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Towards a signature pedagogy for design and technology education: a literature review

Matt McLain[1]

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Abstract
Drawing on the work of Lee Shulman, this article reviews literature exploring the concept of signature pedagogies, which are described as having have surface, deep and implicit structures. These structures are complex and changing; concerned with habits of head, hand and heart. Emerging from professional education and now being explored in STEM and Humanities education, they are characteristic forms of teaching and learning that are common across a sector. Common themes emerge from within a range of disciplines including art, built environment, design, music, religious, social work and teacher education. These include the roles of the curriculum, the teacher, the learning environment, as well as capability, uncertainty and the challenges associated with signature pedagogies. Focusing on literature from design education, the paper explores the nature of signature pedagogy in design and technology, as a tool for professional discourse. The conclusions propose a discursive framework for design and technology education in which the structures are tied together by the three fundamental activities of ideating, realising and critiquing; more commonly thought of as designing, making and evaluating. The deep structure being project-based learning, undergirded by the implicit values and attitudes associated with design thinking; including collaboration, creativity, empathy, iteration and problem solving. Design and technology education has something unique to offer the broad and balanced curriculum through its signature pedagogies and the way that knowledge is experienced by learners.

Keywords Design and technology education · Literature review · Shulman · Signature pedagogies

Introduction

Drawing on Erik Erikson's insight on nurseries as a window to culture, Shulman (2005a) drew parallels between the professions and professional education; coining the term signature pedagogies. Like a signature is an individual's mark, proving her or his identity, pedagogical signatures are "characteristic forms of teaching and learning" (p. 52). Shulman

✉ Matt McLain
m.n.mclain@ljmu.ac.uk

[1] Liverpool John Moores University, IM Marsh Campus, Barkhill Road, Liverpool L17 6BD, UK

argued that pedagogical signatures revealed much about a field's "personalities, dispositions, and cultures" (p. 52). Whilst he does not unpick the meaning of each of these terms in detail, one might infer that in a disciplines unique approaches an observer might see more than a simple set of cognitive or behavioural phenomena, but rather a microcosm of the wider discipline—including its assumptions and biases.

Shulman (1986) is also known for his work on pedagogical content knowledge, commonly known as PCK. As distinct from signature pedagogies, PCK focuses on the interaction between content knowledge and pedagogical knowledge, including teachers' awareness of the most effective ways of teaching certain content and potential misconceptions that learners commonly experience. PCK is a useful tool for recognising the complexities of teacher knowledge and the link between curriculum content and pedagogical methods, whereas signature pedagogies focuses on the shared assumptions and practise in the wider educational communities, beyond the individual classroom or institution. Signature pedagogy is concerned with what is at the heart of a discipline, as exemplified by how subject teaching is framed at the macro level. It also amplifies the tensions between curriculum and pedagogy, whereas PCK seeks to resolve them.

Shulman drew on observations of teaching in a range of disciplines—including medicine, law and design—identifying three critical aspects of learning to *think*, learning to *perform* and learning to *act with integrity* in professional work. Different professions attend to some of the aspects more than others, but he highlighted the need for balance. Signature pedagogies are concerned with more than understanding a field, but to behaving in a capable (performing) and ethical (acting with integrity) manner. This literature review explores the developing dialogue within professional learning domains, using Shulman's framework for signature pedagogies.

Since its introduction, signature pedagogies have been, increasingly, explored beyond the original boundaries of professional learning. In fact, Shulman postulated that both the liberal arts and science would benefit from a "careful consideration of the pedagogies of the professions" (p. 58). Signature pedagogies should not be considered in terms of binaries, such as correct or incorrect, good or bad. Neither are they timeless and unchanging, although they are as difficult to change as the metaphorical oil tanker is to stop or turn! Signature pedagogies have evolved over time in attempts to bridge the gap between theory and practise, but the *conditions* (e.g. forms and environments of practise) and the *technologies* (e.g. affordances facilitated by new tools and techniques) of professions change over time; sometimes requiring that pedagogical approaches adapt and change to reflect the new educational or societal landscape. Whilst change threatens disciplinary coherence, it also presents opportunities for both professional learning and general education.

A signature pedagogy is the centre of instruction, and is pervasive across a discipline, but does not preclude other forms of teaching and learning. They are common approaches concerned more with application of knowledge, than its acquisition as a commodity in its own right. There is a tension between pedagogical signatures and curriculum content; their aims differ subtly, but they cannot exist in isolation. Furthermore, signature pedagogies are concerned with more than the instructional methods employed by the teacher and purposeful activities engaged with by learners. They impact, and are impacted by, the learning environment, including the physical (and increasingly virtual) spaces where teachers and learners meet. Whether it be in a school or a university context, an observer will note how the environment alters the way that teachers and learners interact—be it in a practical space such as a science laboratory or design studio, a dialogic space for whole class or group discussion, or the more traditional classroom arrangement with learners in rows facing the teacher. The learning shapes the environment and vice versa.

In addition to the dispositions of head (thinking), hand (performing) and heart (acting with integrity) that signature pedagogies seek to develop in learners, Shulman described three structures within them: *surface*, *deep* and *implicit*. These structures provide a framework for educators to examine pedagogy beyond the *surface* activities observable in the classroom (such as demonstration or product analysis in design and technology), to the *deep* assumptions about how best to "impart a certain body or knowledge or know-how" (p. 55) and *implicit* beliefs, attitudes, values and dispositions in a discipline's moral framework (Table 1). There is a parallel to the three dimensions of thinking, performing and acting with integrity, with certain similarities between surface, deep and implicit structures—such as the moral imperative implied by the latter point on each list. However, on closer inspection equating surface with thinking and deep with performing does not fit with Shulman's overall thesis. Rather, the former dimensions (think-perform-act) are concerned with the learning intentions and the latter (surface-deep-implicit) with the nature of signature pedagogies.

Shulman presents a framework with flexible boundaries, for educators to engage with disciplinary pedagogical routines; to understand and promote, or to challenge and change them. This paper reviews literature on signature pedagogies from the past two decades, with the aim to explore how the concept is applied in different disciplines. In particular, it will focus on the implications for design and technology (D&T) education.

D&T has experienced a turbulent upbringing since its conception in the 1980s, birth and infancy in the 1990s, where the previously standalone and gendered subjects of craft, design & technology and home economics were brought together with business studies and information technology in the National Curriculum for England (DES/WO, 1989). This curriculum innovation, drawing historic craft disciplines and attempting to rebrand them under the auspices of design, has since been developed and reinterpreted in various curricula around the world. In particular, the interest in so-called twenty first century learning has encouraged the adoption of design-based learning in many OECD countries and key partners.

> "To prepare for 2030, people should be able to think creatively, develop new products and services, new jobs, new processes and methods, new ways of thinking and living, new enterprises, new sectors, new business models and new social models. Increasingly, innovation springs not from individuals thinking and working alone, but through cooperation and collaboration with others to draw on existing knowledge to create new knowledge. The constructs that underpin the competency include adaptability, creativity, curiosity and open-mindedness." (OECD, 2018, p. 5).

The early 2000s saw General Certificate of Secondary Education (GCSE) entries rise to almost 70% of 16 year olds in the United Kingdom, until 2004 when the subject ceased to be compulsory for 14–16 year olds. This was followed by a steady decline to below 15% in

Table 1 Surface, deep and implicit structures of signature pedagogies (Shulman, 2005a, 2005b, pp. 54–55)

Surface structure	"…concrete, operational acts of teaching and learning, of showing and demonstrating, of questioning and answering, of interacting and withholding, of approaching and withdrawing…"
Deep structure	"…, a set of assumptions about how best to impart a certain body of knowledge and know-how…"
Implicit structure	"a moral dimension that comprises a set of beliefs about professional attitudes, values, and dispositions…"

2019. Whilst design and technology education flourishes around the world, in England it finds itself in a somewhat strange and hostile environment.

In addition to the complex and political climate in England for the school curriculum (Spielman, 2019), the creation of design and technology in the late 1980s, now resembles Frankenstein's monster; a well-meaning effort by its creators to enact a technologically modern curriculum, that has become misunderstood and interpreted, feared and maligned. Others have documented D&T's origins and development (e.g. Atkinson, 1990), the challenges it has faced defining itself (e.g. Bell et al., 2017) and the tensions between knowledge and action (e.g. McLain et al., 2019). The intention here is to discover what the literature has to tell us that might help to identify the subject's signature pedagogies and its place in the school curriculum; and develop a discursive framework for design and technology educators to explore (and innovate) pedagogical approaches.

Research design

Reviewing research and theorising literature on signature pedagogies (McEwen, 2018), this article explores the research questions:

- RQ1: How do academic disciplines conceptualise signature pedagogies in research literature?
- RQ2: What can design and technology education learn from how design is taught in higher education?

The sample of articles were selected from the British Education Index (EBSCOHost), using the search term "signature pedagogies" in academic journals for the period 2000–2020. The search returned 21 papers, excluding those written by the author (McLain, 2017, 2019); 6 of which identified 'signature pedagogy' or 'signature pedagogies' in the title, 18 in the abstract and 11 in the keywords—only one article only mentioned the term in the main body of the paper (Table 2).

The disciplines represented ranged from Social Work (n = 4) to Religion (n = 1), the majority representing professional preparation (Table 3).

The majority of papers (n = 17) also represented learning in Higher Education (HE), with only four relating to learning in the primary and secondary phases of education (Table 4); although some papers written in the HE context also focus on Teacher Education and relate to beginning or experienced education professionals in the primary or secondary sectors (Parker et al., 2016; Totterdell et al., 2011; Weiß et al., 2014).

After the initial coding of articles, a smaller sample of 11 were identified as directly relevant to the research question RQ1 (Boling et al., 2013; Caldwell et al., 2016; Domakin, 2014; Hall & Thomson, 2017; Love & Barrett, 2019; Noel & Liub, 2017; Osmond & Tovey, 2015; Parker et al., 2016; Peel, 2011; Robinson, 2015; Thomson & Hall, 2015). A variety of approaches were adopted by the authors in this sample, with 7 identifying at least one research method (Table 5). Two were written as editorials to a journal edition (Peel, 2011; Robinson, 2015) and offered a useful perspective. The last two articles in final sample (Osmond & Tovey, 2015; Thomson & Hall, 2015) were included as directly relevant to the second research question (RQ2), focusing on implications for design and technology education.

Table 2 Reference to 'Signature Pedagogy' or signature pedagogies'

Location	No.	Citation
Title	6	Love and Barrett (2019), Lynch et al. (2019), Parker et al. (2016), Schrand and Eliason (2012), Peel (2011), Hyland and Kilcommins (2009)
Abstract	18	Love and Barrett (2019), Lynch et al. (2019), Hall and Thomson (2017), Noel and Liub (2017), Caldwell et al. (2016), Parker et al. (2016), Spronken-Smith et al. (2016), Osmond and Tovey (2015), Sowbel and Miller (2015), Thomson and Hall (2015), Domakin (2014), Weiß et al. (2014), Boling et al. (2013), Asghar (2012), Schrand and Eliason (2012), Zambo and Isai (2012), Totterdell et al. (2011) and Hyland and Kilcommins (2009)
Keywords	11	Love and Barrett (2019), Kay and Curington (2018), Hall and Thomson (2017), Caldwell et al. (2016), Parker et al. (2016), Thomson and Hall (2015), Domakin (2014), Weiß et al. (2014), Asghar (2012), Schrand and Eliason (2012), Hyland and Kilcommins (2009)
None	1	Robinson (2015)

Table 3 Focus of article

Discipline	No.	Citation
Social Work	4	Lynch et al. (2019), Kay and Curington (2018), Sowbel and Miller (2015) and Domakin (2014)
Art	3	Hall and Thomson (2017), Thomson and Hall (2015), Boling et al. (2013)
Teacher Education	3	Parker et al. (2016), Weiß et al. (2014), Totterdell et al. (2011)
Build Environment	2	Caldwell et al. (2016) and Peel (2011)
Lecturing	2	Asghar (2012), Schrand and Eliason (2012)
Design	2	Noel and Liub (2017) and Osmond and Tovey (2015)
Doctoral	1	Zambo and Isai (2012)
Geography	1	Spronken-Smith et al. (2016)
Law	1	Hyland and Kilcommins (2009)
Music	1	Love and Barrett (2019)
Religion	1	Robinson (2015)

Table 4 Phases of education

Phase	No.	Citation
Primary	2	Noel and Liub (2017) and Thomson and Hall (2015)
Secondary	2	Hall and Thomson (2017) and Robinson (2015)
Higher	17	Love and Barrett (2019), Lynch et al. (2019), Kay and Curington (2018), Caldwell et al. (2016), Parker et al. (2016), Spronken-Smith et al. (2016), Osmond and Tovey (2015), Sowbel and Miller (2015), Domakin (2014), Weiß et al. (2014), Boling et al. (2013), Asghar (2012), Schrand and Eliason (2012), Zambo and Isai (2012), Peel (2011), Totterdell et al. (2011) and Hyland and Kilcommins (2009)

Table 5 Research approaches

Approach	No.	Citation
Case Study	4	Love and Barrett (20,190, Hall and Thomson (2017), Caldwell et al. (2016) and Boling et al. (2013)
Interview	2	Love and Barrett (2019) and Hall and Thomson (2017)
Literature Review	2	Noel and Liub (2017) and Parker et al. (2016)
Observation	2	Love and Barrett (2019) and Hall and Thomson (2017)
Action Research	1	Caldwell et al. (2016)
Documentary	1	Boling et al. (2013)
Questionnaire	1	Domakin (2014)

The inclusion criteria were applied using a 10-point scale to score each article, which included:

- explicit mention of 'signature pedagogy' (full or truncated) in the title, abstract and keywords [3-points]
- relevance to compulsory aged schooling in the primary or secondary phases [2-points]
- disciplinary alignment to design and technology [3-points]
- qualitative evaluation of relevance to the research questions [2-points]

The 11 articles with a score of 5 or more were included in this review. The articles were coded using NVIVO 12 (QSR, 2020). The selected articles were initially analysed using open coding, to identify relevant themes. These codes were then reviewed and combined into four broad themes relating to signature pedagogies (RQ1) and four sub-themes related specifically to design education (RQ2), which are explored below.

Key themes from literature

The introduction explored Lee Shulman's framework for signature pedagogies. This section explores key themes that emerge from literature, concerned with signature pedagogies in general. The subsequent section explores the themes that specifically relate to design, and more particularly design and technology education. Shulman was clear that signature pedagogies, on balance, have a positive effect on learning, forming "habits of mind, habits of heart, and habits of hand" (p. 59). However, it is important not to assume that a signature pedagogy is either a 'good' or a 'bad' thing, but merely a characteristic of educational practises beyond the individual institution. Common practises in disciplinary education may become unsuitable over time, due to changing circumstances. Hyland and Kilcommins (2009) critique flaws in Shulman's assertion that the case method used in legal education was its signature pedagogy, drawing attention to the gap between theory and practise, common to most professional learning. However, they describe the notion of signature pedagogies as an "excellent heuristic device, producing questions and interpretations that can in the course of time be subject to comprehensive debate and analysis" (p. 39). The review of key themes from literature, below, is presented as a contribution to wider and continuing professional dialogue between educators.

The themes from literature are presented below in relation to the two research questions outlined in the previous section. First, themes emerging from how signature pedagogies are written about across a range of disciplines, in the primary, secondary and tertiary phases (RQ1). Second, the implications for design and technology education from literature relating to how design is taught in higher education (RQ2).

How do academic disciplines conceptualise signature pedagogies in research literature?

The themes from literature are discussed under four headings: 'three locations', capability, uncertainty and challenges for signature pedagogy.

Three locations

The focus of signature pedagogies, as represented in literature, reveals a tension between three 'loci' of learning: the curriculum, the teacher and the learning environment. These offer lenses through which signature pedagogies are discussed in the literature. Hall and Thomson place pedagogy in a wider context, including curriculum and assessment in addition to teaching methods, and encompassing "relationships, conversations, learning environments, rules, norms and culture" (2017, p. 108). Relationships and conversations involving teachers and learners, with learning environments being inextricably linked to the idea of 'place', with the associated routines and characteristics of both classrooms and their wider institutions.

Discussing the placement as a signature pedagogy in social work, Domakin (2014) sees practise as an important means of focusing on the individual's learning; and underlines that signature pedagogy starts with application of knowledge as an essential vehicle for understanding theory. Furthermore, the literature highlights the need to focus primarily on practical and experiential ways of knowing (Noel & Liub, 2017; Osmond & Tovey, 2015; Robinson, 2015). Signature pedagogies are intended to support learners in the transition from student to practitioner (Love & Barrett, 2019; Osmond & Tovey, 2015), and whilst it is recognised that a minority of students studying any particular subject in school will enter into a directly related career, they are different to transferable skills (Robinson, 2015). Returning to Shulman's three dispositions, discussed in the introduction, it could be argued that subjects in the curriculum offer learners different ways of thinking, performing and acting with integrity.

Signature pedagogies engage learners and teachers in complex and conflicting roles. Evolving from the master/apprentice relationship, where learners are guided by an expert, there may be a tendency to focus overly on the role of the teacher (Caldwell et al., 2016). However, there is general agreement that both the learner and the teacher play a crucial role in modelling and dialogue (Love & Barrett, 2019; Noel & Liub, 2017) with relationship being central to signature pedagogies (Love & Barrett, 2019; Noel & Liub, 2017; Caldwell et al., 2016; Osmond & Tovey, 2015; Peel, 2011). A key element of this relationship is feedback, particularly that which is informal and immediate, such as what Caldwell et al. (2016) describe as a 'desk crit'—where the teacher and learner engage in a critical discussion about a live project (in this instance related to architecture). Boling et al. (2013) acknowledge the complexity of the multiple roles of the teacher, who must carefully tread a path between coach and judge, and the affect that this can have on building trusting relationships. Signature pedagogies are often described as being in tension between teacher and learner led approaches.

In design education, the importance of the design studio as a formative 'place' where the activity is mediated by how students work and interact with their peers and their tutors (Love & Barrett, 2019; Noel & Liub, 2017; Caldwell et al., 2016; Osmond & Tovey, 2015; Boling et al., 2013; Peel, 2011). The studio represents a liminal space between the theoretical and the practical aspects of the discipline. They situate learning and are key to signature pedagogies (Caldwell et al., 2016; Boling et al., 2013), active spaces involving "making and talking" (Caldwell et al., 2016, p. 1359). In both social work and teacher education, the site of the signature pedagogy of placement is outside of the 'classroom' (Domakin, 2014; Parker et al., 2016), in music it can be a concert hall (Love & Barrett, 2019) or in art it may be adapted spaces in schools (Hall & Thomson, 2017). Wherever the place of signature pedagogy may be, the culture afforded by

and engaged with in that space is important (Hall & Thomson, 2017; Osmond & Tovey, 2015). Discussing design education, DiGano et al. (2009, Ch. 8) suggest that "studio classrooms (e.g., laboratories, workshops, and ateliers) can produce disconcerting and even revelatory learning experiences", reflecting on the impact of different spaces learning environments and potential for cognitive dissonance, including uncertainty.

Capability

One of the most prevalent themes in the literature relates to the perceived gap between theory and practise experienced by students (Love & Barrett, 2019; Hall & Thomson, 2017; Noel & Liub, 2017; Parker et al., 2016; Osmond & Tovey, 2015; Robinson, 2015; Domakin, 2014; Peel, 2011); an experience often shared with professionals involved with mentoring students on work placements in teacher education (e.g. Parker et al., 2016) and social work (e.g. Domakin, 2014). There is a focus on application of knowledge and development of capability as an important feature of signature pedagogies.

Signature pedagogies emerge over time, often centuries, through practical apprenticeship, with learners progressing through a hierarchy of knowledge, skill and value (Love & Barrett, 2019; Osmond & Tovey, 2015; Peel, 2011). Professional bodies of knowledge include traditions that may have been relevant at one time, but do not have the same resonance today. As practises and technologies change over time, the focus on knowledge in (and for) action creates a challenge when attempting to define curriculum content for disciplinary learning based on so-called timeless concepts. Osmond & Tovey postulate that signature pedagogies move "the emphasis away from the content of the curriculum and explores the importance of practical, embodied and experiential ways of knowing" (2015, p. 50).

In a range of disciplines, from social work to teacher education, there are concerns about a divide between theory and practise; exacerbated by the physical and temporal distance between university and placement, as well as the conceptual and philosophical distance between academics and practitioners. Universities are concerned about an over emphasis on practise and students becoming uncritical of "the culture of the organisation in which they are placed" (Bellinger, 2010, p. 602, in Domakin, 2014). Parker et al. (2016) and Domakin (2014) discuss the importance of bridging the theory/practise divide and connecting the domains of learning. However, whilst practise is at the centre of signature pedagogy, practise alone is insufficient for the education of both teachers and social workers. Whilst the issue of the physical gap between the sites of theorising and practicing are not directly relevant to how theory and practise are addressed in the design and technology classroom, the literature does highlight the tension between the two and the importance of practise as a key location for signature pedagogy. Literature on the nature of knowledge in design and technology focuses on capability and knowledge for action (e.g. Hardy, 2021; Kimbell, 2018; McLain et al., 2019).

Uncertainty

A common theme that comes through from Shulman through to the more recent literature, is the emotional nature of disciplinary learning (Love & Barrett, 2019; Noel & Liub, 2017; Caldwell et al., 2016; Osmond & Tovey, 2015; Peel, 2011), often related to the ambiguous nature of 'signature' learning activities (Love & Barrett, 2019; Noel & Liub, 2017; Caldwell et al., 2016; Osmond & Tovey, 2015; Parker et al., 2016; Boling et al., 2013).

This ambiguity is described as deliberate uncertainty inherent in professional learning and essential in the difficult processes of bridging the theory-practise divide. In fact, Shulman has made the bold statement: “no emotional investment, no intellectual or formational yield” (Shulman, 2005b, p. 22, in Love & Barrett, 2019). Problems set in design education, for example, often entail ill-defined or so-called ‘wicked’ problems (Noel & Liub, 2017; Caldwell et al., 2016; Osmond & Tovey, 2015); a wicked problem being defined by Rittel as a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (in Churchman, 1967). This uncertainty and apparent chaos extends to complex and specialist learning environments (Love & Barrett, 2019; Caldwell et al., 2016; Domakin, 2014; Boling et al., 2013), as well as the dialogic nature of both learning (Caldwell et al., 2016) and knowledge (Parker et al., 2016). Uncomfortable emotions or fear, anxiety and stress are associated with signature pedagogies in the literature (Love & Barrett, 2019; Noel & Liub, 2017; Caldwell et al., 2016), as prompted by Shulman (2005b).

The reported benefits of this uncertainty include the development of resilience and empathy (Noel & Liub, 2017; Caldwell et al., 2016; Peel, 2011). Grappling with uncertainty in learning develops agency and confidence when engaging with more challenging projects (Hall & Thomson, 2017; Noel & Liub, 2017; Osmond & Tovey, 2015). A role of the teacher is to support learners “to tolerate great risk along the journey” (Shreeve, 2015, in Noel & Liub, 2017, p. 6); risk-taking and creativity are associated with signature pedagogies (Love & Barrett, 2019; Noel & Liub, 2017; Osmond & Tovey, 2015). The deliberate disequilibrium introduced by teachers (Parker et al., 2016) and imperfect learning environments that have one foot in the school and one in the workplace (Love & Barrett, 2019) follow on from the theme of ‘locations’, exploring where signature pedagogies ‘happen’.

Challenges

> “Studio models of teaching and learning require a lot of time and space, making them difficult to justify in times when budgets and student–teacher ratios are shrinking… and students report difficulties navigating the studio environment.” (Boling et al., 2013, p. 180).“Studio models of teaching and learning require a lot of time and space, making them difficult to justify in times when budgets and student–teacher ratios are shrinking… and students report difficulties navigating the studio environment.” (Boling et al., 2013, p. 180).

In addition to the temporal, spatial and fiscal issues attested to by Boling et al., when considering the role of the design studio in signature pedagogies for design, there are also conceptual challenges to overcome. Caldwell et al. (2016) discuss the difficulties associated with asserting rigour in applied learning and its competing priorities. Similarly, Domakin (2014) highlights the challenges of reconciling practise-based and university-based learning, as discussed above. Furthermore, signature pedagogies should not be automatically accepted as necessarily effective or desirable, without scrutiny and critique. There may be entrenched and siloed practise (Peel, 2011) that may no longer be relevant or current, and practitioners may focus on the means of realising or communicating key ideas rather than the creative content, such as the conventions of musical notation rather than the compositions themselves, in music education (Love & Barrett, 2019). There appears to be a tendency to let cognitive learning dominate practical learning. Additionally, Osmond and

Tovey (2015) comment that a focus on assessment over creativity may lead to a lack of confidence.

Shulman had previously commented on the implicit aspects of signature pedagogies and how they can adapt organically over time and become "compromised" (2005, p. 57). Therefore, rather than to define (or confine) practise, using the notion of signature pedagogies as a tool to engage in professional dialogue may provide educators with opportunities to make the implicit explicit, visible and open to scrutiny. Thus addressing and overcoming some of the challenges, real or perceived.

Having considered the first research question (RQ1: How do academic disciplines conceptualise signature pedagogies in research literature?), there is a developing interest in the notion of signature pedagogies. This interest is predominantly from Higher Education, with some interest from creative and practical subjects in schools. Having emerged from Shulman's studies in professional learning, there is also a growing interest beyond STEM disciplines to the Humanities (Robinson, 2015) and the Arts (Hall & Thomson, 2017). As a subject that appears to have one foot in STEM and the other in the Humanities (McLain et al., 2019), the next section will begin to focus on the second question (RQ2: What can design and technology education learn from how design is taught in higher education?), by exploring four sub-themes from literature related to design education, as an analogue to D&T in schools.

What can design and technology education learn from how design is taught in higher education?

This section discusses the implications of the literature on signature pedagogies for D&T, as a subject defined by the National Curriculum (NC) and taught in primary and secondary schools in England (DfE, 2013). The NC identifies the key activity in D&T as designing and making, adding what pupils should be taught about evaluation and technical knowledge. As a relatively new subject, D&T has struggled to reveal its axioms (Bell et al., 2017) and define itself (McLain et al., 2019). The term signature pedagogy has only recently been used in research literature in the field. For example, Stables (2020) focuses on signature pedagogies for the future and McLain (2017, 2019) on the established pedagogy of demonstration. In the later article, McLain questions whether demonstration was a true signature pedagogy of D&T, which may indeed be part of the 'surface structure' described by Shulman; as a teaching method that contributes to, but does not stand alone as, a signature pedagogy. Stables, on the other hand, looks forward to future D&T pedagogies with a framework for speculation. Should D&T's axioms—"anchoring claims that stand in no need of justification" (Fosl & Baggini, 2020, p. 31)—be revealed, then one might expect there would be a strong alignment with its signature pedagogy (or pedagogies).

As outlined above, signature pedagogies have surface, deep and implicit structures, and they are 'located' in the curriculum, the teacher and the learning environment. Therefore, one must not expect a simple or straightforward definition, but rather, differing facets of praxis (theory and practise). Four of the 11 articles from this literature review are design related disciplines: build environment (Caldwell et al., 2016; Peel, 2011) and design (Noel & Liub, 2017; Osmond & Tovey, 2015). A further three focus on art education (Boling et al., 2013; Hall & Thomson, 2017; Thomson & Hall, 2015) and others refer to aspects of design education as part of their scoping of signature pedagogies within their fields. From these articles, four sub-themes emerge relating to design education: design thinking, the design studio and the design 'crit', all of which interrelate, typically, in the design project.

Design thinking is a relatively new term that has permeated business and industry. Referring to the work of Dorst (2015) and Cross (2011), Noel and Liub (2017) state that designers' thinking is different to that of other professionals. Caldwell et al. (2016) refer to as logical, spatial and formal; Noel and Liub (2017) as empathetic, collaborative, creative, problem-based, human-centred and iterative, and Osmond and Tovey talk about it as "solutioning" (2015, p. 50). Thought and action cannot be separated in design 'thinking', which aligns with the theme of *capability* from the literature, discussed above. It sits in that uncomfortable space between theory and practise, although Osmond and Tovey (2015) emphasise that design thinking is more about acting than about remembering specialist knowledge. It is, therefore, more difficult to articulate and represent the rigour of design thinking (Caldwell et al., 2016).

The *design studio* is an established feature of many design courses in Higher Education. They can appear "chaotic to an observer or *novice"* (Boling et al., 2013), but are drawn together through narrative between the teacher and learners, as well as peer-to-peer between learners themselves. Unlike in the school setting, university students on design courses are often assigned a studio space where they can work alongside students in different years, in both formal and informal learning. Whilst studio learning is seen as transformational, it is also acknowledged to be costly in terms of time and space. Uncertainty and fear can be experienced by students unfamiliar with studio learning, in the "midst of making and talking about design artefacts, rather than writing or reading" (Caldwell et al., 2016, p. 1359). However, these emotions are recognised as an associated and, indeed, necessary formative element of signature pedagogies (Shulman, 2005b), as discussed above under the theme of *uncertainty*. The culture and practises of design studios seek to model the related workplaces (Love & Barrett, 2019; Osmond & Tovey, 2015) affecting the habits of mind, hand and heart through engagement with projects and critique.

The *design 'crit'* (or critique), as a staged presentation for expert and peer feedback, as part of the role of the teacher, has also been a staple of design related degree courses for many years (Downton, 2003 in Caldwell et al., 2016; Peel, 2011). The form of crit described above is a summative, high-stakes event, but Caldwell et al. also describe the 'desk crit', as a more formative form of feedback, where student and teacher work side-by-side as co-designers to break down the master/apprentice barriers. Some of the tensions between student and teacher are attributed to the former worrying more about grades, than valuing the critique of the latter. Noel and Liub (2017) highlight the role of critique as modelling thought processes, as well as the more pragmatic agreement on standards and discussion of alternatives. Love and Barrett (2019) discuss the value of immediate feedback from teachers and peers in terms of disciplinary values and complexity, and Peel (2011) the visibility and accountability it brings. However, the crit is not without criticism, including a tendency to prioritise physical aspects of designs over social or political concerns (Salama, 1995 in Boling et al., 2013). The formal and informal crit are part of a wider dialogue between teachers and students of design, requiring skilful handling.

The *design project* "demonstrates that the students can think in a 'designerly' way, engaging in a 'solutioning' process" (Osmond & Tovey, 2015, p. 50), which relates to the theme of *capability*, described above. Projects develop students capability and rather than marking the end of a programme of study, they (should) "develop in intensity and detail" (p. 50) over time. Discussing uncertainty in the teaching of design, Osmond and Tovey also present four threshold characteristics in design projects: transformative, irreversible, integrative and troublesome. These characteristics resonate with the wider themes in the literature on signature pedagogies discussed above.

Table 6 Publications by Alison Shreeve

Article referenced	Cited by	Type	Summary
Shreeve (2007)	Osmond and Tovey (2015)	Journal article	Student participation in writing design briefs, organising projects and partnership in assessment
Shreeve et al. (2010)	Love and Barrett (2019)	Journal article	Learning through dialogue and exchange between students and teachers in design studios
Shreeve (2011)	Caldwell et al. (2016)	Conference paper	The crit, dialogue and materiality as signature pedagogies in design education
Shreeve (2015)	Noel and Liub (2017)	Book chapter	Expands signature pedagogies in design education to include the studio, projects and briefs, and research

The work of Alison Shreeve on signature pedagogies in design education is referenced by four of the articles in the sample reviewed (Table 6); none of which were elicited in the initial literature search, but nevertheless offer some useful observations on signature pedagogies in design, in response to RQ2. As part of a developing investigation into signature pedagogies in design education, Shreeve builds on the exchange between student and teacher in the studio environment (Shreeve, 2007; Shreeve et al., 2010) proposing the design studio, crit and project discussed in the literature above; adding materiality and research, assuming that dialogue sits alongside the design crit in the literature and the brief with the project. Shreeve questions the inclusion of research as a signature pedagogy, as students are typically required to "to go away and 'do research'" (2015, p. 89). However, the use of research to develop briefs and inform decision making is, arguably, one of the ways of knowing referred to in literature as design thinking. Materiality (or consciousness of materials for designing) is a fundamental element of design education in the design *project*, engaging learners in the fundamental activities of ideating, realising and critiquing. Therefore, could be unhelpful to consider as an isolated pedagogy apart from the design *project*.

The themes specifically associated in the literature with the design studio, crit and project, align with the general theme relating to the aforementioned 'locations' of signature pedagogies; which explored the importance of curriculum, teachers and learning environments. Similarly, design thinking is a disciplinary form of knowledge in action; praxis that is shared by a range of fields associated with design and, to some extent, engineering.

There are subtle differences between design, as taught in higher education, and design and technology (and its various iterations around the world) as a subject taught in primary and secondary schools. Some of this difference lies in the subject's origins in the crafts, which as a result leads to the curriculum encompassing a wide variety of materials/ingredients (e.g. food, metals, polymers, textiles, woods, etc.) and components (e.g. electronic, mechanical, pneumatic, programmable devices, etc.). However, there are parallels to the project, as evident in D&T's external examination requirements (DfE, 2015a, 2015b) and guidance to both primary (e.g. D&TA, 2015) and secondary (D&TA, 2014) teachers.

The learning environments associated with D&T are multifaceted, being tailored to suit the materials (e.g. workshops), components (e.g. laboratories) or ingredients (e.g. kitchens). Therefore the variety of 'design studios' might be better described as signature to the specific material disciplines represented in contemporary D&T (particularly in England, where materials areas include electronics, food, so-called 'resistant' materials and textiles), rather than signature to D&T as the overarching subject. This might also provide an insight into the judgements of perceived disciplinary incoherence that have been levelled at the subject (e.g. DfE, 2011). Furthermore, the *design crit* is not a practise common to D&T as taught in primary and secondary schools. The formal crit associated with many design degrees is also not part of examination requirements for D&T and, therefore, not a common feature represented in literature; although good formative assessment incorporates many similar features, including dialogue and questioning with the teacher and peers (e.g. Black, 2008). However, in preparing young people to study design in further and higher education, and participate critically in the world around them, it may be a pedagogy worth considering in the D&T classroom.

Conclusion and implications

> "Most design courses are taught through experiential methods that focus around a project or design brief. The design outcomes are open-ended which allows the student the space to be creative in developing a solution, which is unknown at the start of the project." (Noel & Liub, 2017, p. 6).

A signature pedagogy is not a 'theory of everything' for a subject, nor should an attempt to construct such a grand theory be viewed as a benign or necessarily beneficial endeavour. Rather, the concept of signature pedagogies provides a framework for recognising, discussing and critiquing pedagogical approaches, or a lens by which to examine them.

In response to RQ1, the literature explored in this paper revealed four broad themes around signature pedagogies—locations (curricula, teachers and learning environments), capability, uncertainty and the challenges for signature pedagogies—that have broad application to general education at primary, secondary and tertiary education. Signature pedagogy seems to be associated with the interface of disciplinary knowledge, where it is applied in simulated scenarios and contexts. Uncertainty being an emotionally uncomfortable, but pedagogically necessary component of learning, where students learn to become autonomous and resilient. The notion of signature pedagogies cannot be separated from the *places* where learning happens, the *people* who support and assess and the curricular *purposes*; and represented a pervasive and reasonably stable collection of pedagogical *practises*, which can be examined through the three structures (surface, deep and implicit) described by Shulman.

In terms of what D&T education in schools can learn from literature on signature pedagogies in design education (RQ2), the themes of design thinking, studios, 'crits' and projects offer insight into shared practise and future possibilities for the subject. Design thinking has become ubiquitous and adopted in all areas of society, beyond the worlds of design and business, from the health (e.g. Ferreira et al., 2020) to the military (e.g. Mitchell, 2017) sectors, as an alternative mental model to those offered by other STEM disciplines for problem solving. A forward looking design and technology curriculum in schools has the potential to educate children and young people to develop divergent thinking and empathetic dispositions, and many do. Similarly, the D&T 'classroom' (studio) should reflect the activity undertaken in lessons, questioning the value and retention of beloved machine tools, often gathering dust in corners. As a dynamic subject, the principles of signature pedagogies encourage teachers to reflect on their learning environments and the subconscious messages that they convey. Design 'crits', whilst not universally incorporated in school curricula and classroom practice, are recognised as a evaluative approaches (e.g. DfES, 2004; Stables, 2020). D&T teachers routinely provide pupils with the equivalent of 'desk crits' as formative feedback during project work. Learning from design education in HE, teachers might embrace the more formal forms of design 'crit', where not only the teacher provides critical feedback, but also external clients or users to provide a more authentic experience of design learning. These three features (design thinking, studios and 'crit') provide the context and support for project-based learning, which is fundamental to design and technology.

Focusing on the implications for D&T, a subject rich in opportunities for knowledge in action (McLain et al., 2019), dialogue around pedagogical approaches have developed over the past three decades. Two common types of project were described in the second National Curriculum programme of study and have become common terms (DfE, 1995): the *design and make assignment* and the *focused practical task*—another non-project kind

of task was described as the *investigate, disassemble and evaluate activity*. More recently, combinations of design and making have been extended to *mainly designing*, *mainly making* and *designing and making* (e.g. McLain, 2021)—similarly another non-project kind of task has been referred to as *exploring technology in society*. McLain (2019) also introduces an additional dimension, proposing pedagogical choices to be made along a restrictive-expansive continuum, scaffolding learning experiences rather than simply categorising types of activity into one of three or four options.

The potential power of signature pedagogies is as a discursive tool, encouraging teacher to discuss and argue the nature of learning, teaching and assessment. Questions that may elicit this dialogue in any particular subject might include:

- Where is disciplinary knowledge applied in meaningful ways to develop capability?
- Where are there tensions evident between theory and practise? Or where/when do learners put theory into practise?
- Where must students productively engage with uncertainty?
- Where are specialist content knowledge, teacher expertise and learning environments necessary for authentic disciplinary learning?
- Where are the most challenging aspects of subject teaching evident?

Teacher educators working with both beginning and experienced teachers might use these questions to explore the nature of subject teaching; and to critically examine practise to either reinforce or challenge it, remembering that signature pedagogy is not a 'status', but rather a term to describe practises that are common in disciplinary learning beyond individual institutions' walls. And that as curriculum, technology and political expedience (to name but three drivers) change, signature pedagogies may need to be nudged (or pushed) into the future!

From design and technology curricula over the past three decades, both in England and elsewhere, it can be inferred that project-based learning is considered to be a (or even the) *deep* structure—i.e. believed to be the 'best' way to impart disciplinary know-how—of the subject's signature pedagogy. The fundamental activities of ideating, realising and critiquing (Irving-Bell et al., 2019; McLain, 2021) are common threads within the more design oriented curricula, with increasing interest being directed towards the processes of designing, and inform pedagogy at all levels from the surface through to the deep and implicit structures. Signature pedagogies in D&T will, therefore, involve the three fundamental activities to greater or lesser degrees in pedagogical approaches relating to designing, making and evaluating. Alongside the underpinning values and dispositions associated with design thinking (and acting), the notion of signature pedagogies not only provides a framework for pedagogical dialogue, it also suggests a structure for strategic research and enquiry into the subject's praxis. Design projects are complex and comprised of common elements, which include resources (materials, components, information, etc.), teaching methods (demonstration, product analysis, etc.), contexts (users, needs, wants, problems, etc.) and activities (designing, making, evaluating, etc.). It is, therefore, important for the current and next generations of teachers to make informed and considered choices, understanding the benefits and drawbacks of their pedagogical decisions. Drawing on the themes emerging from literature, Table 7 suggests questions to prompt dialogue and enquiry in the subject.

Another question to consider is, to what extent D&T should reflect the signature pedagogies of design education in HE, preparing young people for progression into relevant programmes of study. It may benefit the subject to draw on the feedback practises associated

Table 7 Questions for future research and professional dialogue

Surface structure	What teaching methods most effectively promote the fundamental activities of ideating, realising and critiquing? Where is each teaching method positioned on an expansive restrictive continuum? How does scaffolding and fading promote genuine design and technology learning? What types of learning activities promote the fundamental activities? (e.g. designing and making, mainly making, mainly designing or exploring technology in society)
Deep structure	Is the 'project' the deep structure of design and technology signature pedagogy? Why? What are the benefits and limitations of project-based learning in design and technology? Where do learners experience uncertainly in design and technology? And how do were support learners to become resilient and autonomous designers? How do learning environments, activities and feedback combine to promote effective learning through projects?
Implicit structure	Is design thinking (and acting) central to design and technology education? What is the role of materiality? What beliefs, values and dispositions underpin design and technology education? What does design and technology education offer to related industries, e.g. engineering, design, etc.? What does design and technology education offer to individuals and society, beyond related career opportunities?

with the design crit. However, it must also be recognised that the role of any subject in the school curriculum is more than merely the utilitarian preparation for the world of work.

To finish with a visual metaphor, consider signature pedagogies as a rope bridge between the headland of knowledge and an outcrop of practise. Crossing the gap is not a comfortable experience and requires some perseverance and resilience on the part of the traveller, even though the bridge may have been constructed using tried and tested methods. However, these need appropriate maintenance and renewal over time. Alongside the concept of pedagogical content knowledge, which focuses on teacher knowledge, signature pedagogies offers an alternative lens through which to consider how subjects are taught and may prove to be a more productive approach than seeking to define design and technology's bodies of knowledge. The concept of signature pedagogies invites educators to engage in an evolving professional discourse on how we teach design and technology; an how we should challenge and change our practise over time.

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