
Design Thinking for Innovation Research Sensemaking

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Abstract: Early-stage PhD researchers in engineering and technology domains must navigate high uncertainty, complexity, and interdisciplinarity, yet their methodological training remains predominantly analytical and linear. This paper explores how Design Thinking supports innovation research sensemaking when appropriated not as a prescriptive method but as an epistemic capability that scaffolds inquiry. Drawing on reflexive thematic analysis of written reflections produced by thirteen first- and second-year PhD engineering students participating in a pilot course titled *Design Thinking for Researchers*, the study identifies four themes: iterative problem reframing, navigating wicked problems, artefacts and visual thinking as sensemaking tools, and uncertainty as a productive epistemic condition. Findings suggest that Design Thinking functions primarily as epistemic scaffolding, enabling divergent exploration without premature convergence and supporting shifts in epistemic confidence. The paper contributes to innovation management research by repositioning Design Thinking as an epistemic capability that supports framing, sensemaking, and reflective decision-making in early-stage innovation inquiry.

Keywords: Design Thinking; epistemic scaffolding; innovation research sensemaking; doctoral training; epistemic confidence.

1 Introduction

Innovation research in engineering and technology-driven domains is increasingly conducted under conditions of high uncertainty, complexity, and inter-/transdisciplinarity. Early-stage researchers are expected to frame and reframe innovation problems, integrate heterogeneous knowledge, and engage in ongoing sensemaking of evolving contexts (Weick, 1995; Dorst, 2015), yet their methodological training remains predominantly analytical and linear. This creates a gap between the requirements of innovation inquiry and the capabilities typically developed during doctoral research training; it's not a gap in methods, but a gap in the epistemic capacity to act as a researcher when problems are ill-defined, theoretical frameworks are contested, and inquiry directions are provisional.

Design Thinking has been extensively discussed in innovation management research as a process model, a toolset, and an organisational capability (Brown, 2008; Liedtka, 2018; Dell'Era et al., 2025). What has received considerably less attention is whether and how Design Thinking might support innovation research itself, as an epistemic orientation that helps researchers navigate the exploratory and ambiguous phases of inquiry. This paper addresses that question, drawing on reflective accounts produced by first- and second-year PhD engineering students who participated in a course titled *Design Thinking for Researchers* at the Faculty of Engineering of the University of Porto

(FEUP). The study argues that Design Thinking, when appropriated as an epistemic orientation rather than a procedural toolkit, functions primarily as epistemic scaffolding for innovation research sensemaking, enabling divergent exploration without premature convergence and supporting meaningful shifts in researchers' epistemic confidence.

2 Theoretical framing

Design Thinking is by now discussed in its fourth conceptual generation. In its earliest formulation (DT 1.0), design thinking emerged as a scholarly construct within design research, concerned with the cognitive processes, reflective practice, and abductive reasoning through which designers frame and explore ill-defined problems (Cross, Dorst & Roozenburg, 1992; Eastman, 2001; Lawson, 1986, 2004). A second phase (DT 2.0) translated these foundations into accessible innovation frameworks and toolkits for multidisciplinary teams, establishing DT as a human-centred approach to organisational innovation while generating ongoing critique regarding methodological reductionism (Cross, 2023; Liedtka & Ogilvie, 2011; Tschimmel, 2012). DT 3.0 extended the scope towards systemic and sustainability-oriented challenges, repositioning DT as a collaborative framework for collective sensemaking across disciplinary boundaries (Dorst, 2015; Tschimmel & Alves dos Santos, 2024). An emerging fourth phase (DT 4.0) reconfigures design agency through human-AI co-creation, intensifying tensions between reflective depth and process efficiency and raising new pedagogical questions for higher education (Hernández-Ramírez & Batalheiro Ferreira, 2024; Tschimmel, 2026). In this paper, Design Thinking is understood in the overlapping of all four versions: as a reflective, abductive mode of inquiry; as a collaborative capability applicable beyond professional design; as an approach to systemic complexity; and as an evolving epistemic practice that must be critically appropriated rather than mechanically applied.

The argument for applying this framework to research practice rests on a structural parallel: research is itself a form of inquiry that involves problem framing under ambiguity, iterative exploration, and ongoing sensemaking - processes that share the same epistemic logic as design practice. Two theoretical moves support this claim. First, Weick's (1995) sensemaking theory establishes that meaning-making under uncertainty is not a precondition for action but an ongoing, enacted process, and a characterisation that applies equally to researchers navigating ill-defined innovation problems. Schön's (1983) reflection-in-action further reinforces this parallel: just as designers construct knowledge through iterative interaction with materials and context, researchers construct understanding through iterative engagement with their empirical field and emerging findings. Second, Dorst's (2011) account of design reasoning as fundamentally abductive provides the precise theoretical mechanism: abduction involves working backwards from an observed or desired outcome to generate plausible problem framings, a mode of reasoning intrinsic to any inquiry that must proceed before the problem is fully defined. Repositioning DT as an abductive reasoning mode rather than an innovation method makes the transfer from design practice to research practice theoretically motivated, not merely pragmatic.

Three constructs organise the analysis. *Epistemic scaffolding* refers to external structures, meaning conceptual frameworks, visual artefacts, process models, and reflective prompts, that support how researchers build, test, and revise knowledge claims without supplying answers. *Epistemic confidence* refers to a researcher's sense of

legitimacy in pursuing divergent, exploratory, or uncertain inquiry directions - the capacity to inhabit not-yet-knowing as a productive research state rather than a deficiency. *Sensemaking*, used in Weick's (1995) sense, denotes the ongoing interpretive work through which researchers assign provisional meaning to fragmented or ambiguous material through cycles of framing, action, and reflection.

3 Research Design and Context

This study adopts a qualitative, interpretivist research design. The empirical material derives from the doctoral-level course *Design Thinking for Researchers* (MDTI01, 1.5 ECTS), delivered to first- and second-year PhD students in engineering and technology programmes at FEUP across four three-hour sessions. The course introduced Design Thinking explicitly as a mindset and approach for research inquiry, not as a prescriptive innovation method, organised around five thematic areas: Design Thinking's relevance to research and creative confidence in academic work; wicked problems in research contexts; empathy and stakeholder perspectives; the alignment of research problem, purpose, and question; culminating in communication of research through storytelling, visual thinking, and pitching. In the 2025/2026 instance from which this study's data are drawn, thirteen students participated.

The primary data source consists of written personal reflections produced as part of the course's formal assessment (30% of the final grade). Participants were invited to reflect creatively and critically on their individual learning throughout the course, exploring how the Design Thinking approach - its concept, mindset, principles, and tools - can support PhD engineering research and contribute to the framing of a research question and problem. The briefing of this work oriented participants towards their own thinking instead of towards evaluation of the course, reducing though not eliminating the risk of social desirability bias. Analysis followed the principles of reflexive thematic analysis (Braun & Clarke, 2006, 2019), proceeding inductively without a predetermined codebook. Thematic stability rather than formal saturation was used as the criterion for closure. The dual role of the researcher as course designer and analyst is acknowledged as a reflexivity limitation: analytic attention was directed specifically to the texture and specificity of participants' articulations and not to the valence of their reported experience, and accounts were treated as meaning-making rather than as evidence of learning gain.

A methodological consideration requires explicit acknowledgement. The written reflections were produced by participants who knew that the course had been designed and delivered by the same researcher conducting the analysis, and that the reflections formed part of their formal assessment; conditions that create a recognised risk of social desirability bias. Two features of the analytical approach work to contain this limitation. The assessment prompt directed participants towards their own thinking and its implications for their research practice, not towards evaluation of the course; and the analysis attended specifically to how participants described their experience: with what degree of specificity, conceptual precision, or ambivalence, rather than simply recording whether they reported change positively. Accounts that rehearsed generic enthusiasm without connecting to concrete research situations were treated as analytically thin; accounts that traced specific reframings, named tensions, or described partial shifts were treated as analytically substantive. The reflections are treated throughout as accounts of

meaning-making, not as evidence of learning gain, and the study makes no claims about the effectiveness of the course design.

4 Findings

The thematic analysis of participants' written reflections identified four recurring patterns in how early-stage engineering PhD researchers articulated the role of Design Thinking in their research practice. These themes are presented below, each introduced with a conceptual framing, illustrated with anonymised participant excerpts, and interpreted in relation to the constructs of epistemic scaffolding, sensemaking, and epistemic confidence developed in the theoretical framing.

Iterative problem reframing as a research practice

Participants consistently described a shift from treating the research question as a fixed technical starting point to treating it as a provisional object that evolves through successive reframings. The "How Might We" technique and the Research Canvas functioned as epistemic scaffolding that made iterative logic available and legitimate in a context where early convergence is typically expected. One participant working on sustainable urban mobility described how the reframing process made visible a human-centred dimension of her research question that disciplinary framing conventions had obscured: her revised formulation did not change the problem but changed her relationship to it. Another participant noted that working with hypothetical scenarios exposed the low investigative potential of her initial framings, prompting reformulations oriented towards stakeholder relevance and real-world impact. These accounts suggest that iterative reframing functioned not as a corrective intervention applied to a flawed question, but as a generative mode of inquiry through which the research problem itself was progressively constructed. This finding, thus, is consistent with Dorst's (2011) account of abductive reasoning in design.

Navigating wicked problems in academic research

Participants described a recognition - sometimes sudden, sometimes gradual - that their research did not fit the tame problem structures implied by conventional engineering methodologies. The Wickedness Radar Mapping tool functioned as a particularly effective sensemaking artefact, making the nature of research problems legible in ways that analytical description had not achieved. One participant researching multi-level network flexibility reflected that he had initially approached his doctoral problem as a tame one, assuming a mathematical model would resolve it; encountering the wicked problems framework prompted a substantive reorientation towards the human and systemic complexity his research actually involved. What is analytically significant is not that participants found the framework useful, but that engaging with it produced a shift in how they understood the *kind* of problem they were working on, what can be seen as an epistemic reorientation rather than a methodological adjustment.

Artefacts and visual thinking as tools for alignment and sensemaking

Participants described visual and material artefacts, such as the Research Canvas, the Wickedness Radar, Stakeholder Maps, Storytelling formats, and self-generated visual identities, as supporting not merely communication but thinking itself. One participant described the Research Canvas and Wickedness Radar as working together to allow her to observe her research problem from multiple angles, deepening understanding progressively. Another, working on AI applications in transport sustainability, described how the course validated an intuitive visual practice he had already developed (including a project logo, an acronym, and a comic strip), but had not previously been able to articulate as a legitimate epistemic strategy within an engineering research context. These artefacts did not represent existing understanding; they constituted and stabilised it, functioning as what Schön (1983) called a back-talk from the material, prompting further reframing and refinement.

Uncertainty as a productive epistemic condition

The fourth and most analytically consequential theme concerns a shift in participants' relationship to uncertainty itself: from uncertainty as a problem to be resolved to uncertainty as a legitimate and productive condition for inquiry. This is where the construct of epistemic confidence becomes most clearly operative. One participant described the recognition that his decision to diverge from his central PhD theme into generative AI, made under significant institutional pressure to remain within conventional boundaries, was not a methodological failure but a legitimate divergent move: "deciding to diverge from my central PhD theme to understand how Artificial Intelligence could help me embrace the complexity of my theme was clearly a divergent decision." The capacity to name and frame this in Design Thinking terms functioned as retrospective legitimisation - sensemaking that stabilised an already-made but not yet fully understood research choice. A second participant offered a formulation that captures the theme precisely:

"Design Thinking has not replaced the scientific method in my PhD proposal; it has enveloped it. It has provided me with the creative confidence to accept that my research question is a prototype that evolves through iteration."

Across the corpus, the affective shift from anxiety to agency was as consistently reported as the cognitive one.

5 Discussion and Contribution

The findings reveal that Design Thinking was appropriated not as a method for producing innovation outcomes but as an epistemic practice that shaped how participants framed problems, inhabited uncertainty, and made provisional meaning during inquiry. This distinction is the paper's central contribution.

The three constructs introduced in the theoretical framing are each populated by the findings. *Epistemic scaffolding* was enacted through the Research Canvas, Wickedness Radar, and reframing techniques, which created structural conditions under which inquiry could proceed without premature closure, converting paralysing ambiguity into navigable complexity. *Sensemaking*, in Weick's (1995) enacted sense, was triggered by the

disruption participants experienced when confronted with research problems that resisted the tame structures their training had prepared them for; Design Thinking artefacts functioned as enacted cues that externalised, stabilised, and iteratively revised their emerging understanding. *Epistemic confidence* captured both, a cognitive and affective shift: participants did not merely learn new tools but developed a more principled and legitimate relationship to uncertainty, divergence, and the provisional character of early-stage research.

This repositions Design Thinking as an epistemic capability relevant to the practice of innovation researchers themselves, extending capability-based views of DT (Carlgren, Elmquist & Rauth, 2016; Liedtka, 2018) into a unit of analysis that has not previously been systematically addressed: the individual researcher engaged in early-stage innovation inquiry. The argument is not that DT works as a process model for innovation outputs - a claim extensively critiqued in the DT 2.0 literature (Cross, 2023; Kimbell, 2011) - but that DT, appropriated as an epistemic orientation, fills a gap that conventional methodological training in engineering doctoral programmes leaves open. For innovation management research, this suggests that innovation capabilities must be theorised not only at the level of organisations and teams, but at the level of the researchers who study innovation itself.

The practical contribution is equally concrete: a twelve-hour course design pattern, structured around iterative reframing, wicked problem analysis, stakeholder mapping, visual sensemaking, and research communication, that can be adapted across doctoral training contexts as a deliberate epistemic intervention.

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Areas for Feedback and Development

This paper is submitted as research-in-progress and feedback is specifically sought on the following questions:

Theoretical positioning

The paper proposes *epistemic scaffolding* and *epistemic confidence* as constructs that extend capability-based views of Design Thinking into research practice. Feedback is welcome on whether these constructs are sufficiently differentiated from existing concepts in the innovation capability and sensemaking literatures, and on which theoretical traditions beyond Weick (1995) and Schön (1983) the argument should be more explicitly connected to.

The DT-as-epistemic-capability argument

The paper's core claim is that DT for Researchers operates at the level of epistemic practice rather than innovation method. Feedback is sought on whether this distinction is theoretically robust, and on how it might be more precisely positioned in relation to the DT 1.0 - 4.0 distinction developed by Cross (2023) and Tschimmel (2026).

Empirical development

The current study draws on a single cohort of thirteen participants at one institution. Two further course instances are currently underway with approximately twenty-five additional participants, whose reflections will be analysed using the same thematic framework. Feedback is welcome on how cross-cohort comparison might strengthen or complicate the findings, and on what additional data - longitudinal, supervisory, or institutional - would most productively extend the empirical base.

Scope and generalisability

The study is situated within engineering doctoral education. Feedback is sought on the extent to which the argument travels to other disciplinary contexts in innovation management research training, and on what conditions would need to hold for the course design pattern to be transferable across institutional and national settings.