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Why design and technology education never settled, and may never: a historical-conceptual analysis of a hybrid curriculum

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Abstract
Design and technology (D&T) education has occupied a distinctive yet persistently contested position within general education since its formal inclusion as a foundation subject in the national curriculum for England in 1988. Despite repeated reforms, longstanding difficulties concerning assessment, curriculum coherence, teacher supply, and subject status have proven remarkably resilient. This article offers a historical-conceptual analysis of the emergence and evolution of D&T in England, situated within a selective international perspective. It argues that these enduring challenges are best understood not as outcomes of policy failure or poor implementation, but as structural consequences of D&T's formation as a hybrid curriculum, combining partially reconciled traditions of craft, design, and technological knowledge. Drawing on curriculum theory and international scholarship, the analysis traces how attempts to stabilise this hybrid subject have resulted in recurring cycles of epistemic expansion and contraction. To move beyond nationally specific accounts, the article proposes a typology of technology, engineering, and/or design (TED) education, conceptualising international variation as alternative curriculum settlements within a shared problem space. The typology provides a comparative framework for analysing how different systems anchor epistemic authority, define educational purpose, and organise assessment. The article concludes by considering the implications of recognising D&T as an inherently tensioned hybrid curriculum for future research, policy, and curriculum design.

Keywords Curriculum theory · Design and technology education · Epistemology · Historical-conceptual analysis · Hybrid curriculum formation

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Introduction: what is the origin story of D&T in the national curriculum for England?

Since its formal inclusion as a foundation subject in the national curriculum (NC) for England in 1988, design and technology (D&T) has occupied a distinctive (and often contested) position within general education. Conceived as a subject that integrates creative design activity with technological understanding and practical making, D&T has persistently challenged conventional distinctions between academic and vocational knowledge, theory and practice, and creativity and utility (Bell et al., 2017; Kimbell, 1997). Despite more than three decades of curriculum presence, however, the subject continues to face questions concerning its epistemological coherence, educational purpose, and status relative to other curriculum domains (Bell et al., 2017; McLain et al., 2019). These tensions suggest the need for a deeper historical and conceptual examination of how D&T emerged, what it represents as a form of knowledge, and why its position remains inherently unstable.

The article makes three principal contributions to scholarship in D&T education. *First*, it reconceptualises D&T as a hybrid curriculum formation shaped by partially reconciled epistemic traditions. *Second*, it situates the development of D&T in England within a set of international parallels, reframing national variation as alternative curriculum settlements rather than exceptional cases. *Third*, it proposes a typology of technology, engineering and/or design (TED) education that provides a comparative language for analysing curriculum purpose, knowledge form, and assessment across contexts.

Existing accounts of D&T's development frequently emphasise policy chronology or curriculum change, often framing the subject as the outcome of pragmatic reform designed to modernise craft-based and technical education for a technologically advanced society (Paechter 1995a, b; Williams 2002). While such accounts are valuable, they risk understating the extent to which D&T constitutes a historically contingent hybrid discipline; one formed through the convergence of multiple pedagogical traditions, each carrying distinct epistemic values and educational purposes. Craft education, design education, and technical or technological study have long coexisted within English schooling, yet they emerged from different social, economic, and philosophical roots (Layton, 1993; Eggleston, 1976). The synthesis of these traditions within a single curriculum subject was neither straightforward nor ideologically neutral. Rather than treating long-standing concerns in D&T education as matters of curriculum implementation, resourcing, or policy coherence, the argument presented reframes them as symptomatic of a deeper curriculum problem: the institutionalisation of design-led, technological knowledge within education systems historically organised around stable, discipline-bounded forms of knowledge. From this perspective, the enduring instability of D&T is not a weakness to be resolved, but a defining characteristic that warrants historical and conceptual explanation.

From a historical perspective, early twentieth-century manual instruction and craft education were closely aligned with industrial labour, skill formation, and moral development through making (Bennett, 1937; Layton, 1993). Parallel developments in art and design education, particularly influenced by modernist movements such as the Bauhaus, foregrounded creativity, form-giving, and the integration of aesthetic and functional considerations (Souleles, 2013). Technological and technical education, meanwhile, evolved through science-oriented and engineering-informed traditions that prioritised systems thinking, problem-solving, and applied scientific principles (Williams, 2012). These strands

remained largely separate throughout much of the twentieth century, reinforced by institutional divisions between academic and vocational pathways and by deeply ingrained hierarchies of knowledge.

The emergence of D&T in the late twentieth century can therefore be understood not simply as a curricular innovation, but as a deliberate attempt to reconcile longstanding epistemic divides in response to social, economic, and technological change. Policy discourse surrounding the Education Reform Act of 1988 framed D&T as essential preparation for life in a rapidly changing technological world, positioning design capability and technological literacy as core entitlements for all learners (Department of Education and Science, 1990). Crucially, D&T was not intended solely as preparation for technical employment, but as a form of general education concerned with understanding and shaping the made world (Kimbell & Stables, 2007). This positioning distinguished D&T from many of its international counterparts, while simultaneously entrenching tensions regarding assessment, teacher expertise, and curriculum identity that remain unresolved.

Internationally, similar subjects (often labelled technology education, industrial arts, or design education) developed along divergent trajectories shaped by national traditions, industrial histories, and educational philosophies (Raizen et al., 1995; Williams, 2012). Comparative studies indicate significant variation in the balance afforded to engineering knowledge, craft skill, design thinking, and technological critique, underscoring that D&T is not a universally stable construct but a culturally situated curriculum formation (Williams, 2012). Understanding the English experience therefore benefits from being situated within this wider global constellation, enabling both common patterns and distinctive features to be identified.

This article offers a critical historical-conceptual analysis of the emergence and evolution of D&T education in England, situated within a broader international context. It argues that many of the enduring challenges associated with the subject (its fluctuating status, assessment difficulties, and identity tensions) are not the result of policy missteps or implementation failures but are structural consequences of its hybrid epistemic formation. By tracing the converging traditions that shaped D&T and examining parallel developments internationally, the article seeks to reconceptualise D&T as a distinctive but inherently tensioned form of curriculum knowledge. In doing so, it contributes to ongoing debates about the nature of design and technological knowledge, the purposes of general education, and the future of D&T in an increasingly complex and uncertain world.

Framing: what is the approach to the historical-conceptual analysis of D&T education?

This article adopts a historical-conceptual methodology, combining elements of critical curriculum history, conceptual analysis, and selective international comparison. The approach is interpretive rather than empirical and is aligned with established methodological traditions in D&T education research that seek to explain how curriculum forms emerge, stabilise, and persist over time, rather than to evaluate effectiveness or measure outcomes (Kimbell & Stables, 2007; Layton, 1993).

The primary methodological lens is historical-conceptual analysis. This involves examining policy texts, curriculum documents, and scholarly literature to trace the emergence of

D&T education as a curriculum subject and to interrogate the ideas, values, and assumptions that informed its formation (Goodson, 1988; Layton, 1993). Rather than constructing a comprehensive policy chronology, the analysis focuses on identifying key moments of convergence between previously distinct educational traditions (craft education, design education, and technical or technological education) and exploring how these traditions were rearticulated within the NC framework in England.

Conceptual analysis is used to examine how terms such as *design*, *technology*, *capability*, and *technological literacy* have been theorised within the field, and how their meanings have shifted over time in response to broader social, economic, and political influences (Williams, 2002). The concept of 'design' itself has undergone significant re-theorisation within design education, shifting from method-driven formulations toward judgement-based, iterative, and contextually situated practice (Kuvshinova, 2024). This allows the article to move beyond descriptive history and to offer an explanatory account of why certain tensions (particularly those related to epistemology, assessment, and subject status) have proven persistent.

The analysis is informed by curriculum theory perspectives that attend to the epistemic foundations of school subjects and the ways in which knowledge is selected, structured, and legitimised within formal education (Bernstein, 2000; Eggleston, 1976; Young, 2013, 2014). D&T is treated as a *hybrid curriculum formation*, in which multiple forms of knowledge coexist but are not fully reconciled. This framing draws on prior work in D&T education that highlights the subject's distinctive blend of procedural, conceptual, and dispositional knowledge, and the challenges this poses for curriculum coherence and assessment (REDACTED, 2017; Kimbell, 1997; Muller, 2009).

While the primary empirical focus of the article is England, an intentionally selective international perspective is incorporated to avoid methodological nationalism and to situate English D&T within a wider global landscape. Rather than undertaking systematic cross-national comparison, the article draws on secondary literature to identify *family resemblances* among related subjects such as technology education, industrial arts, and design education (Kimbell, 1997; Williams, 2012). This comparative orientation supports the argument that many challenges associated with D&T are not unique to the English context but reflect broader issues inherent in attempts to integrate design and technological knowledge within general education as opposed to vocational education.

As a historical–conceptual study, this article does not claim empirical generalisability or seek to capture lived classroom practice. Instead, its rigour lies in the coherence of its conceptual framing, the transparency of its interpretive stance, and the depth of its engagement with established and contemporary scholarship. The analysis is necessarily selective and interpretive, and alternative readings of the historical record are both possible and legitimate. However, by making its methodological assumptions explicit, the article aims to provide a robust and defensible account that can inform future empirical, comparative, and theoretical research in D&T education. To explain why D&T has never fully stabilised, it is necessary to look beyond its formal naming within the NC for England. The conditions that made D&T both possible and problematic were established earlier, within educational traditions that embodied distinct and often incompatible assumptions about knowledge, skill, and purpose. The following section therefore examines the antecedent craft, design, and technical traditions whose partial convergence would later be institutionalised as D&T.

Antecedents: what knowledge traditions existed before D&T and why were they epistemically distinct?

This section argues that the antecedents of D&T education in England should not be understood as a linear progression or natural evolution of school subjects. Rather, D&T emerged from the convergence of three historically distinct educational traditions (craft, design, and technical education) each underpinned by different epistemic assumptions about knowledge, skill, and purpose. Understanding these traditions as *epistemically misaligned* helps explain both the ambition of D&T and the enduring tensions associated with its curriculum identity.

The conceptual roots of D&T in England extend back further than its formal curriculum designation, tracing through various pedagogical movements and subject transformations in the twentieth century. Prior to the late 1980 s, elements of what would become D&T were dispersed across subjects such as craft, design, and technology, as well as home economics and technical drawing (Souleles, 2013). These earlier subjects often possessed distinct pedagogical traditions and objectives yet collectively contributed to the practical and creative learning experiences available to students.

In the early twentieth century, education in practical subjects was heavily influenced by the manual instruction movement, which focused on developing hand skills and an understanding of materials through repetitive tasks. Manual instruction prioritised *procedural and tacit knowledge*, with educational value located in disciplined making rather than conceptual abstraction (Layton, 1993). This approach was largely vocational, preparing students for roles in manufacturing and industry. Art education, meanwhile, began to incorporate elements of design, moving beyond purely aesthetic appreciation to consider functionality and purpose. The Bauhaus movement, though originating in Germany, exerted an international influence, advocating for the integration of art, craft, and technology, which slowly permeated educational thought in Britain (Whitford, 1984; Droste, 2006). Design education introduced a fundamentally different knowledge orientation, privileging ideation, judgement, and interpretive decision-making over reproducible skill.

The mid-twentieth century saw the emergence of *design education* as a distinct field, particularly in higher education, though its influence gradually filtered down to secondary schooling. This phase emphasised problem-solving, creativity, and the application of design principles across various media and contexts. The concept of *design thinking*, though not explicitly named as such in early curricula, began to shape pedagogical approaches, prioritising iterative processes, user needs, and the generation of multiple solutions to a given problem (Panke, 2019). This shift represented a departure from mere replication of existing designs or pure technical skill acquisition, towards a more intellectual and exploratory engagement with the designed world.

Concurrently, *technical education* evolved from its manual instruction origins, incorporating more scientific and engineering principles. Technical education increasingly aligned with *scientific-rational epistemologies*, where knowledge was validated through systems, measurement, and functional efficiency. Subjects like *woodwork*, *metalwork*, and *technical drawing* started to include aspects of product analysis, material science, and mechanical understanding. However, these subjects often remained separate, with limited integration between the creative and technical dimensions (REDACTED, 2017). The vocational

emphasis persisted, and there was a discernible academic/vocational divide, with practical subjects often perceived as less intellectually rigorous than traditional academic disciplines.

The late 1970 s and 1980 s proved to be a transitional period. Educational reformers and industrial bodies increasingly argued for a more unified approach that would combine the strengths of both design and technology. Reports such as the Cockcroft Report (1982) and the Royal College of Art's "Design in General Education" (1979) advocated for a curriculum that fostered both creative design capabilities and technological understanding (cf. Archer, 1979; Cross, 2001; Layton, 1994). These discussions underscored the need for students to grasp how products are conceptualised, developed, and manufactured, considering both aesthetic and functional criteria. The integration of computing and new materials into manufacturing processes further accelerated this push, highlighting the obsolescence of purely craft-based or purely technical approaches (Archer, 1979; Cross, 2001). The amalgamation of these traditions was therefore not a reconciliation but a strategic alignment, driven by economic pressure and curriculum reform. The resulting subject carried forward unresolved epistemic tensions that would later manifest in debates about assessment, academic legitimacy, and teacher expertise. This historical trajectory illustrates a gradual yet persistent movement towards a curriculum that values holistic engagement with the designed and technological world, bridging the historical chasm between artistic expression and technical proficiency.

D&T emerged in the late 1980 s, not as a resolved curriculum innovation, but as the institutionalisation of long-standing epistemic negotiations between design, craft, and technological knowledge under conditions of economic urgency and political reform. By the late twentieth century, these traditions had neither converged organically nor resolved their epistemic differences. Instead, they coexisted uneasily within compartmentalised school subjects and institutional structures that reaffirmed their separation. The emergence of D&T within the national curriculum therefore represented not the synthesis of these traditions, but their compelled alignment under conditions of economic urgency, curriculum reform, and political intervention.

Emergence: why did these traditions get forcibly aligned in the late 1980s?

In short, D&T emerged because policy, economy and pedagogy demanded it. The formal inclusion of the subject within the NC for England in 1988 marked a significant restructuring of practical and creative education. Its inclusion in the NC was less the creation of a new subject than the formal consolidation of prior curricular debates concerning the status, purpose, and legitimacy of practical and technological knowledge in general education. This development was not an arbitrary decision but the outcome of extensive educational debate, policy formulation, and research findings that underscored a perceived deficiency in the existing educational provision (Department of Education and Science, 1985, 1990). The late 1980 s were characterised by a national discourse concerning the preparedness of the UK workforce for a rapidly changing global economy, where innovation and technological competence were becoming increasingly paramount. There was a clear recognition that traditional subject boundaries often failed to adequately address the interconnected nature of modern industrial and commercial practices.

Policy insights of the time articulated a vision for a subject that would combine the intellectual rigour of design with the practical application of technology. The Education Reform Act of 1988 (UK Parliament, 1988) mandated a NC for all maintained schools in England and Wales, providing a standardised entitlement for all pupils. Within this framework, D&T was positioned as one of the foundation subjects, signifying its importance alongside core academic disciplines like English, mathematics, and science. This elevation in status represented a departure from previous arrangements where practical subjects were often optional or less formally structured (REDACTED, 2017). The intention was to ensure that every student developed an understanding of designing and making, irrespective of their future career paths.

Research preceding and accompanying this curricular change consistently highlighted the educational benefits of integrating design and technology. Studies emphasised the pedagogical effectiveness of experiential learning, where students learn by doing and by solving authentic problems. It was argued that D&T fostered higher order thinking skills, such as analysis, synthesis, and evaluation, which are critical for navigating complex situations (Shuman, 2024). Furthermore, research indicated that D&T could enhance motivation and engagement, particularly for students who might not excel in more abstract, theoretical subjects. The hands-on nature and tangible outcomes of D&T projects offered a different mode of learning that appealed to diverse learners, offering complimentary learning experiences to less practical and creative subjects.

The curriculum content for D&T was deliberately broad, encompassing areas such as materials, control systems, and information technology. This breadth aimed to provide students with a versatile skill set applicable across various sectors. The curriculum privileged *design capability* as an organising principle, positioning knowledge as something enacted through iterative problem-solving rather than transmitted as stable content (McLain et al., 2019). This represented a deliberate departure from both traditional craft instruction and science-aligned technical education. The focus was on the design process: identifying needs, generating ideas, planning, making, and evaluating. This process-oriented approach was a key innovation, moving beyond simply teaching specific craft techniques to cultivating a transferable methodology for creative problem-solving (Panke, 2019). The emphasis on the design processes marked a significant pedagogical departure, but also introduced enduring ambiguities regarding progression, comparability, and assessment validity; issues that would later shape debates about the subject's academic status.

Early policy documents also stressed the importance of linking D&T with other subjects, particularly science and mathematics, to demonstrate the practical application of theoretical knowledge. This interdisciplinary intention sought to make learning more coherent and relevant for students. By positioning D&T as a site where scientific knowledge, mathematical reasoning, and creative design intersected, the curriculum blurred established subject boundaries, raising future, unresolved questions about whether D&T constituted a discrete discipline or a curriculum bridge between disciplines (Department for Education, 2011).

The implementation of D&T was not without its challenges. While foundation subject status conferred legitimacy and universality, it simultaneously imposed standardisation and accountability expectations that sat uneasily with D&T's process-oriented, exploratory pedagogical ethos. Initial concerns included a lack of adequately trained specialist teachers, insufficient resources in schools, and difficulties in assessing a subject that valued process and creativity as much as final product. Despite these hurdles, the establishment of D&T

within the NC represented a visionary step in educational policy, aiming to cultivate a generation of innovative, adaptable, and technologically literate individuals. The foundational principles articulated during its emergence continue to shape the subject's identity and its intended contribution to general education. The implementation challenges can be read not simply as teething problems, but as early expressions of deeper structural tensions arising from embedding a hybrid epistemology within a curriculum framework designed around disciplinary stability.

The emergence of D&T, therefore, represented not the resolution of debates about practical and technological knowledge in education, but their formal incorporation into the architecture of the NC, ensuring both the subject's distinctiveness and its persistent instability. If the emergence of D&T marked the institutionalisation of epistemic compromise, its subsequent evolution provides the critical test of whether that compromise could be stabilised over time. The following section examines how successive reforms, expansions, and retrenchments repeatedly (re)exposed the tensions embedded at the subject's point of formation.

Evolution: what happens when a hybrid subject tries to stabilise itself over time?

Since its formal introduction into the NC in 1988, D&T has undergone continuous evolution, reflecting shifts in educational philosophy, technological advancements, and economic priorities. Developments in the subject do not represent linear progress or decline, but repeated attempts to stabilise a fundamentally *hybrid curriculum formation* within shifting policy, accountability, and technological contexts. This journey has seen periods of significant growth and refinement, alongside challenges and retrenchment, delineating a complex developmental trajectory. These moments of epistemic expansion and contraction are summarised below.

Moments of epistemic expansion:

1. **Broadening Scope and Integration of New Technologies**: The 1990 s and early 2000 s witnessed a substantial expansion of D&T's curriculum content. Initially, the subject often leaned heavily on traditional materials like wood, metal, and textiles. However, policy revisions and pedagogical advancements encouraged the incorporation of new and emerging technologies, such as computer-aided design (CAD), computer-aided manufacturing (CAM), electronics, and control systems. This broadened the practical skill base and intellectual demands of the subject, ensuring its relevance in a rapidly digitising world. The emphasis shifted towards understanding systemic design and technological principles rather than merely craft skills. The incorporation of digital technologies expanded D&T's epistemic scope, moving the subject further from material craftsmanship alone towards systems thinking, abstraction, and digital-physical hybridity.
2. **Emphasis on Design Thinking and Problem-Solving**: A consistent high point has been the subject's enduring commitment to fostering design thinking and complex problem-solving abilities. D&T curricula have consistently promoted an iterative process of identifying needs, researching, generating diverse solutions, prototyping,

testing, and evaluating. This methodology provides students with a transferable framework for tackling open-ended challenges, a competency increasingly valued across all sectors (Panke, 2019). The subject has been instrumental in cultivating creativity, resilience, and an understanding of user-centred design principles. While the emphasis on design thinking strengthened the subject's intellectual legitimacy, it also intensified longstanding tensions between open-ended inquiry and assessment regimes predicated on standardisation and comparability.

3. **Cross-Curricular Links and STEM Promotion**: D&T has often been positioned as a crucial link within the science, technology, engineering, and mathematics (STEM) agenda. Its practical application of scientific and mathematical principles, coupled with engineering design processes, has reinforced its value in promoting STEM uptake (Bell et al., 2017). The subject provides a tangible context for abstract concepts, potentially making STEM fields more accessible and appealing to a wider range of students. Initiatives aimed at promoting STEM careers frequently highlight D&T as a foundational experience but tend to privilege learning in mathematics and science. Positioning D&T within the STEM agenda offered a strategy for curriculum legitimisation by proximity to established disciplines but has risked marginalising the subject's distinctive design-led epistemology in favour of instrumental outcomes. Design-led epistemologies privilege interpretive judgement, iteration, and situated decision-making rather than reproducible procedures, reinforcing the difficulty of fully reconciling design knowledge with discipline-bounded curriculum structures (Cross, 2001; Kuvshinova, 2024).

Moments of epistemic contraction:

1. **Curriculum Crowding and Perceived Status**: Despite its early elevation, D&T has struggled with curriculum crowding and a fluctuating perceived status. The introduction of other subjects and the emphasis on core academic metrics sometimes led to D&T being marginalised, particularly at upper secondary level where it often became optional. The subject has at times been caught between its academic aspirations and its vocational roots, leading to debates about its intellectual rigour compared to other STEM subjects (Bell et al., 2017). D&T's epistemic demands (integrating conceptual understanding, practical skill, and reflective judgement) make it particularly vulnerable within performance-driven systems that reward predictability and examination efficiency.
2. **Resource and Teacher Supply Issues**: A persistent challenge has been ensuring adequate resources and a sufficient supply of specialist teachers. The evolving nature of technology requires continuous investment in equipment and professional development for educators. Recruiting and retaining D&T teachers, especially those with expertise in modern manufacturing techniques and digital design, has remained a concern. Without appropriate resources and skilled practitioners, the ambitious goals of the curriculum can be difficult to achieve. Persistent shortages of specialist teachers reflect the difficulty of sustaining professional identities that span craft expertise, design judgement, and technological knowledge within conventional training and accountability frameworks.
3. **Assessment Challenges**: Assessing D&T effectively has consistently presented difficulties. The subjective nature of design, the emphasis on process over product, and the diversity of outcomes make standardised assessment complex. Critics have pointed to

assessment methods that sometimes overemphasise documentation at the expense of practical making or that fail to adequately capture the full range of design capabilities developed by students. This has at times led to assessment approaches that may inadvertently narrow the curriculum or discourage risk-taking and genuine innovation. Assessment difficulties arise not from technical shortcomings, but from a misalignment between D&T's process-oriented, iterative epistemology and assessment systems optimised for stable, propositional knowledge. Because design knowledge is constituted through situated judgement rather than stable propositional content, conventional assessment frameworks struggle to capture its epistemic substance (Kimbell & Stables, 2007; Kuvshinova, 2024).

4. **Decline in Uptake**: Over certain periods, there has been a noticeable decline in student uptake of D&T at general certificate of secondary education (GCSE) at the age of 16 (McLain, 2025) and general certificate of education advanced level (GCE A Level) at 18 (Department for Education, 2015a, 2015b). This trend has been attributed to various factors, including the perceived academic difficulty, competition from other subjects, and career pathways not always being clearly articulated. This reduction in participation raises concerns about the future pipeline of designers, engineers, and innovators. Declining uptake can be interpreted as a symptom of unresolved curriculum messaging, where the subject's educational purpose (academic, vocational, practical, or creative) remains ambiguously articulated to students and gatekeepers alike.

The evolution of D&T in England thus reflects a dynamic interplay between educational ideals, practical realities, and the changing demands of society and industry. While facing recurrent challenges, the subject has consistently adapted, striving to provide a relevant and enriching educational experience that equips students with essential skills for an increasingly complex world. Taken together, these developments suggest that the evolution of D&T since 1990 has been characterised by cycles of epistemic expansion and contraction, shaped by attempts to reconcile *design-led inquiry* with *accountability-driven curriculum structures*. Rather than stabilising the subject's identity, successive reforms have repeatedly (re)exposed foundational tensions established at its point of emergence.

While the patterns of *expansion* and *contraction* are documented here within the English context, interpreting them as nationally specific would risk methodological nationalism. Similar tensions have emerged wherever education systems have attempted to integrate design and technological knowledge within general education. To illustrate this, the next section situates English D&T alongside a set of international parallels, not to rank effectiveness, but to identify shared curriculum dilemmas and alternative settlements.

Parallels: is this instability uniquely English, or a general phenomenon?

The concept of integrating practical, technical, and design-oriented education into general schooling is not unique to England. Across the globe, various educational systems have developed parallel subjects that share objectives with D&T, albeit with distinct historical trajectories, pedagogical emphases, and nomenclature. These international counterparts often reflect national industrial histories, cultural values, and economic priorities. So, what do

these parallels reveal about the nature, limits, and possibilities of D&T education as a global curriculum domain? Internationally, subjects analogous to D&T have developed along distinct but recognisable trajectories, reflecting differing balances between *craft traditions*, *engineering logics*, and *design-led inquiry*. These variations can be understood not simply as national idiosyncrasies, but as alternative curriculum settlements within a shared problem space: how to position technological and design knowledge within general education.

In many European countries, subjects related to D&T often have strong roots in vocational education and industrial arts. For example, in Germany, "Technik" (Technology) education focuses on technical systems, engineering principles, and practical skills, frequently incorporating elements of materials science, mechanics, and electronics. Subjects such as Technik, particularly in German-speaking contexts, are underpinned by a predominantly *engineering-rational epistemology*, in which technological systems and functional analysis take precedence over open-ended design exploration. This often has a more pronounced engineering and technical problem-solving focus than D&T in England, which typically balances design creativity with technical application. Similarly, Scandinavian countries integrate aspects of "Sloyd" (crafts) with technology education, emphasising practical making, material exploration, and an appreciation for craftsmanship, while also addressing design principles and technological understanding (Souleles, 2013). Scandinavian Sloyd traditions foreground *material engagement* and *embodied knowledge*, maintaining a stronger continuity with craft epistemologies than is typically found in English D&T; although the tradition exerted influence over the subject's predecessor, craft, design and technology (CDT). The existence of these subjects often stems from a long-standing appreciation for skilled trades and a national commitment to industrial innovation.

In North America, particularly in the United States and Canada, technology education evolved from its Industrial Arts roots but has since been substantially reshaped by national standard-setting initiatives (Kimbell, 1997; Kimbel & Stables, 2007). While the Jackson's Mill curriculum model (emphasising communications, energy and power, manufacturing, and construction) historically influenced programme organisation, it no longer represents the primary curricular anchor. A more significant shift occurred with the *Technology for All Americans Project* (ITEA, 2002; TfAAP, 1996), which articulated a coherent vision for technological literacy as a universal educational entitlement and provided the conceptual foundations for contemporary curriculum policy. This work was further consolidated through the *Standards for Technological and Engineering Literacy (STEL)*, now the leading framework guiding technology and engineering education across the United States (ITEEA, 2020). STEL emphasises systems thinking, engineering design, sociotechnical understanding, and technological literacy as multidimensional constructs, thereby repositioning design as one element within a broader technological learning ecology. As a result, North American technology education today reflects a more standards-driven and literacy-oriented trajectory than the Jackson's Mill model suggests, aligning curriculum purpose with national expectations for technological and engineering capability while still retaining space for design as applied problem-solving within defined technological domains, rather than a central epistemic driver.

In Asian countries, the integration of D&T education has seen rapid development, particularly in nations like China and South Korea, driven by ambitions for technological leadership and innovation. Chinese design education, for instance, has evolved significantly from an arts and crafts tradition to embrace modern design principles and industrial appli-

cations, reflecting the nation's manufacturing prowess and creative industries (Buchanan, 2004). These programmes often blend artistic sensibilities with engineering and digital tools, aiming to cultivate designers who can contribute to both aesthetic and functional product development. The existence of such subjects is often a direct response to national economic strategies and the aspiration to move from being a manufacturing base to a design and innovation hub. The emphasis can be quite strong on industrial design and product development, sometimes with a more explicit link to economic outcomes than in the English D&T curriculum. In many East Asian contexts, D&T education curricula are closely aligned with national economic and innovation strategies, often resulting in a stronger emphasis on industrial relevance and performance outcomes than on exploratory or speculative design practices typical of general education models.

Commonalities across these international subjects include the cultivation of practical skills, the promotion of problem solving and critical thinking, and an engagement with technological processes. Most aim to foster creativity, innovation, and an understanding of the designed world. Differences frequently lie in the balance between craft, design, and technology; the degree of vocational versus general educational emphasis; and the specific content areas prioritised. For instance, some countries may have a stronger focus on engineering design, while others might emphasise digital fabrication or sustainable design. The nomenclature itself often indicates these nuances: "design and technology" in England encapsulates the dual emphasis, while "technology education," "technik," or specific "industrial design" curricula highlight their particular focus. Despite these variations, the underlying goal across these diverse educational offerings remains consistent: to prepare students to understand, shape, and adapt to a world increasingly defined by design and technological innovation. A useful international comparative categorisation of technology, engineering and/or design (TED) education is:

1. **Craft-anchored models** (e.g. Nordic Sloyd traditions).
2. **Engineering-anchored models** (e.g. Technik, STEM-integrated technology education).
3. **Design-led hybrid models** (e.g. English D&T at its best).

English D&T strives to sit in category 3, although it struggles to succeed in this within the national context, with the legacy of craft and making predominating in many schools. The international parallels in this section suggest that persistent tensions within English D&T, between *creativity and standardisation*, *design exploration* and *technical rigour*, are not anomalous, but characteristic of attempts globally to integrate design and technological knowledge within general education. The English case is therefore best understood not as exceptional, but as one variant of a broader global curriculum challenge. Taken together, these international parallel examples indicate that variations in D&T-related subjects are not random nor purely cultural but reflect different ways education systems stabilise (or contain) the same underlying epistemic tensions. To move beyond descriptive comparison, a more general analytical framework is needed. The following typology therefore conceptualises D&T-like subjects as alternative curriculum settlements, distinguished by how they anchor epistemic authority, define educational purpose, and organise assessment.

Typology: how can we explain international variation without treating it as idiosyncratic?

Building on the international *parallels* identified above, this section proposes a typology that explains how education systems stabilise the relationship between craft, design, and technological knowledge in general education. Rather than treating cross-national variation as idiosyncratic, the typology conceptualises D&T-like subjects as alternative curriculum settlements within a shared problem space: how to position designerly activity, technological understanding, and making in school knowledge (Archer, 1979; Layton, 1993, 1994; Williams, 2012). It is grounded in the canonical distinction between designerly ways of knowing and engineering/scientific rationalities (Archer, 1979; Cross, 2001), and in curriculum-theoretical accounts of how subjects emerge and institutionalise particular forms of knowledge and assessment (Eggleston, 1976; Goodson, 1988; Young, 2013). The typology complements prior analyses of D&T's hybrid identity and assessment challenges by making the epistemic anchor, educational purpose, and assessment logic explicit (Bell et al., 2017; Kimbell, 1997; Kimbell & Stables, 2007).

The typology rests on six axes commonly invoked (implicitly or explicitly) when systems design or reform D&T:

1. **Epistemic Anchor**: Where authority for "knowing" resides; craft/embodied practice, engineering/scientific rationality, or designerly judgment (Archer, 1979; Cross, 2001; Layton, 1993).
2. **Educational Purpose**: Whether the subject aims primarily at vocational skill, broad technological literacy, designerly capability, civic and ethical techno-critique, or innovation/enterprise (Raizen et al., 1995; Williams, 2002; Layton, 1994).
3. **Knowledge Form**: The dominant form of knowledge enacted; procedural/tacit, propositional/systemic, or reflective judgment in iterative design (Kimbell & Stables, 2007; REDACTED, 2017).
4. **Assessment Logic**: How attainment is validated; product quality, process/portfolio, written/system examinations, or studio critique (Kimbell, 1997; Kimbell & Stables, 2007).
5. **Teacher Identity**: Prevailing expertise; craftsperson-maker, engineer/technologist, designer-facilitator, or hybrid (Bell et al., 2017; McLain et al., 2019).
6. **Curriculum Structure and Relations**: The degree of disciplinary boundedness versus integrative or science and technology Studies (STS)-oriented structures, and relative anchoring to STEM or to arts/design (Goodson, 1988; Williams, 2012; Young, 2013; Souleles, 2013).

These axes allow comparative analysis without presuming that any one settlement is normative. They also render visible why certain tensions (particularly around assessment, status, and teacher formation) recur across contexts (REDACTED, 2017; Kimbell, 1997).

Table 1 outlines six *ideal types* of TED education, capturing recurrent patterns observed internationally. Real systems frequently blend or oscillate between them; the value of ideal types lies in explanatory clarity rather than exhaustive description (Goodson, 1988; Williams, 2012).

Table 1 Six ideal-typical orientations for TED education

	1	2	3	4	5	6
	Craft- Anchored Formation	Engineering- Anchored Technology Education	Design Led Hybrid (Studio Inflected D&T)	Technological Literacy/ Civic Orientation	Innovation & Enterprise Oriented D&T	Critical Socio Technical/ STS Inflected D&T
Aim	Material understanding, workmanship, and embodied skill.	Systems thinking and applied scientific/engineering problem solving.	Designerly ways of knowing and acting in the made world.	Equip all learners to understand, evaluate, and make decisions about technology in society.	Opportunity identification, prototyping, and venture literacy with external briefs/partners.	Ethical, sustainable, and political literacy about the made world: critique and make.
Epistemic anchor	Craft/embodied knowledge; learning through disciplined making.	Engineering/scientific rationality; modelling, measurement, and function.	Designerly judgment integrating user, context, and technical feasibility.	Broad technological literacy across concepts, systems, and impacts.	Design practice fused with entrepreneurship and value creation.	Design combined with STS/critical curriculum theory; responsible innovation.
Knowledge and assessment	Procedural/tacit knowledge; artefact quality and workmanship evidence.	Propositional/systemic knowledge assessed via structured tasks and tests.	Reflective, iterative inquiry; portfolio/critique balancing process and outcome.	Conceptual and socio technical understanding; cases and applied scenarios.	Problem framing, user research, prototyping; pitch + prototype + reflective iteration.	Sociotechnical analysis, speculative/critical design, research through design.
Teacher identity	Master craftsperson–pedagogue.	Engineer/technologist.	Designer facilitator with hybrid technical literacy.	Generalist technology educator with a societal lens.	Hybrid educator with industry or partnership networks.	Hybrid educator comfortable with ethics, systems, and futures thinking.
Strengths and risks	Deep material literacy and resilience; potential under-theorisation and status vulnerability in academic regimes.	Conceptual clarity and STEM alignment; potential subordination of open-ended design creativity.	Creativity, transfer, and authentic problem framing; comparability and resource demands	Accessibility and citizenship relevance; thinner engagement with designing/making.	Motivation and authenticity; risks of instrumentalism and inequitable access to resources.	Future relevance and sustainability; assessment complexity and teacher preparation demands.
Citations	(Layton, 1993; Souleles, 2013)	(Raizen et al., 1995; Williams, 2012)	(Kimbell & Stables, 2007; REDACTED, 2017)	(Williams, 2002; Raizen et al., 1995)	(Kimbell & Stables, 2007; Williams, 2012)	(McLain et al., 2019; Crilly, 2022)

The typology enables diagnosis of why reforms often fail to 'settle' D&T. For example, moves to standardise assessment typically (re)anchor practice toward engineering-aligned or literacy-oriented types, trading comparability for reduced designerly and material depth (Kimbell, 1997; Bell et al., 2017). Conversely, efforts to revitalise creativity and authenticity pull practice toward design-led hybrids or enterprise orientations, heightening pressure on resources, teacher expertise, and assessment validity (Kimbell & Stables, 2007; Williams, 2012). Placing English D&T within this landscape clarifies the gap between intended and enacted curriculum: policy and leading practice aspire to a *design-led hybrid* with *ethical/sustainability inflections*, while accountability regimes and resource constraints often re-vector enactment toward *engineering-anchored* or *craft-anchored* forms, depending on local conditions (Bell et al., 2017; Layton, 1993; Kimbell, 1997).

Finally, the typology provides a comparative language for international analysis. Rather than asking whether one country "does D&T better," it asks how different systems stabilise hybridity; and at what costs and benefits for knowledge, assessment, teacher identity, and equity (Layton, 1994; Williams, 2012; Young, 2013). This frames subsequent sections on future directions and policy implications in terms of which settlement a system intends, what architecture it requires, and how risks will be mitigated. Understanding these orientations as alternative settlements clarifies not only why reform efforts often fail to stabilise D&T, but also what kinds of futures are structurally plausible within existing curriculum architectures. The final section considers how emerging emphases (e.g., digital technologies, sustainability, ethics, and entrepreneurship) are likely to reconfigure, rather than resolve, these enduring tensions.

Future: what trajectories are plausible given these structural constraints?

The future of D&T education is not singular or predetermined, but contingent upon how education systems resolve enduring tensions between design-led inquiry, technological advancement, accountability structures, and competing curriculum priorities. The trajectory of D&T in England and its global counterparts suggests a future shaped by accelerating technological advancement, evolving societal needs, and dynamic pedagogical approaches. To remain relevant and impactful, D&T must continually adapt, integrating emerging technologies and refining its pedagogical core. Its enduring value lies in its capacity to prepare individuals not just for specific careers, but for a world requiring adaptive thinking, creative problem-solving, and technological literacy. This section asks: What futures are *plausible*, *contested*, and *structurally constrained*, and what trade-offs they entail?

One primary area for future development involves the deepening integration of advanced digital technologies. The rise of artificial intelligence (AI), robotics, virtual, augmented and mixed reality (VR/AR/XR), and advanced manufacturing techniques (e.g., 3D printing, CNC machining) presents both challenges and opportunities (Baker & Manweiler, 2017). D&T curricula will need to move beyond foundational digital literacy to encompass computational thinking, data analysis for design, and ethical considerations surrounding AI and automation. This requires substantial investment in teacher training and school infrastructure to ensure equitable access to cutting-edge tools and knowledge. The emphasis will shift towards students designing intelligent systems and interactive experiences, rather than

solely physical products. While emerging technologies offer new opportunities for design activity, they also *risk reinforcing inequities* in provision and reshaping curriculum time around *rapid technological cycles* rather than *enduring forms of design knowledge* and *materiality*.

Another crucial aspect is the expansion of *design thinking* methodologies across the broader curriculum. D&T inherently fosters an iterative approach to complex problems, an essential skill for navigating multifaceted global challenges such as climate change, public health, and social equity (Crilly, 2022; Panke, 2019). D&T can contribute to general education by acting as a pedagogical model for other subjects, demonstrating how to move from abstract concepts to tangible solutions. This cross-pollination could lead to more project-based learning in science, humanities, and even mathematics, making education more engaging and relevant by connecting learning to real-world impact. However, although design thinking offers a powerful pedagogical model, its transplantation across the curriculum risks dilution, if detached from substantive engagement with *materiality* (in the form of making, materials, and technological constraints) that give D&T education its distinctive epistemic character.

The subject also holds significant potential in promoting sustainability and ethical design. As environmental concerns grow, D&T can embed principles of circular economy, responsible material selection, energy efficiency, and waste reduction into its projects. Students can learn to design products and systems that are not only functional and aesthetically pleasing but also environmentally benign and socially equitable. This moves D&T beyond mere technical proficiency to a more holistic understanding of a designer's responsibility within society. Furthermore, the global interconnectedness of supply chains and design cultures could be explored, offering insights into fair trade practices and cultural sensitivity in design. Embedding sustainability requires not only new curriculum content, but revised criteria for success, where ethical reasoning, lifecycle analysis, and sociotechnical awareness are recognised as legitimate forms of attainment.

Furthermore, D&T can play a significant part in developing entrepreneurial skills. By engaging in design challenges that mirror real-world innovation cycles, students gain experience in identifying market needs, developing propositions, and understanding the commercial viability of their ideas. This prepares them for a diverse range of careers, from launching start-ups to contributing to established industries. The process of taking an idea from conception to a viable product or service cultivates resilience, communication skills, and an understanding of economic principles, which are valuable for all learners. While entrepreneurial approaches can enhance relevance and motivation, their curricular dominance risks narrowing D&T's educational purpose to market-oriented outcomes at the expense of exploratory, critical, and civic dimensions.

To realise this future, D&T requires sustained policy support, continuous curriculum refreshment, and strong advocacy for its unique contribution to education. It must continue to champion creativity, practical intelligence, and critical engagement with technology. By doing so, D&T can empower individuals to not only adapt to future challenges but actively shape a more innovative, sustainable, and equitable world, transcending traditional academic boundaries and demonstrating its profound utility for all learners (McLain et al., 2019). Viewed through the *typology* developed in the previous section, proposed futures for D&T can be understood as shifts in epistemic anchoring (towards *innovation-led* or *critical sociotechnical* orientations) rather than wholesale transformation of the subject. Future

development of D&T will therefore involve navigating persistent tensions rather than resolving them. Attempts to expand *ethical*, *digital*, and *entrepreneurial* dimensions must contend with assessment architectures, teacher preparation pathways, and curriculum time that are comparatively slow to change. The future of D&T education will be determined, less by the emergence of new tools or policy ambitions, than by how effectively education systems can reconcile *enduring epistemic tensions* within *evolving social*, *technological*, *and accountability contexts*.

Conclusions: what does this mean for research, policy, and practice?

This article has argued that D&T education in England (alongside its international siblings in the wider TED education cluster of subjects) is best understood not as a resolved curricular innovation, but as a *historically contingent hybrid discipline* formed through the partial and ongoing reconciliation of *craft*, *design*, *and technological knowledge traditions*. Tracing the subject's *antecedents*, *emergence* within the NC in England, subsequent *evolution*, and international *parallels* reveals that many of the persistent challenges associated with D&T (concerning status, assessment, teacher expertise, and curriculum purpose) are structural consequences of its *epistemic hybridity*, rather than the result of *policy missteps* or *implementation failure*. Recognising D&T as a subject 'in formation' helps to explain why repeated reforms have struggled to stabilise its identity and why similar tensions are evident across international contexts.

By situating English D&T within a wider global landscape and proposing a *typology of curriculum orientations*, this article contributes a comparative and conceptual language for understanding variation in TED education. The typology illustrates how national systems resolve the shared problem of integrating design and technological knowledge in different ways, privileging alternative *epistemic anchors*, *educational purposes*, and *assessment architectures*. Seen through this lens, debates about curriculum breadth, interdisciplinarity, STEM alignment, and assessment are reframed as questions of *curriculum settlement* rather than matters of local preference or quality alone. This reframing offers a more productive basis for explaining both convergence and divergence in TED subjects' development internationally.

The analysis carries important implications for stakeholders, which are best understood as illustrative consequences of the subject's hybrid character rather than prescriptive solutions. For **teachers**, professional development should be conceived not simply as periodic skills updating, but as sustained support for maintaining *hybrid professional identities* that integrate material expertise, designerly judgement, and technological understanding. Without such support, the epistemic demands placed on D&T teachers risk becoming unsustainable, particularly in contexts of rapid technological change and increased accountability pressures.

For **senior leaders** (e.g., school leadership teams, curriculum directors, or trust-level executives), the challenge extends beyond resourcing and advocacy. D&T requires curriculum stewardship that recognises the necessity of protected spaces for exploratory, iterative learning within performance-driven school systems. Where curriculum time, assessment structures, or option choices are narrowly optimised for predictability and examination efficiency, the distinctive educational value of D&T is disproportionately vulnerable. Leader-

ship decisions therefore play a critical role in shaping whether D&T's hybrid knowledge base can be enacted with integrity.

For **scholars** of D&T education, this article points toward the value of *historical-conceptual* and *typological* approaches for reframing long-standing debates in the field. Future research could productively employ comparative frameworks to examine how different curriculum settlements shape learner experience, assessment practices, and equity of access, as well as to investigate how emerging emphases (such as sustainability, ethics, and artificial intelligence) reconfigure existing epistemic balances. Longitudinal and cross-national studies will be particularly valuable in tracing how shifts between typological orientations manifest over time.

Teacher education and professional learning programmes face a related challenge. The **initial teacher education (ITE)** and **continuing professional development (CPD)** sector must grapple explicitly with the problem of forming *hybrid expertise* within institutional structures traditionally organised around disciplinary specialisation. Without deliberate attention to this tension, attempts to modernise curricula risk outpacing the capacity of the teaching profession to enact them meaningfully.

Finally, **policymakers** are confronted with a central paradox. While D&T is frequently invoked as essential to innovation, economic competitiveness, and technological literacy, efforts to simplify, instrumentalise, or standardise the subject risk destabilising the very epistemic hybridity that underpins its educational value. Sustained curriculum vitality is therefore unlikely to be achieved through episodic reform alone; rather, it depends on a willingness to engage with, and design for, the enduring tensions inherent in hybrid curriculum forms.

Several areas warrant further scholarly attention. A significant gap exists in understanding the long-term economic impact of D&T education on national innovation and productivity metrics. While anecdotal evidence and theoretical arguments suggest a positive correlation, robust empirical studies are less common. Research could also delve deeper into the psychological benefits of D&T, specifically its role in developing resilience, managing failure, and fostering a growth mindset in students. These dispositions are deeply embedded in the iterative, exploratory nature of design-led activity, where ambiguity, revision, and setback are not peripheral but central to progress. Because D&T provides structured opportunities for students to encounter uncertainty, test ideas, and respond constructively when outcomes do not initially succeed, it offers a uniquely rich context for studying how learners develop persistence and adaptive judgement over time. Incorporating greater scholarly attention to these affective and dispositional dimensions would not only strengthen the theoretical foundations of the field but also deepen understanding of the broader educational value of design- and technology-rich learning environments, particularly in relation to students' confidence, agency, and long-term engagement with creative and technological problem-solving. Comparative studies examining the effectiveness of different national approaches to D&T education, including the influence of cultural context on pedagogical outcomes, would also offer valuable insights. Finally, the ethical dimensions of technology education, particularly concerning AI, data privacy, and the societal implications of new designs, require more dedicated research to inform curriculum development. Addressing these gaps will further solidify the academic and practical standing of D&T/TED education on the global stage.

In conclusion, the future viability of D&T/TED education will be determined less by the adoption of specific technologies or policy initiatives than by how effectively education systems acknowledge and work with the subject's hybrid epistemic foundations. Recognising D&T's instability not as a weakness, but as a defining characteristic, offers a more robust basis for its continued development within an increasingly complex and uncertain global curriculum landscape.

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