Design and Technology Education: An International Journal

31.2

The Name You Can Say Isn't the Real Name: A Typology of Ideation for Design and Technology Education

Matt McLain, Liverpool John Moores University, United Kingdom

Abstract

This article is the first in a planned four-part series exploring the ideating-realising-critiquing triadic model of design and technology (D&T) activity. It develops a theoretically grounded typology of ideation for D&T education. Drawing on creativity research, design cognition, distributed and participatory creativity, and phenomenological accounts of embodied practice, it identifies eleven categories of ideation: abduction, adaption, collaboration, collection, combination, generation, participation, somaticisation, speculation, transformation, and transposition. These categories are organised along three analytically independent dimensions: *epistemic orientation* (the relationship between the ideative act and the problem frame), *social orientation* (how ideation is distributed across persons and systems), and *mediational resources orientation (*the mode of engagement through which the idea emerges). The resulting *multi-dimensional model* resists reduction to a single progression ladder. While the epistemic categories can be loosely ordered by cognitive demand, from adaptive modification within an accepted frame to transformative reframing, this ordering is neither rigid nor exhaustive; the *sociomaterial dimensions* (and a secondary *temporal dimension*) crosscut the *epistemic axis*. The article argues that progression in ideation is better understood as the expansion of a repertoire (in breadth, depth, and fluency) than as movement up a fixed hierarchy. Implications for curriculum design are discussed, including the need for more precise specification of the kind of ideation a learning activity is intended to develop, the visibility of gaps in curricula that attend to only one dimension, and the risk of deficit framing when adaptive ideation is treated as merely a stepping stone to real creativity. The emergent typology was developed in the context of the 2025 curriculum and assessment review in England and requires empirical validation through classroom-based research.

Keywords

curriculum design, design and technology education, ideation, iteration, typology

Introduction

The title of this article, "The name you can say isn't the real name," is borrowed from Le Guin's (Lao Tzu, 1997, p.15) translation of the fourth century BCE Taoist text, the Tao Te Ching (sometimes translated as "the way of virtue," 'tao' variously meaning way/path, technique, etc.; Figure 1). In doing so, I want to emphasise the problematic nature of definitions and categorisations, particularly when viewed as concrete and bounded. The limitations of language and sociotechnological variations of the use of terms mean that, whilst useful, meanings and classifications change subtly and significantly by crossing social, cultural, geographical and temporal boundaries. That being said, this study seeks to explore and outline the nature of the term 'ideation' in design and technology (D&T) education, particularly in the context of the

Department for Education (DfE) curriculum and assessment review in England (DfE, 2025) and provide a framework for teachers and curriculum designers to engage meaningfully with its concepts, principles and processes. This article is the first in a planned four-part series exploring epistemological structures for a revised version of the *design-make-evaluate paradigm* of D&T activity (re)presented as an *ideating-realising-critiquing triadic activity model*. The series is planned as follows: this first article develops a typology of *ideation*; the second will address *realising*, examining the material and procedural knowledge through which ideas are given form; the third will address *critiquing*, concerned with appraisal, judgement and the assessment of designerly work; and the fourth will *integrate the three activities* into a coherent account of D&T capability. The wider intent is not to prescribe a fixed sequence of classroom procedures but to offer teachers, curriculum designers and researchers a theoretically grounded vocabulary for the epistemic work of designing, of which this article contributes the first element.

Figure 1. The Chinese character for "Tao" (or "Dao"), meaning the "way" or "path" (Wikipedia, 2026a)

The inspiration for this article emerged from a conversation with a colleague, in which it became evident that the term ideation was insufficiently defined and integrated into current D&T practice. The current programme of study for D&T in the national curriculum for England (DfE, 2013) and subject content for the national examination at age 16 (DfE, 2015) do not mention the term but introduced the related and often conflated term *iteration* (discussed below in relation to ideation). It is understood here, tentatively, as a reflexive process of moving back and forth between ideas, materials and action in response to the pragmatic demands of making. The term was introduced to describe non-linear design processes, but with limited guidance on what this meant for the classroom and school curricula. Therefore, the introduction of the term ideation into the D&T lexicon would benefit from an expanded definition and understanding, from the outset, rather than retrospectively. When my colleague asked, simply, "So, what do you mean by ideation?", my ensuing hesitation highlighted how far the term's usage in current D&T curriculum discourse has outpaced its definition; accelerated by the proliferation of 'design thinking' models such as those presented by IDEO (2012) and Stanford's D.School (2018). The resultant findings provide a map of the ideation 'territory,' noting Korzybski's maxim "the map is not the territory" (1994, p.xvii), intended to foster a more nuanced understanding and to help specialist and non-specialist teachers and curriculum designers engage with meaningful content. The insights from this study have broad applicability and relevance to the globally diverse, yet fundamentally connected, expressions of technology education in school curricula (McLain et al., 2026).

Across the literature, ideation is consistently characterised as an early-stage process of producing and exploring novel ideas through the interplay of *divergent thinking* (for breadth) and *convergent thinking* (for refinement); a *dual-process framing* traceable to Guilford's (1950; 1967) foundational distinction between divergent and convergent production, captured in many models of design process including the Design Council's (2026) double diamond model.

The scope of ideation is typically framed around concept generation and development, *excluding prototyping (or realising)* and *evaluation (and critiquing)*, and is bounded by what Schön (1983) would recognise as the *reflective conversation* with the situation before that situation (or problem) is materially resolved. Theoretical frameworks converge on models linking idea expansion and judgement, with cognitive mechanisms including *analogical reasoning* (Casakin & Goldschmidt, 1999; Gentner, 1983), *design heuristics* and *structured exploration* of conceptual spaces (Boden, 2004). A review of the literature indicates that structured methods such as protocol analysis and controlled experimentation can increase idea volume and diversity but may constrain originality, particularly among novices (Jansson & Smith, 1991; Shah et al., 2003). Contextual variations emerge, including participatory approaches that extend ideation's scope to include stakeholder engagement in resource-limited settings (Sanders & Stappers, 2008), and embodied/material methods that foreground *thinking-through-making* as a legitimate ideative mode (Ingold, 2013; Sennett, 2008).

Several existing classification frameworks address parts of this terrain. Boden's (2004) distinction between exploratory, combinational and transformational creativity provides a powerful epistemic typology but does not differentiate within the exploratory category (where most D&T ideation falls) or account for social and material dimensions. Guilford's (1950; 1967) divergent–convergent production model captures a single axis of cognitive operation and says nothing about the mediational resources or social configuration in which that operation occurs. Kirton's (1976; 2003) adaption–innovation continuum maps cognitive style onto a bipolar scale but, by design, collapses the multi-dimensional space this article seeks to open up. Process models such as the double diamond describe when divergent and convergent phases occur but not the epistemic character of the ideation within them. What is missing is a framework that integrates the epistemic, social and mediational resources dimensions of ideation in a form sufficiently granular to support curriculum development, planning, pedagogy and assessment in D&T education. The typology proposed in this article addresses that gap.

Method

This article employs a conceptual framework analysis (Jabareen, 2009) to develop and propose a typology of ideation for D&T education. The approach is synthetic rather than empirical, drawing on established theoretical frameworks across research on *creativity* (Boden, 2004; Guilford, 1967), *design cognition* (Cross, 2006; Dorst, 2015; Schön, 1983), *participatory and distributed creativity* (Glăveanu, 2014; Sanders & Stappers, 2008; Sawyer, 2007), and phenomenological accounts of *embodied practice* (Ingold, 2013; Merleau-Ponty, 1962; Sennett, 2008). Jabareen's protocol was selected because it is designed for multidisciplinary phenomena that resist a single disciplinary lens, proceeding through iterative phases of mapping, categorising, deconstructing and integrating concepts drawn from heterogeneous literatures. The aim is to construct an analytically coherent classification of ideation types that is grounded in theory, responsive to the epistemic demands of D&T education as a curriculum entity, and useful for planning curriculum, pedagogy and assessment. The method involved four phases.

First, a structured review of the theoretical literature on creativity, design cognition and design education was conducted to identify the principal *epistemic orientations* through which ideation operates. The corpus was assembled through three routes: (i) systematic searches of Scopus, Web of Science and ERIC using the terms ideation, design cognition, creativity typology and design education; (ii) backward citation chaining from seminal texts identified in the initial searches (Boden, 2004; Cross, 2006; Guilford, 1967; Schön, 1983); and (iii) forward citation tracking of key works to capture recent extensions. Sources were included if they met at least two of three criteria: (i) foundational status, defined as attracting 500+ citations or constituting a field-defining monograph; (ii) direct relevance to the epistemic character of ideation (as distinct from general creativity or divergent thinking); and (iii) applicability to the specific context of D&T education, particularly in light of the current curriculum review in England (DfE, 2025). Sources that addressed creativity measurement, psychometric testing or domain-general innovation management without reference to design cognition were excluded.

Second, the identified orientations were organised into categories through an iterative process of analytical comparison across four refinement cycles. An initial long-list of sixteen candidate categories was generated from the literature; each was tested against three discriminant criteria: internal coherence (does it describe a distinct epistemic operation not already captured by another category?), theoretical grounding (is it supported by an established and independent research base?), and pedagogical utility (does it name something a teacher could recognise, plan for and assess?). Categories that failed the internal-coherence test were merged (e.g., early separate entries for metaphor and analogy were consolidated into transposition); categories that lacked an independent theoretical base were subsumed as strategies within a broader type. This process yielded the eleven categories presented in Table 1.

Third, the categories were clustered along three analytically independent dimensions (*epistemic*, *social and mediational resources)* through a process of cross-tabulation: each category was plotted against each dimension to test whether it could, in principle, co-occur with any value on the other dimensions. Categories that could not were treated as dimension-specific; those that could crosscut freely confirmed the independence of the axes. For example, combinatorial ideation can be conducted individually or collaboratively (the social dimension) and through sketching, digital modelling or physical making (the mediational resources dimension), so it crosscuts both axes. By contrast, transformation is tied to the epistemic dimension and does not vary independently along it. The interrelationships were modelled diagrammatically (Figure 2).

Fourth, the resulting typology was stress-tested against four known problems in D&T curriculum discourse: (i) the *conflation of ideation with iteration*, tested by asking whether any category in the typology necessarily entails iterative cycling or whether iteration is better understood as a temporal structure within which ideation operates; (ii) the tendency to treat *epistemic categories as a simple developmental hierarchy*, tested by examining whether the social and mediational resources categories could be rank-ordered on the *same axis;* (iii) the *marginalisation of adaptive and embodied forms of ideation* in assessment frameworks, tested by asking whether the typology provides a vocabulary that positions these as substantive rather than deficient; and (iv) the *risk of category proliferation*, tested by attempting to generate a classroom scenario that required a twelfth category not reducible to any combination of the

existing eleven. A fuller typology of iteration itself, as distinct from the temporal structuring of ideation treated here, is beyond the scope of this article and is reserved for the companion article on realising within this series.

As a conceptual study, this work does not present primary empirical data. Its contribution lies in the originality of the typological framework itself: specifically, a multi-dimensional model (Figure 2) that resists reduction to a single progression ladder and instead treats the three orientations as independent axes of *a repertoire that expands and deepens over time*. This contribution matters for D&T education, and more broadly for the global phenomenon of "technology education," where existing accounts of ideation tend either toward under-theorised catch-all terms ("ideating", "generating ideas", "developing ideas") or toward borrowed creativity taxonomies that do not attend to the distinctive epistemic character of designing. The rigour of the approach rests on the transparency of the analytical process, the depth of engagement with source theories, and the systematic testing of the typology against its own limitations.

The development of this article involved the use of a generative artificial intelligence (GenAI) tool, Claude Opus (Anthropic, 2024–2025), as an interlocutor during the analytical and drafting phases of the work. I engaged in extended dialogue with the GenAI to: (a) test and refine the epistemic categories of the typology against theoretical sources; (b) identify weaknesses in proposed clustering logics; (c) explore the implications of treating the typology as a hierarchy versus a multi-dimensional repertoire; and (d) draft and iteratively revise the prose of the article. The GenAI's role was not to independently generate the typology or determine the article's argument but to support the selection of theoretical sources. The intellectual contributions were human led throughout the process (Downes et al., 2026). The GenAI functioned as a *critical respondent*, surfacing counterarguments, flagging internal inconsistencies, and helping to articulate distinctions that I had identified but not yet expressed with sufficient precision or where there was unhelpful overlap between the types. All outputs from the GenAI were reviewed, revised and verified by me against the primary theoretical sources. I take full responsibility for the content, argument and any errors in this article.

Results

This section presents findings from the literature, culminating in an emergent typology that classifies ideation according to *epistemic orientation* (the relationship between the design idea and existing knowledge) and extends to encompass *sociomaterial and temporal dimensions* of iterative design practice. Each category in Table 1 is grounded in established theoretical frameworks and illustrated with approaches and strategies relevant to D&T education. Table 1 presents the types in alphabetical order, emphasising the largely non-hierarchical nature of their relationships. Ideation and iteration are conceptually distinct but operationally entangled processes. **Ideation** names the *generative moment* (the production of design propositions that did not previously exist) and encompasses a range of epistemic orientations from *adaptive modification* to *transformative reframing* (Boden, 2004; Dorst, 2015). **Iteration** names the *temporal structures* within which ideation operates: the *deliberate cycling of ideating-realising-critiquing sequences* in which the output of each pass becomes the input for the next (Rittel & Webber, 1973; Schön, 1983).

The distinction matters because the two are routinely conflated in D&T curriculum discourse, where "iterative designing" is often used as a catch-all for any *non-linear* activity. Yet they answer different questions: **ideation asks,** *"what kind of epistemic work produces the idea?"* while **iteration asks**, *"what cyclical structure enables that work to develop over time?"* Critically, neither is self-sufficient. *Ideation without iteration* produces propositions that are never tested against material, social or functional realities. *Iteration without ideation* degenerates into incremental optimisation within a fixed frame, foreclosing the possibility of reframing that Schön (1983) identified as central to reflective design practice.

In classroom settings, both are vulnerable to the same structural pressures: assessment regimes and timetable constraints that reward linear progression toward a predetermined outcome tend to flatten ideation into superficial sketching and reduce iteration to a single *ideate-realise-critique* cycle, hollowing out the epistemic substance of each while preserving their procedural form.

Because the categories in Table 1 share overlapping theoretical terminologies, reliable use of the typology requires explicit diagnostic tests for the most easily confused pairs. The discriminant question in each case targets the cognitive operation, rather than the surface activity:

- **Combination versus Transposition:** combination synthesises elements from multiple sources into a novel configuration in which the elements lose their original identity; transposition preserves the relational structure of a single source domain and maps it onto a target domain (Gentner, 1983).
    - Diagnostic question: *Can the pupil identify a single source domain whose structure has been carried across, or have elements from several sources been blended beyond individual traceability?*
- **Abduction versus Transformation:** abduction reasons backward from a surprising observation to a plausible design proposition within the existing problem frame; transformation reconstitutes the frame itself (Dorst, 2011; Boden, 2004).
    - Diagnostic question: *Has the problem definition changed, or has a new solution been inferred for the same problem?*
- **Generation versus Speculation:** generation produces novel propositions oriented toward a present design need; speculation projects ideation toward counterfactual or future scenarios without requiring immediate resolution (Dunne & Raby, 2013).
    - Diagnostic question: *Is the idea intended to solve the problem as currently framed, or to open debate about whether the framing itself should change?*
- **Collaboration versus Participation:** collaboration involves joint ideation among peers with comparable epistemic standing; participation positions users or stakeholders as co-designers with legitimate authority derived from lived experience (Sanders & Stappers, 2008).
    - Diagnostic question: *Does the social configuration include people whose authority comes from being affected by the design outcome rather than from design expertise?*

Table 1. A typology of ideation with epistemic categories for design and technology education

Category	Description	Theoretical basis	Approaches & Strategies
Abduction	Reasoning backward from an observed situation, anomaly or user behaviour to a plausible design proposition. Inference to the best explanation; the cognitive move is from effect to cause or from need to possible response.	Abduction as the logic of discovery: generating explanatory hypotheses from surprising observations (Peirce, 1903/1998). Design abduction: the working principle and the object are co-evolved through iterative framing (Dorst, 2011; 2015). Designerly ways of knowing emphasising solution-focused, conjectural reasoning (Cross, 2006; 2011). Abductive synthesis through sensemaking in design research (Kolko, 2010).	Design ethnography / user observation: identifying latent needs from observed behaviour. How Might We… questions: reframing observations as actionable design prompts. Root cause analysis: tracing a problem manifestation back to its generating conditions. Scenario construction: building plausible use narratives from fragmentary evidence.
Adaption	Deliberate modification of an existing solution to meet changed constraints, contexts or user requirements. Retains the core logic of the source while altering contingent features.	Adaption–Innovation Theory: individuals differ in preferred cognitive style along an adaptor–innovator continuum. Adaptors solve problems within accepted paradigms (Kirton, 1976; 2003). Functional creativity framework positioning adaptive ideation as purposeful and context-sensitive (Cropley & Cropley, 2010). D&T assessment research showing that much pupil design activity is adaptive rather than generative (Kimbell, 2011).	SCAMPER: systematic modification prompts (Substitute, Combine, Adapt, Modify, Put to other use, Eliminate, Reverse) (Eberle, 1971). Product analysis leading to redesign: structured disassembly followed by targeted modification. Constraint shifting: changing one variable (material, scale, user, context) while holding others constant. Parametric variation: adjusting dimensional or material parameters within a fixed topology.
Collaboration	Joint ideation where interaction between participants generates outcomes that no individual could produce alone. The social process is constitutive of, not merely a context	Group creativity and collaborative emergence; ideas as interactional achievements (Sawyer, 2007; 2012). Cognitive stimulation model of group brainstorming (Paulus & Nijstad, 2003). Group cognition: collaborative knowledge-building as irreducible to	Co-design workshops: structured sessions with mixed stakeholders. Design charrettes: intensive, time-bounded collaborative design sessions. Thinking Hats: structured role-rotation in group ideation (de Bono, 1985).

Category	Description	Theoretical basis	Approaches & Strategies
	for, idea generation.	individual contributions (Stahl, 2006). Creative collaboration and complementarity of expertise (John-Steiner, 2000).	World Café: rotating small-group conversations building on each table's output. Gallery walk / critique: iterating through peer feedback cycles.
Collection	Distributed ideation across a network of actors (human and non-human) where ideas emerge from the system rather than from any individual or bounded group. Emphasises cultural, material and institutional mediators.	Distributed creativity: creativity as action distributed across actors, audiences, artefacts and affordances (Glăveanu, 2014; 2020). Expansive learning and collective concept formation in activity systems (Engeström, 2008). Distributed creativity in performance: emergent properties of interaction (Sawyer & DeZutter, 2009). Systems model: creativity at the intersection of individual, domain and field (Csikszentmihalyi, 1999).	Open innovation / crowdsourcing: distributed idea generation across organisational boundaries. Wiki-based / platform-mediated design: asynchronous collective contribution. Maker communities: ideas emerging through shared practices, tools and norms. Actant mapping: tracing how ideas circulate and transform across a network of human and non-human actors (Latour, 2005).
Combination	Synthesis of elements drawn from two or more existing solutions or domains into a novel configuration. The resulting idea has traceable lineage to multiple sources but is not reducible to any single one.	Combinational creativity: making unfamiliar connections between familiar ideas (Boden, 2004). Bisociation: connecting habitually incompatible frames of reference (Koestler, 1964). Structured imagination: new concepts are generated by combining and modifying stored category exemplars (Ward, 1994). Concept–Knowledge Theory: design as expansion through concept–knowledge interaction (Hatchuel & Weil, 2009).	Morphological analysis: systematic combination of parameter values across a matrix (Zwicky, 1969). Forced connections: juxtaposing unrelated objects or concepts to generate hybrid ideas. Concept fan: broadening and combining alternative directions (de Bono, 1985). Bio-inspired design / biomimicry: transferring biological strategies to technical problems via structural mapping.
Generation	Production of ideas with no direct antecedent in the designer's existing repertoire. Emphasises novelty and originality; the idea cannot be	Divergent production as a measurable cognitive operation distinct from convergent thinking (Guilford, 1950; 1967). Exploratory creativity: generating novelty by exploring a conceptual space	Brainstorming: deferred-judgement idea generation (Osborn, 1953). Blue-sky sketching: unconstrained graphic exploration without reference to existing products.

Category	Description	Theoretical basis	Approaches & Strategies
	traced to a single prior source.	without transforming its rules (Boden, 2004). Geneplore model: ideation as cycles of generative and exploratory phases producing pre-inventive structures (Finke, Ward & Smith, 1992).	Random input / provocation: introducing arbitrary stimuli to displace fixation (de Bono, 1970). Brainwriting 6-3-5: written variant generating volume through structured rotation.
Participation	Ideation conducted with (not for) the people who will use, inhabit or be affected by the designed outcome. Users and stakeholders are positioned as co-designers with legitimate epistemic authority.	Co-creation and co-design: moving users from 'subjects' to active partners in the design process (Sanders & Stappers, 2008). Participatory design: Scandinavian tradition of democratic involvement (Simonsen & Robertson, 2013). Design as political practice: participation as empowerment (Bannon & Ehn, 2013). Participatory design in architecture: dialogue as the medium of design (Luck, 2018).	Generative toolkits: card sorts, collage, mapping kits enabling non-designers to externalise ideas (Sanders & Stappers, 2008). Empathy mapping: structured capture of user perspectives to inform co-ideation. Experience prototyping: stakeholders physically enacting scenarios with rough prototypes. Photovoice / cultural probes: participants documenting their own contexts as ideation stimuli.
Somaticisation	Ideation that proceeds through physical manipulation of materials and tools rather than through prior mental representation (materiality). Thinking-through-making: the material resists, suggests, and co-produces the idea.	Making as a process of growth and correspondence with materials, not imposition of form on matter (Ingold, 2013). Craftwork and the dialogue between hand and head (Sennett, 2008). Designerly thinking as embodied, situated practice (Kimbell, 2012). Reflective conversation with the situation (Schön, 1983). Phenomenology of perception and bodily intentionality as the ground of cognition (Merleau-Ponty, 1962).	Sketch modelling: rapid physical models in card, foam or clay to think through form and spatial relationships. Material exploration / tinkering: open-ended interaction with unfamiliar materials. Rapid prototyping: iterative physical testing to generate and refine ideas simultaneously. Haptic sketching: using gesture and touch to develop spatial and ergonomic ideas.
Speculation	Ideation oriented toward imagining alternative or counterfactual futures rather than solving present	Speculative and critical design: design as a medium for debating implications of emerging technologies (Dunne & Raby, 2013).	Design fiction: creating diegetic prototypes that embed a technology in a plausible narrative world. What-if scenarios: systematically varying

Category	Description	Theoretical basis	Approaches & Strategies
	problems. The purpose is to open debate, provoke reflection, or make values and assumptions visible.	Speculative design and public engagement with technology futures (Auger, 2013). Design futuring: redirective practice oriented toward sustainability (Fry, 2009). Experiential futures: making alternative futures tangible through designed artefacts (Candy & Dunagan, 2017).	assumptions about the future to generate provocative propositions. Counterfactual artefacts: designing objects from imagined alternative presents or pasts. Futures wheel / cone: mapping possible, probable and preferable futures to orient ideation.
Transformation	Reconstitution of the problem space itself. The designer does not solve the problem as given but reframes it such that the solution category changes. The design space shifts rather than being explored or exploited.	Transformational creativity: changing the rules of the conceptual space, not merely exploring within them (Boden, 2004). Reframing in reflective practice: problem-setting as distinct from problem-solving (Schön, 1983). Frame creation: developing new frames that reconstitute paradoxical situations (Dorst, 2015). Transformative learning theory: critical reflection leading to perspective transformation (Mezirow, 1991).	Frame creation: deliberately constructing new problem frames from themes (Dorst, 2015). Problem reversal / inversion: inverting core assumptions to expose alternative framings. First principles reasoning: decomposing to fundamental truths and rebuilding without inherited assumptions. Paradigm mapping: making implicit frames visible in order to deliberately transgress them.
Transposition	Transfer of a relational structure, or structures, from a known source domain to a less understood target domain. The cognitive operation is structural mapping: identifying correspondences between systems rather than surface similarities.	Structure-mapping theory: analogy involves alignment of relational (not object-attribute) structure (Gentner, 1983). Analogy use in design: expert designers draw on more distant and structurally deeper analogies (Casakin & Goldschmidt, 1999). Analogical reasoning in design cognition. Multi-constraint theory of analogical mapping (Holyoak & Thagard, 1995). Synectics: making the strange familiar and the familiar strange (Gordon, 1961).	Case-based reasoning: retrieving and adapting prior design cases. Cross-domain transfer: deliberately searching distant domains for structural parallels. Metaphor generation: using figurative language to map source–target relationships. Stranging: making the strange familiar and the familiar strange through systematic analogy types, including personal, direct, symbolic, fantasy, etc.

Discussion

The evidence supports a broadly developmental trajectory in cognitive demand. Drawing on the typology, the epistemic categories can be loosely ordered by (i) the complexity of the cognitive operations an act requires (challenge), (ii) the degree of epistemic distance (progression) it opens from existing knowledge, and (iii) the extent to which it demands metacognitive awareness of one's own framing (learning). These three criteria are analytically distinct and need not co-vary. Epistemic distance, in particular, should not be read as a single linear scale: a learner may move a considerable distance from familiar knowledge while performing cognitively modest operations, so the criteria are better pictured as separate dimensions that a given ideation episode occupies to differing degrees. In a Key Stage 3 project, for instance, a pupil adapting a familiar bag design for a new user (adaptive) and a pupil reframing 'a bag' as 'a way to carry belongings hands-free' (transformative) are not simply lower and higher on one ladder; they are doing different epistemic work along these distinct criteria. Adaptive ideation (modifying an existing solution within a stable frame) makes fewer demands on working memory and tolerance of ambiguity than combinatorial ideation, which requires the simultaneous manipulation of elements from multiple sources. Transposition (analogical) requires the additional operation of structural mapping across domains, which Gentner (1983) and Casakin and Goldschmidt (1999) show is developmental: novice designers rely on surface-level analogies while experts draw on structurally deeper and more distant ones. Abductive ideation adds the demand of reasoning backward from incomplete evidence to a plausible generative explanation, which Dorst (2011) positions as the most sophisticated form of design reasoning. Transformative ideation sits at the far end because it requires not just operating within a problem frame but recognising and reconstituting the frame itself; what Schön (1983) calls problem-setting as opposed to problem-solving, and what Boden (2004) distinguishes as transformational rather than exploratory or combinational creativity.

A rough (and imperfect) progression might look like this, reading from the typology:

Adaptive → Generative → Combinatorial → Transposition → Abductive → Transformative

This sequence reflects increasing epistemic distance from the source material, increasing tolerance of ambiguity, and increasing metacognitive demand. There is empirical support for elements of this sequence: Kirton's (1976; 2003) adaption–innovation continuum maps the adaptive–generative axis onto measurable cognitive style differences; Finke, Ward and Smith's (1992) 'Geneplore' model shows that generative phases require exploratory phases to become productive, implying a developmental dependency; and Cropley and Cropley (2010) demonstrate that functional creativity in technology education progresses from routine to contributory stages that map loosely onto the *adaptive-combinatorial-transformative* arc.

Problems treating the typology as a simple hierarchy

First, several categories resist placement on a single axis of cognitive complexity. Somatic ideation (Ingold, 2013; Sennett, 2008) involves a different kind of knowing (often more sophisticated in its responsiveness to material affordance but less amenable to formal articulation) rather than a simpler one; collective ideation (Glăveanu, 2014) involves distributed processes irreducible to the sum of individual operations; and speculative ideation (Dunne & Raby, 2013; Stables, 2020) is not necessarily cognitively harder than adaptive ideation but is

epistemically different in kind, oriented toward opening possibilities rather than resolving them.

Second, and most fundamentally, there is a risk that a hierarchical model inadvertently reproduces the deficit framing that the typology was partly designed to challenge. If adaptive ideation sits at the bottom of a progression ladder, and assessment systems reward position on that ladder, then the sophisticated analytical work involved in skilled adaptation (identifying which features of a source solution are load bearing, manipulating contingent features while preserving function) gets devalued as a lower-order activity. Kimbell's (2011) work on D&T assessment is relevant here: much pupil design activity is adaptive and treating that as merely a stepping stone to 'real' creativity misrecognises the epistemic substance of what pupils are actually doing.

What might work better is a *multi-dimensional progression model* that treats the typology's categories not as rungs on a ladder but as a repertoire that expands and deepens over time. On this account, progression would involve three things simultaneously: an increasing range of epistemic orientations the learner can draw upon (*repertoire breadth*), an increasing sophistication within each orientation (*repertoire depth*), and an increasing capacity to move deliberately between orientations in response to the demands of the design situation (*repertoire fluency*). A novice might operate predominantly in adaptive mode with occasional generative episodes; an advanced learner might fluidly shift between abductive framing, combinatorial synthesis and embodied-material exploration within a single design session, selecting the epistemic mode that fits the moment.

If curriculum-making is assemblage work, then progression in ideation is not a movement up a fixed hierarchy but an enrichment and expansion of the assemblage: *more actants*, *more connections*, *more capacity to reconfigure* the relations between them in response to an emerging situation. The learning objective is not 'to move from adaptive to transformative,' but 'to develop the capacity to assemble and reassemble a wider range of ideative resources with greater deliberateness and contextual sensitivity.'

Clustering and Categorising the Types

That the types can be grouped in several defensible ways is itself revealing: it confirms the typology is genuinely multi-dimensional rather than a single ordered list.

Clustering by *primary dimension* is the most straightforward. The eleven categories are not all answering the same question, and separating them by the question they address produces three clear clusters and two that sit more ambiguously:

- The first cluster addresses **epistemic** orientation (the relationship between the idea and existing knowledge). This contains the six categories that describe the cognitive-epistemic character of the ideative act: adaptive, generative, combinatorial, transposition, abductive and transformative. These are the categories that answer the question *"what kind of knowledge work is the designer doing?"*
- The second cluster addresses **social** orientation (how ideation is distributed across persons and systems). This contains collaborative, collective and participatory. The distinction between them matters: collaborative describes bounded group processes

where interaction generates emergent outcomes (Sawyer, 2007); collective describes distributed, networked ideation across a system that exceeds any bounded group (Glăveanu, 2014; Engeström, 2008); and participatory specifies a political-ethical commitment to positioning users and stakeholders as co-designers with epistemic authority (Sanders & Stappers, 2008). They share a concern with the social unit of ideation but differ in scale, structure, and normative orientation.

- The **mediational resources orientation and speculation** sit less comfortably in this clustering because they answer different questions. Somaticisation (embodied cognition) addresses the mediational resources orientation of ideation (through what mode of engagement does the idea emerge); speculative addresses the temporal orientation (toward what horizon is the ideative work directed). Both crosscut the epistemic and social clusters.[1]

Clustering by *relationship* to the existing frame produces a different and arguably more pedagogically useful grouping:

- Categories that work within an **accepted problem frame** (adaptive, combinatorial, transposition) all take the design situation as given and operate within its terms. The ideative work involves modifying, recombining or transferring elements without questioning the framing assumptions. This maps onto the exploitation side of March's (1991) exploration-exploitation distinction and onto Kirton's (1976) adaptor pole.
- Categories that generate **beyond the existing frame** (generative, abductive, speculative) all involve producing propositions that exceed what the current knowledge base or problem frame would predict. Generative ideation produces novel propositions from within a conceptual space (Boden's exploratory creativity); abductive ideation infers new framings from surprising observations (Dorst, 2011); speculative ideation projects ideation into counterfactual or future design spaces (Dunne & Raby, 2013). They share

[1] The mediational resources orientation is not merely an additional variable but rests on a distinct account of what ideation is. Where the epistemic categories tend to presuppose ideation as mental representation that precedes and directs action, somaticisation draws on a phenomenological tradition in which cognition is embodied and enacted rather than prior to the body's engagement with the world (Merleau-Ponty, 1962). On this view the idea does not exist fully formed in the mind and then await expression; it is constituted in the designer's bodily intentionality and in the 'correspondence' between maker and material (Ingold, 2013), in the dialogue between hand and head (Sennett, 2008), and in the reflective conversation with a resistant situation (Schön, 1983). The typology therefore treats the mediational resources orientation as more than a channel of communication: the medium of engagement is partly constitutive of the idea, so that a form worked out in clay, in code or in conversation is not the same idea rendered differently but, in an important sense, a different act of ideation. This phenomenological grounding has a direct consequence for pedagogy and assessment. If somatic and material ideation is constituted in action rather than recovered from a prior mental plan, then it cannot be fully evidenced through the propositional and representational traces (sketchbooks, written rationales, evaluations) on which school-based assessment typically relies. Embodied ideation leaves its record in the handling of tools and materials and in the qualities of the artefact itself, forms of knowing that are resistant to written articulation (Kimbell, 2012). This is one reason holistic, comparative approaches to judging designerly work, such as Adaptive Comparative Judgement, have gained traction (Kimbell, 2012): they attend to qualities of the whole that analytic mark schemes fragment. Recognising the mediational resources orientation as a distinct axis of ideation thus foregrounds a challenge that a purely epistemic account of creativity leaves invisible.

the characteristic of reaching beyond what is currently known or assumed, but they do so through different cognitive operations.

- Transformative ideation stands alone as the category that **reconstitutes the frame/framing**. It is not working within the frame (like adaptive or combinatorial) nor generating beyond it (like generative or speculative) but changing it; what Boden calls transformational creativity, what Schön calls problem-setting, what Dorst calls frame creation. This is why it resisted a simple position in the progression hierarchy we discussed earlier: it is not just harder than the other categories, it is operating at a different logical level; on the rules of the conceptual space rather than within them.
- The **social** cluster (collaborative, collective, participatory) then crosscuts the entire epistemic landscape. Any of the epistemic orientations can be enacted individually or socially, and the social configuration changes the character of the ideation without changing its epistemic type. A group can do collaborative-adaptive ideation (a design team systematically modifying an existing product together) or collaborative-transformative ideation (a co-design workshop that reframes the problem). This cross-cutting relationship is important because it means the social categories are not alternatives to the epistemic categories but a separate axis that operates simultaneously.

The **pedagogical implication** is that curriculum planning for ideation must attend to at least three things at once: which *epistemic orientation* is being developed, what *social configuration* is being used, and through what *medium* the ideation is conducted. A scheme of work (medium-term planning) that cycles only through epistemic orientations while holding the social and material dimensions constant develops only one axis of the repertoire.

The multi-dimensional structure also clarifies the typology's relationship to existing frameworks. Boden's (2004) exploratory category is distributed here across generative, abductive and speculative, each involving a distinct cognitive operation that the single label elides. Guilford's (1950; 1967) divergent–convergent axis does not distinguish between epistemic types of divergent work; Kirton's (1976; 2003) adaption–innovation continuum captures one pole and collapses the rest. In each case, the existing framework illuminates one facet of ideation but suppresses others; the present typology holds multiple facets in view simultaneously.

Modelling the Typology of Ideation

The model proposed in Figure 2 presents a typology of ideation for D&T education organised around a single structuring principle: the *epistemic relationship* between the *ideative act* and the *problem frame* within which it operates. Seven categories of ideation are arranged across three zones. The *first zone* (adaption, combination and transposition) describes ideation that works within an accepted problem framing, modifying, synthesising or structurally mapping existing knowledge without questioning the terms in which the design situation has been constituted. The *second zone* (abduction, generation and speculation) describes ideation that reaches beyond the problem framing, producing propositions that exceed what the current knowledge base or frame would predict, whether through backward inference from surprising observations (Dorst, 2011; Peirce, 1903/1998), de novo (from the beginning) exploration of a conceptual space (Boden, 2004; Guilford, 1967), or projection into counterfactual futures

(Dunne & Raby, 2013). The *third zone* (transformation) describes ideation that reconstitutes the problem framing itself, changing the rules of the conceptual space rather than operating within or beyond them (Boden, 2004; Schön, 1983). The model does not propose a rigid hierarchy. Rather, it describes an increasing epistemic distance (progression) from existing knowledge and an increasing demand for metacognitive awareness of one's own framing assumptions. In practice, ideation episodes frequently move across zones as a design situation develops; a combinatorial synthesis may surface a contradiction that triggers abductive reframing, which may in turn precipitate a transformative reconstitution of the problem. The model's purpose is analytical: to provide a vocabulary for identifying the kind of epistemic work involved in ideation, and thereby to support more deliberate curricular and pedagogical decision-making about which forms of ideation are being taught, practised, and assessed.

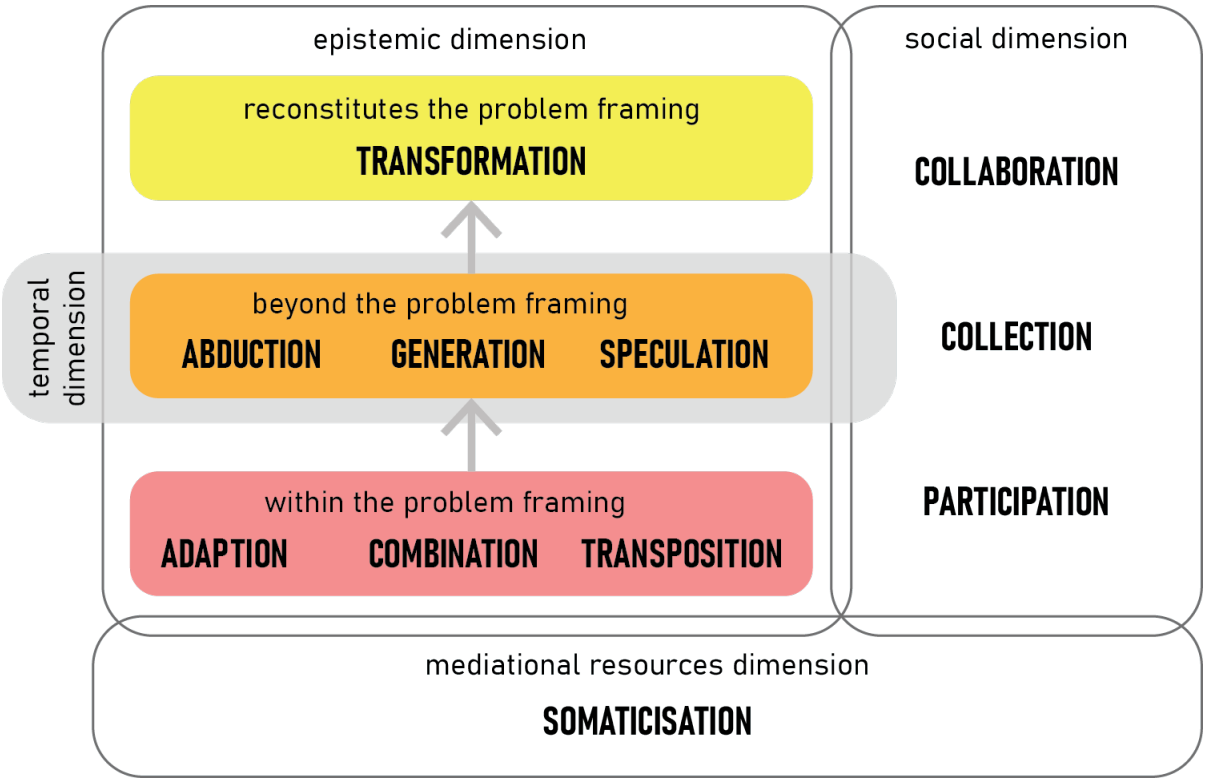

Figure 2. Ideation model with three dimensions (epistemic, social and mediational resources orientations)

Figure 2 captures the three-axis clustering logic (with a fourth crosscutting the central theme) discussed above. A few things to note about how it reads include:

- The main box presents the **epistemic** (vertical) axis organising the epistemic categories by their relationship to the design frame, with upward arrows indicating increasing epistemic distance from existing knowledge. This axis most closely maps onto a progression model, with the caveats discussed above about not treating it as a simple hierarchy.
    - Cutting across the epistemic dimension, the **temporal** bar highlights terms with a time-and-space dimension: abduction focuses on what already exists around the

design (past), generation draws on the designer's internal resources (present), and speculation projects beyond immediate experience (future).

- The **social** column spans all three epistemic zones deliberately: collaborative, collective and participatory are not a fourth rung on the ladder but an independent dimension that can be combined with any epistemic orientation.
- The **mediational resources** bar at the bottom crosses everything because it describes the *medium* through which ideation is conducted, not the epistemic or social type. It sits on a different axis entirely.

What the diagram makes visible is that a fully specified description of any ideation episode requires at least three coordinates: where it sits on the epistemic axis, what social configuration it uses, and through what medium it proceeds. It could be argued that most curriculum planning in D&T attends only to the first and, even then, only loosely.

A brief worked example illustrates what a three-coordinate description can do. Consider a Year 9 (age 13-14 years), key stage 3 (lower secondary), project in which pupils are asked to design a product that reduces single-use plastic in their school. In the *first lesson* the teacher uses a *'How Might We…'* prompt to reframe observational data from a lunchtime waste audit; the epistemic work is *abductive* (reasoning backward from observed behaviour to a design proposition), the social configuration is *collaborative* (pairs generating inferences from shared data), and the medium is *verbal-conceptual*. In the *second lesson*, pupils use SCAMPER to modify an existing reusable container; this is adaptive, individual and verbal-graphic. A *third lesson* introduces sketch modelling in card and foam, where the medium shifts to *somatic* (embodied-material) and the epistemic orientation to *combinatorial* (pupils synthesise features from multiple existing products or ideas). In a *fourth lesson*, pupils co-design with younger pupils who will use the product; this is participatory and, depending on whether the session stays within the existing brief or surfaces a need to reframe the problem entirely, could be adaptive or transformative.

Read through the typology, this four-lesson sequence covers three epistemic orientations, two social configurations and two media; but it does not include any speculative, generative or collective ideation, nor does it test whether pupils can shift deliberately between orientations within a single session. Without the typology, the scheme of work might be described simply as 'pupils develop ideas through a range of activities.' With it, a teacher can see exactly which parts of the ideation repertoire are being exercised and which are absent and can make a curricular decision about whether those absences are *intentional* (justified by the project's scope) or *inadvertent* (a gap in the learners' developing repertoire).

Conclusion

This article set out to develop a theoretically grounded typology of ideation for D&T education, motivated by the observation that the term remains insufficiently defined in curriculum discourse; often reduced to a procedural catch-all or borrowed from creativity taxonomies that do not attend to the distinctive epistemic character of designing. Drawing on established frameworks in creativity research, design cognition, distributed and participatory creativity, and phenomenological accounts of embodied practice, the article identifies eleven categories of ideation and organises them along three analytically independent dimensions: *epistemic*

orientation (the relationship between the ideative act and the problem frame), *social orientation* (how ideation is distributed across persons and systems), and *mediational resources orientation (*the mode of engagement through which the idea emerges).

The resulting model (Figure 2) resists reduction to a single progression ladder. Whilst the epistemic categories can be loosely ordered by cognitive demand (from adaptive modification within an accepted frame, through combinatorial synthesis and analogical transposition, to abductive inference, generative exploration, speculative projection and transformative reframing), this ordering is neither rigid nor exhaustive. The social and material dimensions crosscut the epistemic axis entirely: any epistemic orientation can be enacted individually or collaboratively, through verbal-conceptual or embodied-material means. Progression in ideation, on this account, is better understood not as movement up a fixed hierarchy but as the expansion of a repertoire; in *breadth* (the range of epistemic, social and mediational resources orientations a learner can draw upon), in *depth* (increasing sophistication within each orientation), and in *fluency* (the capacity to move deliberately between orientations in response to the demands of a design situation).

Three implications follow for curriculum design in D&T education. *First*, the typology provides a more precise vocabulary for specifying what kind of ideation a learning activity is intended to develop, moving beyond generic directives to generate and develop ideas toward deliberate selection of and engagement with epistemic, social and mediational resources orientations. *Second*, the multi-dimensional structure makes visible what a balanced curriculum for ideation would need to address and, perhaps more usefully, what is typically absent. A scheme of work that cycles only through epistemic orientations while holding the social and material dimensions constant develops only one axis of the repertoire. *Third*, the model challenges the deficit framing that arises when adaptive ideation is positioned at the bottom of a progression ladder. The sophisticated analytical work involved in skilled adaptation (identifying central features, manipulating contingent variables while preserving function) demands recognition as substantive epistemic activity, not merely a stepping stone to real creativity.

The typology has clear limitations. Its eleven categories represent a principled count, not an arbitrary inventory: the upper bound was tested during the stress-test phase (no scenario required a twelfth irreducible category) and the lower bound by pairwise merges (each merge eliminated a theoretically grounded distinction). The three-dimensional structure itself is a parsimony device, reducing the descriptive space to three independent coordinates. Nevertheless, the count is revisable; empirical work may reveal categories that teachers cannot reliably distinguish in practice (suggesting a merge) or epistemic operations the typology does not yet capture (suggesting an addition). As a conceptual framework, it requires empirical validation. Classroom-based research is needed to test whether the categories are recognisable and usable by teachers, whether the proposed dimensions genuinely operate independently, and whether the repertoire model of progression is borne out in longitudinal studies of learner development (cf. Kimbell & Stables, 2007). The boundaries between categories are, by design, permeable (an ideation episode may shift between abductive and transformative orientations within a single design session) and the framework does not prescribe how such boundary-crossing should be assessed. Furthermore, the typology was developed in the specific context of D&T education in England and its transferability to other national curricula and to broader conceptions of technology education remains to be explored.

Figure 3. Taoist yinyang, or 'taijitu,' symbol that represents opposition forces (e.g., light/dark, active/passive), interconnected, interdependent, and dynamically balanced in a greater whole (Wikipedia, 2026b)

Returning to the Taoist provocation with which this article began: "the name you can say is not the real name." The typology offered here is, necessarily, a naming and an attempt to make the epistemic substance of ideation visible and articulable. It does not capture ideation as it is lived in all its situated, emergent, materially entangled complexity. But it provides, I hope, a more differentiated and theoretically grounded vocabulary than we currently have, one that enables teachers, curriculum designers and researchers to ask more precise questions about what kinds of ideation are being taught, practised and assessed; and to notice what is missing. The Taoist yinyang symbol (Figure 3) captures this sense: apparently binary concepts interact in a complex and cyclic manner, the dot of each within the other acknowledging the connectedness of opposing forces. This resonates with the head-and-hand iterative design model developed by Kimbell et al. (1991) at the birth of the subject in the late 1980s.

Disclosure

My current role as one of the three D&T curriculum drafters for the DfE (the names being in the public domain and appointed by a rigorous tendering process), in response to the curriculum and assessment review in England, should not be taken as indicative of future content in the national curriculum programme of study or public examinations. Rather, it is an emergent theoretical framework that was developed to inform the creation of knowledge (and action) rich curriculum content; ensuring that revisions were evidence-based and theoretically robust.

References

Auger, J. (2013). Speculative design: crafting the speculation. *Digital Creativity, 24*(1), 11–35. https://doi.org/10.1080/14626268.2013.767276

Bannon, L. J. & Ehn, P. (2013). Design: design matters in participatory design. In J. Simonsen & T. Robertson (Eds.), *Routledge International Handbook of Participatory Design* (pp. 37–63). Routledge.

Boden, M. A. (2004). *The Creative Mind: Myths and Mechanisms* (2nd ed.). Routledge.

Candy, S. & Dunagan, J. (2017). Designing an experiential scenario: the people who vanished. *Futures, 86*, 136–153. https://doi.org/10.1016/j.futures.2016.05.006

Casakin, H. & Goldschmidt, G. (1999). Expertise and the use of visual analogy: implications for design education. *Design Studies, 20*(2), 153–175. https://doi.org/10.1016/S0142-694X(98)00032-5

Cross, N. (2006). *Designerly Ways of Knowing*. Springer.

Cross, N. (2011). *Design Thinking*. Berg.

Cropley, D. H. & Cropley, A. J. (2010). Recognizing and fostering creativity in technological design education. *International Journal of Technology and Design Education, 20*(3), 345–358. https://doi.org/10.1007/s10798-009-9089-5

Csikszentmihalyi, M. (1999). Implications of a systems perspective for the study of creativity. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 313–335). Cambridge University Press.

de Bono, E. (1970). *Lateral Thinking: A Textbook of Creativity*. Ward Lock Educational.

de Bono, E. (1985). *Six Thinking Hats*. Little, Brown and Company.

Department for Education (2025). *Curriculum and Assessment Review: Building a world-class curriculum for all: Final Report* (pp. 66–70). https://www.gov.uk/government/publications/curriculum-and-assessment-review-final-report

Department for Education (2015). *Design and Technology GCSE Subject Content*. www.gov.uk/government/publications/gcse-design-and-technology

Department for Education (2013). *National Curriculum in England: Design and Technology Programmes of Study (Key Stages 1–3)*. https://www.gov.uk/government/publications/national-curriculum-in-england-design-and-technology-programmes-of-study

Design Council (2026). *The Double Diamond: A universally accepted depiction of the design process* [webpage]. https://www.designcouncil.org.uk/our-resources/the-double-diamond

Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies, 32*(6), 521–532. https://doi.org/10.1016/j.destud.2011.07.006

Dorst, K. (2015). *Frame Innovation: Create New Thinking by Design*. MIT Press.

Dunne, A. & Raby, F. (2013). *Speculative Everything: Design, Fiction, and Social Dreaming*. MIT Press.

Eberle, R. F. (1971). *SCAMPER: Games for Imagination Development*. D.O.K. Publishers.

Engeström, Y. (2008). *From Teams to Knots: Activity-Theoretical Studies of Collaboration and Learning at Work*. Cambridge University Press.

Finke, R. A., Ward, T. B. & Smith, S. M. (1992). *Creative Cognition: Theory, Research, and Applications*. MIT Press.

Fry, T. (2009). *Design Futuring: Sustainability, Ethics and New Practice*. Berg.

Gentner, D. (1983). Structure-mapping: a theoretical framework for analogy. *Cognitive Science, 7*(2), 155–170. https://doi.org/10.1016/S0364-0213(83)80009-3

Glăveanu, V. P. (2014). *Distributed Creativity: Thinking Outside the Box of the Creative Individual*. Springer.

Glăveanu, V. P. (2020). A sociocultural theory of creativity: bridging the social, the material, and the psychological. *Review of General Psychology, 24(*4), 335–354. https://psycnet.apa.org/doi/10.1177/1089268020961763

Goel, A. K. (1997). Design, analogy, and creativity. *IEEE Expert: Intelligent Systems and Their Applications, 12*(3) 62–70 https://doi.org/10.1109/64.590078

Gordon, W. J. J. (1961). *Synectics: The Development of Creative Capacity*. Harper & Row.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*(9), 444–454. https://psycnet.apa.org/doi/10.1037/h0063487

Guilford, J. P. (1967). *The Nature of Human Intelligence*. McGraw-Hill.

Hatchuel, A. & Weil, B. (2009). C–K design theory: an advanced formulation. *Research in Engineering Design, 19*(4), 181–192. https://doi.org/10.1007/s00163-008-0043-4

Holyoak, K. J. & Thagard, P. (1995). *Mental Leaps: Analogy in Creative Thought*. MIT Press.

IDEO (2012). *Design thinking for Educators Toolkit*. https://page.ideo.com/design-thinking-edu-toolkit

Ingold, T. (2013). *Making: Anthropology, Archaeology, Art and Architecture*. Routledge.

Jabareen, Y. (2009). Building a conceptual framework: philosophy, definitions, and procedure. *International Journal of Qualitative Methods, 8*(4), 49–62. https://doi.org/10.1177/160940690900800406

Jansson, D. G., & Smith, S. M. (1991). Design fixation. *Design Studies, 12*(1), 3–11. https://doi.org/10.1016/0142-694X(91)90003-F

John-Steiner, V. (2000). *Creative Collaboration*. Oxford University Press.

Kimbell, L. (2012). Rethinking design thinking: Part II. *Design and Culture, 4*(2), 129–148. https://doi.org/10.2752/175470812X13281948975413

Kimbell, R., & Stables, K. (2007). *Researching design learning: Issues and findings from two decades of research and development*. Springer.

Kimbell, R. (2011). Wrong…but right enough. *Design and Technology Education: An International Journal, 16*(2), 6–7. https://doi.org/10.24377/DTEIJ.article1728

Kimbell, R. A., Stables, K., Wheeler, A. D., Wozniak, A. V., & Kelly, A. V. (1991). *The assessment of performance in design & technology.* SEAC / HMSO.

Kirton, M. J. (1976). Adaptors and innovators: a description and measure. *Journal of Applied Psychology, 61*(5), 622–629. https://psycnet.apa.org/doi/10.1037/0021-9010.61.5.622

Kirton, M. J. (2003). *Adaption–Innovation: In the Context of Diversity and Change*. Routledge.

Koestler, A. (1964). *The Act of Creation*. Hutchinson.

Kolko, J. (2010). Abductive thinking and sensemaking: the drivers of design synthesis. *Design Issues, 26*(1), 15–28. https://www.jstor.org/stable/20627839

Korzybski, A. (1994). *Science and sanity: An introduction to non-Aristotelian systems and general semantics* (5th ed.). Institute of General Semantics.

Lao Tzu (1997). *Tao Te Ching: A book about the way and the power of the way* (U. K. Le Guin, Trans.). Shambhala.

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press.

Luck, R. (2018). Participatory design in architectural practice: changing practices in future making in uncertain times. *Design Studies, 59*, 139–157. https://doi.org/10.1016/j.destud.2018.10.003

McLain, M., Murphy, P., El Fadil, B., Yang, Q., Soobik, M., Kangas, K., Roy, E., Schröer, F., Leung, W. Y. A., Buckley, J., Sera, K., Lemon, R., Chia, S. C., McFarlane, C., Du Toit, A., Nordlöf, C., Fan, S.-C., & Wells, J.G. (2026). Technology education as a global curriculum phenomenon: A theory-led definition and typology [Poster]. *The 43rd Pupils' Attitudes Towards Technology Conference: Technology Education Across Boundaries*, 15 to 18 June, Linköping University, Norrköping, Sweden.

Merleau-Ponty, M. (1962). *Phenomenology of Perception* (C. Smith, Trans.). Routledge & Kegan Paul.

Mezirow, J. (1991). *Transformative Dimensions of Adult Learning*. Jossey-Bass.

Osborn, A. F. (1953). *Applied Imagination: Principles and Procedures of Creative Problem-Solving*. Scribner.

Paulus, P. B. & Nijstad, B. A. (Eds.) (2003). *Group Creativity: Innovation Through Collaboration*. Oxford University Press.

Peirce, C. S. (1903/1998). *The essential Peirce: selected philosophical writings* (Vol. 2). Indiana University Press.

Sanders, E. B.-N. & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign, 4*(1), 5–18. https://doi.org/10.1080/15710880701875068

Sawyer, R. K. (2007). *Group Genius: The Creative Power of Collaboration*. Basic Books.

Sawyer, R. K. (2012). *Explaining Creativity: The Science of Human Innovation* (2nd ed.). Oxford University Press.

Sawyer, R. K. & DeZutter, S. (2009). Distributed creativity: how collective creations emerge from collaboration. *Psychology of Aesthetics, Creativity, and the Arts, 3*(2), 81–92. https://psycnet.apa.org/doi/10.1037/a0013282

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. Basic Books.

Sennett, R. (2008). *The Craftsman*. Allen Lane.

Shah, J. J., Vargas-Hernandez, N., & Smith, S. M. (2003). Metrics for measuring ideation effectiveness. *Design Studies, 24*(2), 111–134. https://doi.org/10.1016/S0142-694X(02)00034-0

Simonsen, J. & Robertson, T. (Eds.) (2013). *Routledge International Handbook of Participatory Design*. Routledge.

Stables, K. (2020). Signature Pedagogies for Designing: A Speculative Framework for Supporting Learning and Teaching in Design and Technology Education. In P.J. Williams & D. Barlex (Eds), *Pedagogy for Technology Education in Secondary Schools. Contemporary Issues in Technology Education*. Springer. https://doi.org/10.1007/978-3-030-41548-8_6

Stahl, G. (2006). *Group Cognition: Computer Support for Building Collaborative Knowledge*. MIT Press.

Stanford University (2018). *Design Thinking Bootleg*. https://dschool.stanford.edu/tools/design-thinking-bootleg

Ward, T. B. (1994). Structured imagination: the role of category structure in exemplar generation. *Cognitive Psychology, 27*(1), 1–40. https://doi.org/10.1006/cogp.1994.1010

Wikipedia (2026a). *The Chinese character 道, which represents Tao and is often translated as 'way', 'path', 'technique', or 'doctrine'* [image]. Wikimedia Commons. https://en.wikipedia.org/wiki/Taoism

Wikipedia (2026b). *The taijitu* [image]. Wikimedia Commons. https://en.wikipedia.org/wiki/Yin_and_yang

Zwicky, F. (1969). *Discovery, Invention, Research Through the Morphological Approach*. Macmillan.