often through single material areas, as single subjects. This mode of delivery is commonplace and it reinforces the concept of individual subject disciplines, each holding on to their own body of knowledge and delivering it in their own established ways. Often the use of common, overarching, assessment criteria is the only way the subjects are drawn together. According to Morgan et al. (2013), this approach does not reflect the true nature of the subject, however, in the overwhelming majority of instances, it is the reality of the subject in practice. Paechter (1995) documents teacher experiences and explores the impact of early struggles within the subject for power and control, and the:

> retreat by some teachers and departments into the subcultures of their originating subjects and thus [move] further away from the integrated intentions of design and technology.
>
> Paechter (1995)

In the decades following her observations (ibid), this state of affairs has not changed, and as a consequence, a lack of development has led to entrenched opinions and an absence of agreement between those working within the field as to what exactly design and technology is (Morgan et al., 2013).

The reasons for this remain unclear, and could lie within the deep-rooted personal philosophies and fixed ideas by those charged with facilitating delivery of the subject in schools. This determination offers an explanation as to why there is reluctance for school leaders and teachers to surrender individual subject axiomatics in favour of teaching a multifaceted subject working in more than one defined material area at any one time.

A further reluctance by those engaged in the delivery of the subject, to teach design and technology at Key Stage 3 as a single disciplinary subject, could be

attributed to the curriculum arrangements for assessment at Key Stage 4 (ages 15–16). At Key Stage 4 in order to cater for the needs of GCSE examination qualifications, the subject is forcibly disaggregated back into its distinct subject disciplines, for example product design, electronic products, food technology and graphic products.

Over 20 years have passed since its inception and it is difficult to envisage how these entrenched practices can be reformed. Attempts are being made by policy-makers to tackle this, as evidenced by the latest curriculum iteration (DfE, 2015a; Ofqual 2015). From September 2017, policy-makers have sought to introduce a single design and technology GCSE designed to replace individual GCSE subjects. However, this excludes food technology, which in its most recent iteration has been renamed as 'Food and Nutrition', and consequently as a new subject it holds its own position as a discrete subject at Key Stage 4, divorced from the design and technology collective set of subjects for teaching from September 2016 (DfE, 2015b).

Further to this, most recent developments would suggest that discreet assessment in both electronics and engineering will also be introduced at GCSE Level (DfE, 2015c, 2016). A state of affairs which will only serve to cement the situation of separate subjects and in doing so it will do little to address, nor discourage those working within design and technology to deliver the subject as a single discipline during its compulsory phase.

Design and technology: discipline, interdiscipline or multidiscipline?

In the years since its creation (DES/Welsh Office, 1988, 1990), there has been little or no literature within the field to establish the disciplinary characteristics of design and technology, or to support the development of a shared pedagogical approach. Donald (2002, p. 8) defines the term 'discipline' as being:

> a body of knowledge with a reasonably logical taxonomy, a specialized vocabulary, an accepted body of theory, a systematic research strategy, and techniques for replication.
>
> Donald (2002, p. 8)

However, difficulties in defining what constitutes disciplinary, interdisciplinary or multidisciplinary conceptual differences are illuminated by Krishnan (2009) in his report for the Economic and Social Research Council. Whilst acknowledging the compelling argument behind interdisciplinary working, Krishnan (2009) explores the conceptual differences between cross disciplinary, multidisciplinary, supradisciplinary and transdisciplinary relationships between subjects, which he acknowledges are often incorrectly referred to as the same thing. Referring to

Moran (2002), he describes attempts to define the exact nature of an interdiscipline as 'vague' and so insufficient that they render the term 'almost meaningless'. He concludes that part of the problem is the lack of a clear working definition around the use of the term discipline, which appears to involve the crossing of a subject boundary, however where the boundary lies, and how and when it is crossed adds to the complexity of a clear definition.

Chynoweth (2009) specifically explores the difficulty of establishing a new interdisciplinary vocational subject area. Exploring the built environment, he asserts that as a consequence of its vocational orientation the theoretical nature of its academic knowledge base is poorly developed, an issue which is reflective of, and thus holds parallels with, the disciplinary development within design and technology. He goes on to state that true interdisciplinarity occurs only when individual disciplines surrender their discrete axiomatics, and collectively define themselves by reference to a single strategic axiomatic applicable to all.

Over four decades earlier, Jantsch (1972) described the transition from discipline to interdiscipline as taking place when individual disciplines are brought together to share a single focus, rather than reflecting their own individual disciplinary identities. Only then, through the presence of a shared axiomatic, epistemological integration is expedited, and a single hybrid subject with a common subject identity evolves. This is something which Klein (1990) later referred to as an 'interdiscipline'.

Working from definitions provided by Chynoweth (2009), Jantsch (1972) and Klein (1990, 1996, 2006), it is clear that over 25 years on from its original inception as a subject, design and technology has failed to establish itself as a single discipline. This perspective further supports the philosophy as to why as a subject, design and technology is not fully understood by those working outside of compulsory schooling, nor is it recognised as a field in its own right within the academic community and hence is perceived as subject lower in value than its EBacc (DfE, 2016f) and STEM counterparts.

Design and technology: positioning of an identity

In order to further support our understanding as to why design and technology is perceived to be a subject of lower status than its EBacc and STEM counterparts, this paper now moves to considers the classification and hierarchal status of academic disciplines.

The hierarchal status of academic disciplines, what counts as valuable or legitimate knowledge, and how best should that knowledge be imparted has long been a matter for debate (Biglan, 1973a, 1973b). Drawing upon the work of Kuhn (1962),

Biglan's research (1973a, 1973b) explores the organisation of subjects within higher education.

In his original work, Biglan (ibid) categorised 36 subject areas or disciplines, from which he created a typology of academic disciplines. In doing so, he created a structural framework through which disciplines could be compared, by using elements which he refers to as dimensions (Biglan, 1973a). The first is concerned with the degree to which subjects subscribe to a central body of theory, which is known as hard–soft. In this dimension, hard disciplines are concerned with knowledge adhered to by all subjects, whereas soft disciplines place greater emphasis on knowledge acquisition, content and method. The second dimension, known as pure-applied, is concerned with knowledge application. Finally, the third dimension is called life-non-life, and this categorisation supports the coding of human or other biological systems. In a subsequent study, Biglan (1973b) applied his newly defined dimensions onto academic departments having used his first study to introduce the classification system.

According to Biglan (ibid) within the hard/pure disciplines, there is a greater focus on knowledge application that adopts an atomistic approach that archetypally relies on facts and logic. Within those subject's disciplines considered to be soft/applied the focus places greater emphasis on reflective practice, personal development and knowledge acquisition, adopting a more holistic approach to the development of ideas, innovation, creativity and expression (Table 2).

	Hard		Soft	
	Life	Non-life	Life	Non-life
Pure	Botany Entomology Microbiology Physiology Zoology	Mathematics Physics Chemistry Geology Astronomy	Psychology Sociology Anthropology Political science	Philosophy Linguistics Literature Communications
Applied	Medicine Pharmacy Dentistry Psychiatry Agriculture Horticulture	Civil engineering Nuclear engineering Mechanical engineering Electrical engineering Computer science	Education Nursing Conservation Counselling	Economics Accountancy Finance Architecture Journalism Law Arts Dance Music

Table 2

Classification of disciplines, adapted from Biglan (1973a)

Within his typology (Biglan, 1973a, 1973b), the traditional, long established subjects of mathematics and science sit comfortably within the 'hard-pure' territories of knowledge, with engineering sitting firmly within the hard-applied dimension. However, as it did not exist at the time, Biglan's framework (ibid) does not classify design and technology.

Biglan's typology of disciplinary dimensions offers a heuristic device for examining disciplinary differences. A clear strength in his methodology is the way which he groups individual subject disciplines together based on their similarities, rather than their organizational structures. In doing so he created a typology of academic disciplines based on administrative structure, and in particular his 'pure versus applied' dimension provides a powerful elucidation of attitudes held by academics.

Applying the work of Biglan, 1973a, 1973b in his seminal work, Becher (1989) interviewed over 200 academics representing 12 disciplines and categorised their disciplines in terms of four basic properties: hard/soft and pure/applied in the cognitive realm; and convergent/divergent and urban/rural in the social (Tight, 2003). In subsequent work, Becher (1994), and later Becher and Trowler (2001), and subsequently Trowler et al. (2012) extended the research to explore the characteristics of disciplines, how academics perceive themselves, and how they rate co-workers working in subject disciplines other than their own. In doing so, Trowler et al. (ibid) conceptualised the link between the academic and disciplinary knowledge as the tribes [academic culture] and their territories [the discipline]. Although set within the confines of higher education, there are clear associations with the organisation of secondary age phase education. Although Becher and Trowler (2001) make clear:

> the steadily changing … nature of knowledge … makes it difficult to claim that any attempt at categorising it can be permanent and enduring.
>
> Becher and Trowler (2001, p. 38)

Empirical work undertaken through correspondence analysis by Simpson (2015) sought to test the validity of Biglan's classification scheme, and citing work by Stoecker (1993) and Drees (1982), findings would suggest that validity of the scheme is maintained when utilised to consider and classify previously unconsidered disciplines.

Utilising the same metrics and methods adopted by Simpson (2015) and employing Biglan's original frameworks (Biglan 1973a, 1973b), Bell's work (Bell, 2015) explores the link between the individual academic and disciplinary knowledge territories within design and technology.

Drawing consensus between the opinions of serving design and technology teachers, and university academics working within the field of design and technology teacher training, findings illustrate (Figure 1) the location where participant's engaged in the study (ibid) agreed that each individual discipline that encompasses the current iteration of design and technology [as defined under the national curriculum (DfE, 2016f)] could be positioned.

Bell's (2015) findings would suggest that it is impossible to position design and technology as a single disciplinary subject and within the context of Becher (1989, 1994), Becher and Trowler (2001), Biglan, 1973a, 1973b), and Trowler et al. (2012) work, from this perspective, it is easier to understand why those working within design and technology frequently have to justify the position their subject holds in relation to other subjects and even within the wider curriculum itself.

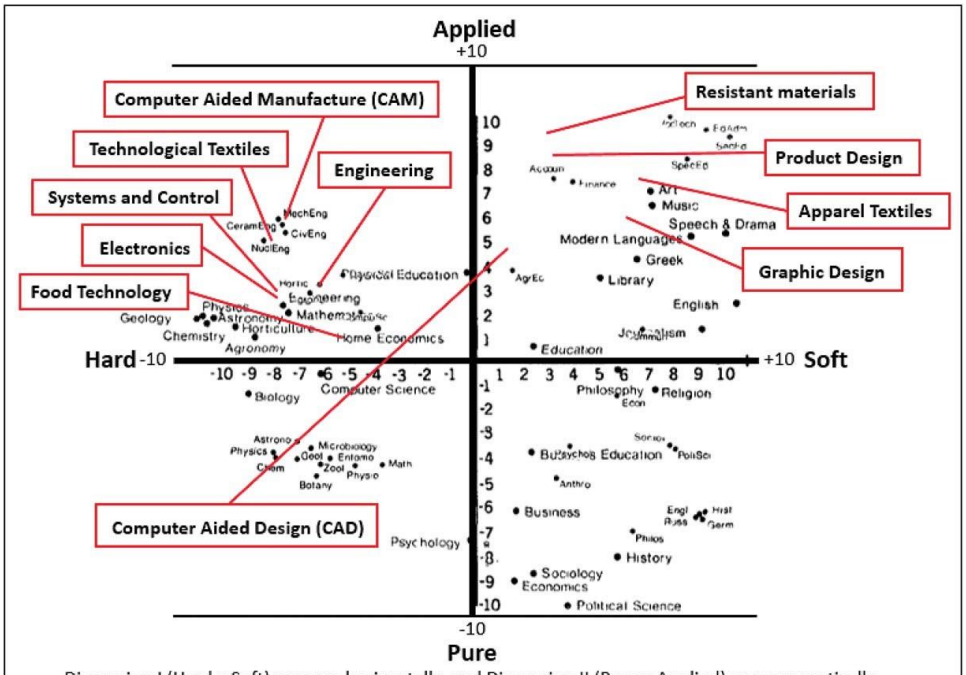

Figure 1. Knowledge territories within design and technology (Bell, 2015), adapted from Biglan's original typology (1973a, 1973b).

The hierarchical status of subjects within the school curriculum results from a welldefined, long established body of knowledge which remains consistent over time (Bernstein, 1971a, 1971b). This domination by subjects perceived to be more academic than others is reflective of current education policy (Abrams, 2012; Gove 2012), enacted through prevalent characteristics of the EBacc subjects, where arguably the pedagogical approach adopted by each means that framing of subject boundaries is also strong.

In stark contrast, arising because of design and technology's need to consistently embrace, adapt and accommodate change, the subject's physiognomies are distinctly different to other subjects [for example mathematics and science], where arguably curriculum content has remained unchanged for a number of years.

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 when compared directly with strongly framed subjects, such as mathematics and science, design and technology finds itself in a weaker position and seemingly at a distinct disadvantage (McGarr & Lynch, 2015).

Conclusions

Brought about by the need to consistently embrace and adapt to change in order to meet curriculum demands, whilst reflecting an ever advancing technological world, findings from this work suggest that it is design and technology itself, 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, this leads to design and technology as a subject being misunderstood and perceived to be lower in status than its well-established curriculum counterparts. In practice this means that those working to deliver the subject have to constantly justify design and technology's place within a hierarchy of well-established curriculum subject disciplines. This is in direct contrast to science and mathematics, which are classified as subjects with strong external boundaries typical of pure subject disciplines (Becher, 1994; Biglan, 1973a, 1973b). When presented as a single subject, with its nomadic vocational characteristics, design and technology manifests as a soft, applied subject (ibid) with weak, poorly defined external boundaries. Having ill-defined boundaries isolates design and technology from its counterparts both in the wider curriculum and within the context of STEM.

Prior to its inception (DES/Welsh Office, 1988, 1990), design and technology comprised of several individual subject disciplines, each with their own recognised body of knowledge. Through amalgamation each has been diluted, with individual subjects stripped of their unique identities. Whether defined as a discipline,

interdiscipline or multidisciplinary subject, design and technology is both complex and difficult, and like an awkward child it refuses to sit in one place. Coupled with a divergence of opinion surrounding what should be taught, this lack of clarity only serves to divide those working within design and technology, and in so doing, if indeed it ever had one, design and technology has lost its identity.

Whilst the application of theory has proven to be a useful tool to support a developing understanding as to why design and technology is perceived to be of less value than its EBacc and STEM curriculum counterparts, redressing this perception is considerably more of a challenge.

Within a curriculum that places value predominantly upon disciplines perceived to be 'academic', perceived by many to be 'vocational' in nature, in seeking to justify its place within the curriculum, design and technology has sought to establish knowledge and values that align with academic rather than vocational characteristics. However, there are inherent difficulties with this approach, not least of which is the inability to separate academic attributes from those which manifest, and are integral to, vocational subjects. Specifically, within design and technology this is further compounded by a struggle for effectual delivery of a uniquely creative process within the confines of an assessment focused curriculum, which blurs the boundaries of the subject even further.

The development of lateral thinking, and communication, are essential transferable skills which are easily developed through the study of design and technology. By removing the opportunity for children to experience the real-world application of STEM subjects, as they do through the study of design and technology, there is a genuine risk that these same students will not pursue STEM subjects at a higher level. Even for those not wishing to pursue further study, this potential curricula omission is particularly significant for those who struggle to contextualise mathematics and science in real-world situations.

As an interdisciplinary subject, design and technology has demonstrated clearly its ability to continually adapt, and this has been an underlying strength of the subject since its inception. In teaching, how something is learnt can be as important as what is being taught. Utilising knowledge can be likened to using tools, both are only to be completely understood through their use (Perkins, 1986). One can study theory and memorise facts, but until they are used in practice one cannot truly understand the meaning and value behind them.

In a complex world of social and economic change, perhaps more so than ever before, in order to help prepare our children for the twenty-first century, there is a need to ensure that all are equipped with skills which are transferable. In practice, this means reviewing and redefining subject boundaries and exploring the development of a truly interdisciplinary curriculum. In viewing the individual STEM

disciplines of mathematics and science as building blocks, only when they are assembled is something of value constructed. From this perspective, where learners are provided with the opportunity to apply knowledge through practical skills, they are able to cultivate their ability to solve problems, and in doing so become adept in thinking across subject boundaries (Saunders, 2006), within this context it is clear that design and technology has real curricular value.

Rooted in an effective and accessible pedagogy, design and technology, presents an effectual way for all pupils to access the STEM curriculum. This is achieved through the provision of opportunity for the application of theoretical knowledge in an educational context, one that by default supports equitable access for all learners. In order to move forward and facilitate the subject's development, further work, to define design and technology and establish its identity as a subject of inherent value is required.

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