**Processing the Method: Linking Deweyan-logic and Design-in-Research**

This paper explores the relationship between design logic and reasoning and the methodological and epistemological positioning of design-based knowledge production. Examining the relevant literature, we propose that the naturalistic logic of the American pragmatist philosopher John Dewey offers a potentially useful contextualisation of how logic, reasoning, method and, ultimately, knowledge can be understood as arising from, and be responsive to, context. This is considered in relation to the long-term delivery of a design research programme—termed Experience Labs—which was seen to undergo a gradual methodological shift in response to contextual concerns. It is our core argument that Dewey’s logic can function as a valuable theoretical device, mediating between design and the necessity of methodological and epistemological explication in research.

Keywords: logic of design; design reasoning; practice in research; pragmatism; John Dewey

Over the last number of decades, several contributors have set forth design research frameworks that each offer categories by which the field may be divided and comprehended. For example, there is Cross’s famous distinction between the science of design, design science and scientific design (Cross 1993). Alongside Cross’s categories, we also find Finger and Dixon’s (1989) useful separation of descriptive approaches (i.e., offering an outline of what *happens*) and prescriptive approaches (i.e., offering an outline of what *should* happen). Another more recent example comes from Buchanan (2009; 2007), who proposed a tripartite split between into design science, dialectical perspectives and design inquiry, with the latter category focused partly on the discipline of making in particular.

Latterly, linking to Cross’s concept of design science, Finger and Dixon’s prescriptive category, and the ‘making’ focus within Buchanan’s design inquiry, an increasing number of design researchers have begun to explore the possibilities of *integrating* the design *process* within design research programmes. In recent years, discussions have largely focused on the methodological ‘how’ of linking the activities of designing and knowledge production (e.g. Koskinen et al., 2011), with a relatively wide range of perspectives in circulation (e.g., Rogers and Yee 2015). Here, a number of formalised models positioning situated experiments as the means by which design research programmes may advance a larger inquiry (e.g., Binder and Brandt, 2007; Bang and Eriksen, 2014).

Though useful as guiding frameworks—i.e., prescriptive outlines (Finger and Dixon 1993) in the context of a prospective ‘design science’ (Cross 1993)—these models generally lack an underpinning epistemological narrative (see e.g., Dixon, 2019). While some have argued that an explicit, formal epistemology is perhaps unnecessary in this context (Matthews and Brereton, 2015), it would nonetheless appear that a more robust anchoring is required if the approach is to be advanced beyond its current manifestations.

Accordingly, seeking to explore the questions of method and epistemology further, the present paper introduces a novel perspective by approaching the subject with a focus on the logic of the design process or, to put it another way, the reasoning of the designers. In an effort to ground our argument, we will explore the evolution of a specific design research programme — termed Experience Labs – operating in the context of digital health and care. Over the course of its delivery, the programme underwent a gradual methodological shift, moving from a fixed/structured approach to a more fluid/open *process*. Here, a turn design logic allows us to retrospectively rationalise how the programme’s methodological and epistemological integrity was preserved in spite of this apparent shift.

 The paper has two key aims. In the first instance, we aim to examine the possible relationship between methodological models of design in research and design logic and reasoning. Leading on from this, our second aim is to provide an account of how the implicit epistemological commitments design-based research might profitably be conceived of through the lens of the logic of the late classical pragmatist philosopher John Dewey.

There are five sections. To open we consider recent methodological models and positions which discuss the potential role of the design process in research. In doing so, we argue that such models/positions do not offer a satisfactory epistemological or theoretical rationale. In the second section, seeking to better understand the design process, we explore literature relating to design logic and design reasoning, as well as a series of frameworks which consider the nature of designing in context. Here, while observing a lack of consensus, we also note a general emphasis on situated modes of operation and recursivity – characteristics which align well with models and positions of the previous section. Set against this, we next argue that John Dewey’s naturalistic logic offers a perspective which, helpfully, accommodates the apparent situatedness and recursivity of design at the same time as providing an epistemological narrative consistent with the design process. Following on, in the fourth section, we illustrate this perspective through reference to the abovementioned Experience Labs. Lastly, in the final section, by way of conclusion, we outline what we see as the value of Deweyan-logic for the epistemological positioning of the design process in research.

**1. Design in Research**

Since the turn of the twenty-first century, with varying degrees of success, efforts have been made to embed the design process *in* design research. Numerous design-based research programmes have been established at institutions of higher education around the globe (see e.g., Koskinen et al., 2011; pp. 40-41). Alongside these programmes, many doctoral centres now actively encourage the practice-research relationship in design (e.g., Vaughan 2017). One may observe a general emphasis on investigating the instrumental value of design in predefined social and/or technological contexts. Whether relating to healthcare, public policy or general wellbeing, it is assumed that design process may offer a means by which challenges can be addressed.

Recent decades have seen the emergence of a literature focusing on the methodology of such research, with a number of formal models and positions being proposed by various commentators. Most of these present the design-process-as-method in experimental terms. On this account, through the live testing of questions in practical experiments, it becomes a way of working which can drive large-scale, extended research programmes (Binder and Redström, 2006). Experiments can modify questions, leading to a forward and back relationship between the two (Brandt and Binder, 2007; Fallman, 2008). It has been proposed that such experimentation is guided by designer-researchers’ motivations, whether contextual, i.e., drawn from real-world concerns, or philosophical, i.e., derived from theoretical observation (Zimmerman and Forlizzi, 2008). Others have gone on to suggest that such motivations may aid the formulation of designerly hypotheses, which, in turn, frames research questions and experiments, opening up the possibility of looped iterative cycles where motivations, hypotheses and questions will all undergo regular change (e.g, Bang and Eriksen, 2014).

 Another account sees the design process as a flexible creative strategy-come-method that spans a wide – indeed, possibly infinite – methodological arena. From this perspective, the design process has been linked to a broad base of research traditions, including the natural and social sciences and the arts (Koskinen et al., 2011), as well as be presented as a ‘trans-domain’, wherein multiple disciplinary approaches may converge around the aim of practical, knowledge-based transformation (see e.g., Jonas, 2012; 2015; Buchanan 2001).

While we note the usefulness of the above models and positions, we find that surprisingly little attention has been paid to the epistemological concerns and general theoretical commitments of such work. When such issues are tackled, one of two approaches are generally taken. In the first approach, authors seek to position the practical design research programme as something akin to an empty container around which beliefs may accrue (see e.g., Koskinen et al., 2011; p. 39). These authors do not relate epistemology and theory to the design-process-as-method, but rather to the programme’s ideological orientation.

The second approach to epistemology/theory is less explicit. Here, we see commentators generally eschew epistemological and theoretical questions, to focus on the methodological (e.g., the ‘how’ of their proposed model or position). Here, the design-process-as-method becomes something akin to a self-justifying mode of operation; a way of working that does not require an accompanying argument or epistemological positioning beyond a nod to the practice-based, practice-led or constructive research label (e.g., Bang et al., 2012).

This problematic relationship to epistemology/theory has not gone unnoticed. Matthews and Brereton (2015) have recently attempted to tackle the question of what they refer to as the ‘methodology mire’ of design-in-research from a novel perspective. The pair propose that a solution might be found in the concept of a ‘practical epistemology’. Following this course, one need not demonstrate a strict adherence to a specific methodological tradition, but rather a coherent research strategy which has a clear purpose, and is built on a solid body of data, evidence and, finally, claims.

In another example, Jonas (2012; 2015), argues favour of an ‘operational epistemology’ (von Foerster, 1981) – that is, epistemology which relates knowledge production to the intentions of the researcher – he foregrounds a logical model that integrates design and science. Here, knowledge is seen to emerge via a macro-level, three-phase process beginning with analysis moving through to projection and synthesis. It is argued that science has traditionally managed analysis (i.e., through the accumulation of facts) and design synthesis (i.e., through creation of novel artefacts/outcomes). However, it is only in a design-based approach to research, grounded in projection (i.e., the envisaging of new artefacts/outcomes on the basis of facts), that all three phases are to be related (Jonas, 2012; p. 33).

Drawing inspiration from both of the above proposals, the present article turns to design logic in order to chart a way out of this apparent epistemology quandary. Logic is, of course, at the heart of Jonas’s proposal. Like Matthews and Brereton’s practical epistemology, logic does not align with any one methodological tradition. Rather, it notionally sits behind all traditions. This basic idea will underwrite your eventual proposal. Before going further however, we must turn to consider logic of the design process itself.

**2. Design Logic and Reasoning**

The question of logic in the design process have emerged intermittently over the course of the last forty years, with contributions dating at least as far back as the work of March (e.g., 1976) and, more generally, to the design methods movement of the 1960s and 70s. Recent years have seen advances in the discourse, with the emergence two key lines of investigation.

We see the first as focusing on the macro-level. Here, researchers aim to give conceptual form to general logical procedures or reasoning processes in design, as well as outlining the basic parameters by which the design process as a whole is likely to advance. Then, the second line of investigation is seen to target the micro-level. Here, the aim is generally to uncover the reasoning patterns which underpin specific points of decision-making at various stages in the design process, whether early or late.

**2.1 The Macro-Level**

In our survey of literature, we have identified to general strands of macro-level theory. The first focuses the logic of abduction and its relationship with the traditional logical forms of deduction and induction.[[1]](#endnote-1) The second strand presents an alternative to these perspectives by seeking to articulate a unique design logic founded the concept of recursion.

The term abduction was coined by the American pragmatist philosopher and logician Charles Sanders Peirce in the late nineteenth century (see Peirce 1998; pp. 75-114). It first appears in the design literature in March (1976; 1984) On this account, abduction – or the ‘logic of design’ as March has it – is said to allow for the introduction of new ideas through the formulation of original hypotheses. Here, design as a whole is seen to advance along a path from abduction, to deduction to induction.

Leading on from March, Roozenburg (1993) focused in on the concept of abduction in particular. Roosenburg highlights what are alleged to be two separate types of Peircean abduction – ‘explanatory abduction’ and ‘innovative abduction’. In explanatory abduction, the aim is for a best guess explanation, providing both a plausible and satisfactory answer. Innovative abduction – later termed innoduction (see Roozenburg and Eekels 1995, pp. 72–81) – however is non-explanatory in nature, and holds a future orientation. Here one moves from a novel problem or issue through to an envisaged novel solution.

In other work, Kolko (2010) has argued that abduction is central to the activity of sense-making in design. Linking to Roozenburg’s thesis, Dorst (2011) has proposed the existence of two alternative forms of abduction, distinguishable on the basis of their complexity. A further important contribution comes from Koskela et al. (2018), who suggest that abduction-in-design remains under-theorised. Surveying the literature, they propose a novel framing of the concept. Here, abduction is said to be grounded in subconscious activity and may occur at any point in the design process. Equally, drawing a distinction with abduction in *science*, the group argue that abduction-in-design will generally lead to a limited change in specific context (as opposed to a wholly original idea), as well as aim towards utility (as opposed to truth).

Beyond the above, there is Eekels’s (2000; 2001) consideration of the ‘fundamentals’ of engineering design science. On Eekels’s account, this domain may be understood as taking form across five stratified levels moving from general epistemology through to engineering design practice. He argues that, in design activity, reasoning often diverges from the notional deductive ideal of science by also enfolding inductive and abductive approaches (Eekels, 2000; p. 384). Here, he highlights the earlier abduction/innoduction work undertaken with Roozenburg (i.e., Roozenburg and Eekels 1995) and notes that this aspect of engineering design science requires further attention; particularly in relation to how teamwork and organisational/institutional management and their multiple reasoning processes.

Leading on from the first strand, the second strand of the macro-level theories, relating to recursion, derive primary from the work of Zeng (e.g., Zeng and Cheng, 1991; Zeng 2015). Here, Zeng and Cheng (1991) rejected March’s presentation, claiming instead that the design process relies on a distinctive logic ­– termed recursive logic – which departs from deductive, inductive and abductive forms. Through notation, they pair demonstrate how recursive logic begins with an initial ‘atomic design’ formulation that then develops progressively through trial and error until a final design is arrived at. In essence, the initial formulation undergoes a layered adaption wherein no conclusion can be true until the final form is realised.

In continuing to develop this thesis, Zeng has devised a prescriptive model of the design process termed ‘environment-based design’ (see Zeng 2015). On this framing, design is presented as an inevitably situated activity, which aims to bring about change in the environment. As the process advances, the relationship between the design problem, the design knowledge (i.e., what is known about the broader context) and the design solution is found to undergo to a ‘recursive evolution’. Against this, environment-based design offers a strategy for managing the design activity, with particular focus being directed towards enabling greater efficiency through special forms of analysis and problem-framing.[[2]](#endnote-2)

Beyond Zeng’s work, there is Gero and Kannengiesser’s (2004) situated function-behaviour-structure framework, where function-behaviour-structure refers to an actual/possible design object’s function (i.e., what it is for); behaviour (i.e., what it does); and structure (i.e., what it is) (p.374). Though this framework not grounded in logic, it is notation-based and, like Zeng’s environment-based model (2015), offers a keen insight into the complex interrelationship between design activity and context and the recursive layering this implies. In tackling the activity-context interrelationship, the framework offers a model of ‘situatedness’, which is seen to involve on three different types of ‘environments’: the external world (i.e., the world apart from the designer/agent); the interpreted world (i.e., the world the designer/agent constructs through experience); and expected world (i.e., the imagined impact of a designer’s/agent’s actions) (pp. 337–338). Recursivity enters in via the act of interpretation and ‘constructive memory’, i.e., memory understood as a dynamic process undergoing constant adjustment as an individual interacts with the external world.[[3]](#endnote-3) These along with two additional categories (i.e., ‘focussing’ and ‘action’), allow designers to move between ‘worlds’, with their interpretations undergoing a gradual transformation via constructive memory as the expected and external worlds interact. Taken together, all of this allows for a step-by-step accounting of design activity in *situated* terms.

**2.2 The Micro-Level**

As a general rule, work which explores micro-level design logic is empirical in nature (i.e., based on observations) and accordingly, offers a level of detail unavailable at the macro-level**.**

In an early example Galle and Kovács (1996), analysed one designer’s attempt to replicate the reasoning of another. In this, they identified a pattern where ends and means, the ‘that’ and ‘how’ of decisions, are closely interlinked; with an end often requiring a search for a means, which in turn gives rise to new ends (p. 198).

Eris (2004) studied question-asking behaviour in design teams, with his analysis revealing the both the type and timing of questions have a significant impact upon the structure of a team’s design activities. Here, two types of questions in particular, were found to be important – those which decreased ambiguity (termed deep-reasoning questions) and those which increased ambiguity (termed generative-design questions).

Focusing on the process of concept evaluation, Dong et al. (2015) report the results of an experiment where participants were tasked with applying both abductive and deductive reasoning patterns as they examined individual concepts. The results show that the application of abductive reasoning led to more concepts being accepted, underscoring the productive aspect of this logic.

Dong et al. (2016) report the results of analysis of design review conversations, identifying a previously unacknowledged form of design thinking which they term ‘generative sensing’. According to their analysis, generative sensing commences with the deductive testing of a concept. This leads to conclusion regarding its value, which, in turn, forms the basis for an abductive reformulation of the original concept, ultimately resulting in its recursive development as a design proposition.

Noting that macro-level reasoning is often characterised as following an abductive-deductive pattern, Cramer-Petersen et al. (2019) set out to test whether this holds at the micro-level. Their results demonstrate in a general trend towards an abductive-deductive pattern. However, the group note that, at an individual level, many patterns are interdependent and in some cases ‘disorderly’, not adhering to any particular ‘formal reasoning types’ (p. 64).

As will be apparent from the above overview, there is an evident lack of consensus across the macro-level and an insufficient level of evidence, as yet, available at the micro-level. Consequently, we take the view that it would not, at this point, be possible to make any definite claims regarding the logic of design or, indeed, the design reasoning process.

That said, we note that the concept of abduction is a central concern topic of discussion across both levels. Equally, we have also noted how others argue that, regardless of positioning, abduction alone cannot adequately capture the inherent complexity of design logic/reasoning (i.e., Zeng and Cheng 1991; Cramer-Petersen et al., 2019; Galle 1996). Acknowledging this gap, one might seek to chart a forward course through an appraisal of the macro-level presentations, asking which most faithfully represents design’s logical forms and where amy amendments or corrections might be made.

This, however, is not our task. Our concern lies with the design-process-in-research. As such, while the general concept of abduction intrigues us, we believe that the complex intricacies of micro-level empirical studies offer a more revealing insight into the logic/reasoning of design than any of the macro-level presentations. Reflecting on these studies, we identify a general underlying impulse towards a form of flexible dynamism whereby ‘the logic’ of the activity cannot be defined by a formal theory, per se, or indeed a notation system, but rather must understood as acquiring an eventual form through the accumulative outcome of individual responses to situational constraints. In many ways, mirroring what are termed ‘situational’ theories of action, which hold that an activity cannot be understood apart from context (see e.g., Suchman, 1987).

This is a subject we will return to later. For now, we will return to consider the design process in design research with reference to the above presentations.

**2.2 The Logic of Design-in-Research**

Revisiting to the last section’s overview of models/positions of design-in-research, we note that it would appear that there has been little discussion of logic/reasoning as such. Understandably, most authors are concerned only with the operationalisation of the process and not its logical complexion. There are a few exceptions however. As was noted, Jonas (2012; 2015) foregrounds logic through his macro-level, three-phase model of analysis, projection and synthesis. These three phases are said to correspond directly to logical forms of induction (analysis), abduction (projection) and deduction (synthesis). Another exception is found in Bang and colleagues work (Bang et al., 2012; Bang and Eriksen, 2014), where abduction and deduction are explicitly discussed in reference to the overarching process of hypothesis formulation and testing.

Reflecting on the generic outlines of most the experimentalist literature, it would seem many authors hold a general alignment March’s abduction-deduction-induction model. The formulation of questions and hypotheses notionally requires that one think in abductive terms. Framing an experiment, requires deductive thought. Collating results across experiments, requires an inductive evaluation. Beyond this, we note the general recursive structure of most of these models (e.g., Brandt and Binder, 2007; Bang et al., 2012), roughly aligning with Zeng’s and Cheng’s (1991; Zeng, 2015) identification of a recursive logic in design. This aspect is especially apparent in Bang and colleagues’ work (i.e., Bang et al., 2012; Bang and Eriksen, 2014), as the groups acknowledge both the possibility of constant iteration, as well as the reframing of the programme.

Another observation is made with regard to what we perceive to be a general emphasis on situatedness. All the of experimentalist literature, as far as can be ascertained, characterises in-inquiry decision-making as dependent on the practical, empirical results of the live testing of questions and hypotheses. It would seem that next steps – whether that be reformulating questions, hypotheses, or the experimental approach – are always to be determined in relation to previous steps and their situational impact.

An emphasis on situatedness can also be detected in the creative strategy literature (i.e., Koskinen et al., 2011; Jonas 2012; 2015; Buchanan 2001). However, on this view, it is not so much individual instances of decision-making which matter but rather the perspectives and methods that drive the inquiry. To a greater or lesser extent, these authors argue that the problem under investigation will determine both the disciplinary knowledge one brings to bear upon the problem (i.e., Jonas, 2012; 2015; Buchanan 2001), as well as the techniques one seeks to apply – whether related to the natural sciences, the social sciences or the arts ­(Koskinen et al., 2011). Accordingly, following this course, the imported disciplinary perspectives and techniques will inevitably inform the logic of the study.

With these observations to hand, we now wish to push the subject of design logic/reasoning in design research a little further. We do so by returning to where we left off in the last section. As was noted here, most if not all the existing literature on design logic/reasoning makes at least passing reference to the concept of abduction, with various views, both positive and negative, being advanced regarding its possible role(s).

While we acknowledge the value of this concept, it is our belief that it is possible to move beyond the question of abduction’s role by turning fresh attention to its source in pragmatist philosophy. We note that few, if any, contributors have gone so far as to draw links between Peirce’s work and the wider context in which it sits. For our part, we intend to map a path from Peirce to the logic of fellow pragmatist John Dewey, who offers a directly related and relatable perspective to that of the former. As will be explored in detail below, we believe that, alongside Peirce’s work, Dewey’s logic has significant relevance for those investigating design logic and reasoning, especially in relation to design-in-research. Accordingly, in next section, we aim to link Peirce and Dewey and, from this, to make the case for relating a Deweyan perspective on logic to design-in-research.

**3. Dewey’s Logic**

To move from Peirce to Deweyan-logic it is necessary to leave aside the concept of abduction and look, instead, to what has been referred to as Peirce’s ‘doubt-belief theory’ (Sleeper, 1986, p. 49), a biologically-orientated account of the human reasoning process (see especially Peirce, 1992; pp. 109 – 141). The theory’s basic premise is that, in daily activity, we, as active thinking humans, regularly progress through cycles of doubt and belief. Doubt emerges in relation to a need. In response, a belief is subsequently arrived at through a progressive effort to overcome our doubt; in other words, through problem-solving. Once established, it can give rise to what are referred to as ‘rules for action’ or ‘habits’ (ibid; p. 129); ways of seeing and approaching the world, which may be judged good if they are ‘valid’ (ibid; p. 112). Grouping the whole together, Peirce proposes that what he is describing – the movement from doubt to belief to habit – is, ultimately, the process of ‘inquiry’ (p. 114).

This brings us to Dewey. Through pedagogic research and intermittent readings of Peirce over a period stretching roughly from the 1890s to the 1930s (Shook, 2000; p. 212), Dewey gradually arrived a theory not dissimilar to former’s doubt-belief presentation, which he termed the ‘theory of inquiry’. This theory sits at the core of his philosophy (see e.g., Sleeper, 1986), threading through his treatments of such areas as education, democracy, ethics, aesthetics, but most especially in his logic. Indeed, for Dewey, the theory of inquiry is a *logical* theory, with the two subject matters of inquiry on the one hand, and logic, on the other, being understood literally as one in the same.

Concisely stated, his position may be summarised in the following terms: ‘logical forms (with their characteristic properties) arise within the operation of inquiry and are concerned with control of inquiry so that it may yield warranted assertions’ (LW 12, p. 11). In other words, on the Deweyan view, logic is no longer to be seen as something standing apart from the world as an abstract theoretical form, but an empirical outgrowth of successful inquiries.

This constitutes a bold repositioning of Peirce’s theory. The possibility of a timeless, formal logic is all but abandoned. In its place, we are left only with our thought processes or, more accurately, our reasoning processes as set against the existential conditions with which we are confronted. The question of how such reasoning progresses are dealt with in what Dewey titles the ‘pattern of inquiry’ – a generic outline of the inquiry process and its likely phases.

Mirroring Peirce, Dewey’s pattern opens with the proposal that inquiries are launched when the would-be inquirers encounter especially doubtful situations. On the basis of these encounters, Dewey argues, inquirers are compelled to define the problem at hand, as well as to explore possible solutions. Once a reasonable solution is defined, it is expected that a process of experimentation will be launched. In this, the inquirer will generate and test hypotheses, as well as observe and integrate the results of these tests. New results beget new hypotheses, which in turn beget new tests. It is proposed that this cycle of experimentation and observation will ultimately lead to a point where experimentation is no longer necessary.

With regard to the end of inquiry, Dewey argues that the aim is not attain absolute knowledge, in a definite and final sense, but rather workable conclusions which may guide further inquiry. As such, there is no question of whether or not conclusions are ‘true’ (i.e. a faithful representation of reality). Instead, he proposes that we consider whether or not our conclusions hold warranted assertablity – in other words, whether or not our claims are founded on sufficiently sound evidence (see LW 12; pp. 109–122).

The concept of abduction, innovative or otherwise, does not explicitly figure in Dewey’s theory but notions of ‘suggestions’, ‘meanings’, ‘ideas’ and ‘possibilities’ underpin the whole. We are told that suggestions are both the ‘conditions and primary stuff of logical ideas’ but, equally, are not in themselves logical (ibid; p. 114). An idea, in turn, is ‘an anticipation of something’ and ‘marks a *possiblity*’ (p. 112, italics in the original). Ideas direct both the formulation of hypotheses and framing of tests and observations. They each carry a particular set of meanings which must be reconciled against the broader meanings underpinning the inquiry as a whole. As such, each new idea must be reasoned into shape – progressed through a series of ‘intermediate meanings’, as Dewey has it, until a more relevant idea is developed (p. 115). As the inquiry advances, so too do the ideas – the problem and the solution become clearer (p. 112).

For Dewey, the pattern as a whole reveals an interrelation or ‘functional correspondence’ between induction and deduction, deduction and induction. In each individual experiment, the inquirer deductively tests ‘if-then’ propositions underpinning a hypothetical proposed solution, i.e., an idea or possibility as set against the problem. Equally, through our progressive experimentation, we inductively obtain data, i.e., we reason against our former ideas. This is said to amount to a ‘continued ‘to-and-fro movement’ between the ideas-as-possibilities in the form of hypotheses and ideas-as-meanings which then are linked to the inquiry as a whole (ibid; p. 423).

Viewed in practical terms, we believe that the pattern affords design-in-research a means by which logic may be approached directly, in action. It is a naturalistic logic, one which does not need a background metaphysics or epistemological theory – in Dewey’s words it is ‘autonomous’ (ibid; p. 28). The results of past inquiries inform the structure of future inquiries (p. 25). These inquiries, in turn, will each require that a special operational logic be determined, one that responds adequately to the existential conditions and problems at hand. As such, no logical form is ever the last but, rather, always progressive (p. 21), always building on what has come before. Importantly, on Dewey’s account, logic is also social. He insists that inquiry is grounded in communication and culture. It will inevitably grow ‘out of a background culture’ and take ‘effect in the greater or lesser modification of the conditions out of which it arises’ (pp. 26–27).

All in all, this constitutes a radical perspective when compared to traditional logic. Indeed, it is possible to view Dewey’s theory as an argument against traditional logic. On his account, there is work to be done. Logic must become an ongoing concern, something which is seen to be both historically and contextually bound but most importantly lived and worked through according to the immediate needs of the situation. It does not exist beyond us.

It is important to point out that many design scholars have referenced and contextualised the pattern in relation to design practice and design research (e.g., Steen, 2013; Buchanan, 2009; Schön 1983; Dixon 2019). Equally, Dewey’s work (and indeed pragmatism in general) has found a firm footing in literature relating to the design thinking process (e.g., Dalsgaard, 2014) and the structuring of the field of design research (e.g., Melles, 2010). However, so far as we can ascertain, no authors have, as yet, discussed the theory of inquiry in terms of design logic and reasoning. Accordingly, in the following two sections, we will move to explore how this may inform approaches to applying the design process in the context of research projects. We begin turning to look at how Dewey’s logic helps us understanding the evolution of a design research approach known as Experience Labs.

**4. The Experience Labs Approach**

The Experience Lab approach was developed at The Glasgow School of Art as part of the Digital Health and Care Institute (DHI) programme,[[4]](#endnote-4) a Scottish Funding Council sponsored innovation initiative. At their launch, the aim of the Labs was to support the early-stage design of digital products and services in response to complex healthcare challenges. Over five years, examples of such challenges included: person-centred data sharing, supporting self-management of long term conditions, and exploring the role of technology in health promotion topics such as breastfeeding.

The Labs departed from traditional evidence-based research in healthcare – i.e., quantitative analysis and causal modelling (see e.g., Wan 2002) – in that, from the outset, collaboration and creativity were positioned as central values. Each Lab was framed by design-led strategies and brought together a diverse range of stakeholders. Co-design was applied throughout, with tools and artefacts being designed to support participants’ (i.e., intended users) engagement in the process of developing and testing low-fidelity prototypes.

Holding a focus on ‘real’ experiences, early Labs sought to replicate prosaic scenarios and tasks through the staging of everyday environments (e.g., home or clinical settings) and person-to-person interactions. The view was taken that, in mirroring the patterns of ordinary life, specific problems and opportunities would be identified and responded to in immediate terms.

To a degree, this ambition was fulfilled. For example, in one case, the team worked with ambulance clinicians to explore how a digital application might enhance their capacity to identify alternative pathways to hospital while on-call (French and Teal 2015). Over the course of the two-day duration of the Lab, it was possible to move from an initial concept through to two low-fidelity prototypes that successfully met the clinicians’ needs. However, beyond successful examples such as this, it was often not possible to achieve rapid development cycles, particularly when the background exploratory work was limited. Indeed, it become increasingly clear that most, if not all, Lab projects required intensive preparatory work to ensure that participants could engage in the co-design process.

This led to the incorporation of a new phase within the Labs, termed ‘Pre-Labs’, which were framed around activities such as horizon scanning, literature searches and informal public engagement exercises (e.g., on-street pop-ups and in-depth interviews). Pre-Labs allowed the team to not only build up a rich understanding of the challenge context but also ensured that trust was established with key stakeholders and prospective participants (see Teal et al., 2016).

Along with the Pre-Labs, a further phase was formalised, which can be described as a ‘Post Lab’ activity. Post-Labs took place after the Experience Lab proper and functioned as a handover session where the initial findings and outcomes of the Lab were presented to partners as a single package. It was intended that the inclusion of such Post-Lab handover sessions would allow the team to enter into detailed discussions with partners, providing both parties with an opportunity to learn from the overall experience.

Though well-defined, the Pre-Experience-Post Lab model was not, in the end, final. After an initial three-year period, the onset of a new funding cycle led to a shift in the DHI’s agenda. Whereas before the programme had operated on the basis of small-scale, public-facing innovation calls for digital products/services, teams were now required to respond to system-level challenges identified by management. This meant that the design team’s task was expanded to include the development of innovation pathways for existing contexts, e.g., outpatient services.

Reflecting on the new situation, the team took the view that, in its current form the Labs approach would not allow them to adequately respond to the expanded challenge contexts. Drawing on their overall experience of the Labs, it was argued that a more responsive, less defined approach would be preferable. As such, changes were pursued and, in the end, the approach was revised and evolved.

It was agreed that the Labs were no longer to be called Labs. This was to avoid any confusion between past and present structures, as well as the past and present agendas. Equally, the team were no longer required to fit activities within a specific sequence (Pre-, Experience and Post-); rather, it was expected that, on a project-by-project basis, they would chart a unique and flexible design research strategy to frame the needs of the challenge context.

For example, in a project exploring the possibility of developing a person-centred vision for outpatient care for those living with multiple long-term conditions, the team developed a range of bespoke experience-mapping techniques in the form of tools and artefacts. As these tools and artefacts were specially designed for the challenge context, it was possible to gain a deep insight from the diverse range of stakeholders involved, including patients, health and social care professionals, and members of the general public (see Teal, 2018).

In cases such as these, decisions relating to which methods might be used (and when) were to be determined in accordance with what was judged to be the most appropriate response in a given situation, based on the framing of the challenge context. Further, responding to the expanded task of developing innovation pathways, the team were now producing more targeted outputs such as contextual overviews, visualisations of complexity and roadmaps. In short, a fixed approach to structuring activities within a specific sequence had been dissolved into a more fluid and open, yet situated, process.

 Having discussed the Experience Labs’ evolution, we will now consider the above evolution with reference to the Dewey’s perspective on logic, outlined in the last section.

**4.1 The Labs and Deweyan-logic**

At the outset, it is important to note that logic was never an explicit topic of discussion among the Labs team. Their concern was always directed towards the aims and structure of the individual Labs. Nonetheless, despite this absence of logical discussion, reflecting on the Labs with reference to Dewey’s logic allows us to set out a useful account of their meaning and evolution, one that might otherwise remain unavailable if the approach were to be considered in singularly methodological terms.

To begin with, in adopting a Deweyan perspective, we cease to view the Labs as a unique ‘method’ and, instead, come to see them as a set of individual inquiries which each relate to one another on the basis of a shared if adapting logic. Following Dewey, we see this as a ‘progressive’ logic, one that emerged on the basis of the team’s efforts to define best practice.

To a greater or lesser extent, when viewed in this way, each of the ‘inquiries’ can be related via Dewey’s proposed pattern of problem identification, problem definition and the testing of possible solutions through experimentation. Surveying the Labs’ evolution, we note that, in the early Labs, the team’s focus was directed almost solely towards experimentation in relation to the *already* identified and defined ‘problems’ of the challenge context. With the introduction of the Pre-Labs however, this changed – problem identification and definition became integral to the approach. Now, the team were not only experimenting through co-design but also shaping their inquiry. On this view, the movement from Pre-Labs to Experience Labs may be read as a transition from problem definition to experimentation. The inclusion of the Post-Lab activity extended the model, providing a post-experimentation mechanism by which the outcomes of an Experience Lab could be validated, or, as Dewey would have it, conferred with ‘warranted assertability’.

The later dissolution of the Labs approach, i.e., the Labs’ revision, of course, marked a further shift. The inquiries were no longer bound by phases (i.e., Pre, Experience, Post-) but, rather, were given over entirely to the logic of situated activity. Here, in seeking to develop challenge-based innovation responses, the task of identifying and defining present problems was as important, if not more important than that of experimentation. In this iteration, the latter (i.e., experiments) would have literally been meaningless without the clarity of the former (i.e., problem identification/definition).

Reflecting on the Labs as a whole and again following Dewey, we take the view that ideas were the currency by which each inquiry moved forward. Ideas emerged in Pre-Labs and helped the team to shape Experience Labs, which, in turn, allowed for their testing. Gradually, as results emerged these were integrated, directing the development of further ideas. Of course, as was highlighted above, this to-and-fro of ideas links to Dewey’s interrelation of deduction (i.e., the testing of ideas-as-possibilities) and induction (i.e., the relation of ideas-as-meanings), a view that we believe is accurate. It also mirrors what we identified above as likely generic traits of the logic of design-in-research; namely, situatedness and recursivity. Actions and decisions were always grounded in context, which in turn was always shaped by what had already been done.

Beyond the specifics of particular patterns of inquiry and their drivers, the Labs’ evolution must also be understood as inherently social. Each inquiry was shaped by the people and partners involved. In all cases, any changes relating to the approach were collectively discussed and, ultimately, agreed upon based on the consensus through the reflective practice of the design research team.

Here, we may draw useful additional insight from the work of Steen (2013), who has linked Dewey’s pattern inquiry to the practice of co-design. Steen does not discuss Dewey’s logic directly, nor is he concerned with academic knowledge production as such; however, he does accentuate the pattern of inquiry’s social dimension by highlighting Dewey’s belief that communication enables cooperation and shared activities. Thus, linking Deweyan inquiry and co-design, the latter is re-presented as a process of ‘collaborative design thinking’ (p. 18) or ‘joint inquiry’. Here, communication is seen as key to the whole – ultimately, underwriting each phase, whether defining the problem or a solution, conducting experiments and so on. Viewed from the perspective of standard pragmatist design logic/reasoning models (e.g., Roozenburg, 1993; Dorst, 2011), this marks a shift in emphasis from individual to collective formulation.

Thus, enfolding Steen’s perspective, we may view each inquiry’s ‘currency of ideas’ as the product of the communication processes both of the team internally, as well as their interactions participants and external partners; with each exchange layering in and gradually redirecting the logic of the whole over time. In this way, we give more definite form to Dewey’s claim that logic is social.

Leading on from the latter, there is another point of note to be made in relation to the contribution of the design process to the process of knowledge production. Here, Dong et al. (2017) offer a helpful ‘design-based’ theory of the firm. On their account, a design-based view of the firm promotes a shift in emphasis from stable product-production (i.e., firms as fixed entities with a given remit) to firms as dynamic value-creators. In holding this orientation, firms will ‘seek new ways to frame the existing resources to create novel outputs’ (p. 21). These new framings are seen to function as hypotheses, which the firms must test and evaluate through a process of generative sensing (Dong et al, 2015; and 2.2 see above). The authors conclude by proposing that, if a firm is function efficiently, any novel creative outputs (i.e., any newly realised value) must be accompanied by new work routines and organisational structures.

We believe that this theory goes some way to providing a rationalising narrative for the overarching evolution of the Experience Labs method. Here, we can posit that the team’s design-led strategy will likely have encouraged their ongoing efforts to work to reframe the method over time. Each iteration of the Labs may, in itself, been seen as a hypothesis which, along with the specific design proposals at hand, was also being tested and evaluated. Equally, through the Labs evolution, we also see a clear change in work routines, e.g., in the move from Pre-, Experience, Post- Labs to the latter, more fluid and open process.

**5. Deweyan-logic in Design Research**

Referring back to the earlier theories of macro-level and mirco-level logics/reasoning, we may note a number of differences between these and Deweyan-logic as presented in the context of the Experience Labs. In relation to the macro-level abductive strand (e.g., March, 1976; 1984; Roozenburg 1993; Dorst 2011; Koskela et al. 2018) and some micro-level theories (e.g., Dong et. al. 2015), we may note that Dewey does not problematise idea-generation (i.e., the kernels of hypotheses), as such, but rather foregrounds an inquiry’s existential conditions as the site of questioning and problem-framing. For him, it is situations, experiences and observations – not a specific pattern of argumentation (e.g., abduction/innoduction) – which beget suggestions-ideas-possibilities-hypotheses. This opens up a phenomenological angle within design-in-research, allowing for a consideration of what occurs in the experience/performance of ideation.

 Beyond this, as was noted in the last section, social-factors and communication are also significant for Dewey and indeed, was so in the Labs. Much like the micro-level logics (e.g., Cramer-Petersen et al., 2019; Dong et al., 2015; 2016; Eris, 2004; Galle and Kovács, 1996), we find that we must go to the interaction in order to understand the chain of ideas-meanings-hypotheses-experimentation. If it is accepted that Dewey offers a macro-level logic then this is a distinguishing feature from other macro-level abductive theories (e.g., Roozenburg 1993; Dorst 2011).

 Turning to the recursive/situated strand of macro-level logic (i.e., Zeng and Cheng, 1991; Zeng, 2015; Gero and Kannengiesser, 2004), we may say it is arguable that such work might allow for a similar formulation to what has been presented. Indeed, we find these perspectives offer immense value as alternative macro-level theories, in that they *do* afford the possibility of accounting for the experience/performance of ideation. Nevertheless, so far as we can ascertain, these models do not explicitly tackle knowledge production – which, of course, is also true of the above abductive logics. Equally, we find the recursive/situated work overly prescriptive in its reliance on structure (i.e., specific terms/categories) and notation.

In contrast, Deweyan-logic offers a model of knowledge production which disavows structure and notation. On his account, there can be no final logic and, as such, no final structure or notation. In terms of a logical pattern, there was only before and what might have come after. In the context of knowledge production, we are encouraged to ‘see’ this, to be alert to it and act accordingly. Indeed, in working to understand the dissolution of our original Experience Labs approach, the value of this perspective revealed itself to us.

Beyond logic/reasoning and connecting to Dong et al.’s (2017) work, we also note the possibility of there being a ‘generative sensing’ of method at play within design-in-research, whereby the approach becomes an implicit, evolving hypothesis to be tested in-and-of-itself. We find this notion both plausible and compelling and, as such, believe that it is worthy of further investigation.

In concluding, it is important to recall that our application of Deweyan-logic in the context of the Experience Labs functioned only as a *retrospective* rationalisation. In other words, we turned to Dewey’s work in order to make sense of what *had* happened, not what *was* happening. Nonetheless, it is our proposal that the theory – in particular its twin guiding premises that logic *only* exists in action and successful action enables the production of knowledge – might be applied in the live context of ongoing research as a means of tracking one’s process and assessing the overall strength of one’s inquiry.

In relation to design studies and the experiential/performativity aspect, it would be worth exploring whether a form of a reflective accounting for ‘team framing’ (Stumpf and McDonnell, 2002) – i.e., a means of collectively maintaining oversight of the development of a design research team’s ideas (either in communication or practice) – might support their efforts to think backwards or move forwards in their process. For example, attention might be paid to whether the focus of a particular activity is ‘testing ideas as possibilities’ (i.e., deduction) or ‘relating ideas as meanings’ (i.e., induction). We believe that such terminology would offer the advantage of translating these concepts into functional terms, as well as highlighting the relationship between both.

A further proposal would be that design research teams aim to collectively develop an explicit internal mechanism (e.g., criteria), which would clearly demarcate *warranted assertability*, i.e., that the inquiry had reached an appropriate endpoint and knowledge was ‘produced’. We envisage that such a strategy would reduce the ambiguity surrounding what defines validity in a specific case.

 In the end, we believe that, if applied *to* design-in-research (whether actively or retroactively), Dewayn-logic may ultimately yield a helpful epistemological rationale that begins to operationalise the potential of design in knowledge production. This is because Dewey’s inquiry-as-logic is explicitly *autonomous*, without a metaphysics or *outside* epistemology. Instead, it functions as an *active* epistemology. The question of knowledge is subsumed into the activity of inquiry, which is here understood as a logical enterprise driven by the ideas we form in relation to the existential conditions we encounter. What matters it is being able to *re-present* the process, what one did, how one did it and, ultimately, why.

If we, as designer-researchers, are to follow Deweyan-logic, our task is clear. We must work to identify and define what is problematic in a given situation, experiment with solutions until an appropriate endpoint is reached and, thereafter, present our argument and evidence. In other words, we must inquire in response to the situation *as it is* and be able offer something back in response; we must *engage* in the design process. In this way and only in this way, do we act logically.

**Funding**

This research was supported through the Scottish Funding Council’s DHI Innovation Centre scheme.

**References**

Bang, A. L., & Eriksen, M.A. (2014). Experiments all the way in programmatic design research. *Artifact: Journal of Design Practice* 3(2), 4-1.

Bang A. L., Krogh, P., Ludvigsen, M., & Markussen, T. (2012). The Role of Hypothesis in Constructive Design Research. Paper presented at the 4th *The Art of Research: Making, Reflecting and Understanding*, Aalto University School of Arts, Design and Architecture, Helsinki, Finland.

Binder, T., Redsröm, J. (2006). Exemplary Design Research. Paper presented at the *Design Research Society Wonderground Conference*, Sociedade de Geografia de Lisboa, Lisbon, Portugal.

Brandt, E., & Binder, T. (2007). Experimental Design Research: Genealogy, Intervention, Argument. Paper presented at the *International Association of Societies of Design Research Conference*, Hong Kong, China.

Buchanan, R. (2001). Design research and the new learning. *Design Issues* *17*(4), 3-23.

Buchanan, R. (2007). Strategies of Design Research: Productive Science and Rhetorical Inquiry. In M. Ralf M (Ed.) *Design Research Now* (pp. 55-66). Basel: Birkhäuser.

Buchanan, R. (2009). Thinking about design: An historical perspective. In A. Meijers (Ed.) *Philosophy of Technology* (pp. 409-453). Amsterdam: North-Holland.

Cramer-Petersen, C. L., Christensen, B. T., & Ahmed-Kristensen, S. (2019). Empirically analysing design reasoning patterns: Abductive-deductive reasoning patterns dominate design idea generation. *Design Studies*, 60(1), 39-70.

Cross, N. (1993). Science and design methodology: a review. *Research in Engineering Design*, 5(2), 63-69.

Dalsgaard, P. (2014). Pragmatism and Design Thinking*. International Journal of Design*, 8 (1), 143-155.

Dixon, B. (2019). Experiments in Experience: Towards an Alignment of Research through Design and John Dewey's Pragmatism. *Design Issues*, 35(2), 5-16.

Dewey, J. (LW 1–17). Boydston, J. A. (Ed.), *John Dewey, The Later Works*, 1925–1953. University of Southern Illinois Press: Carbondale IL.

Dong, A., Garbuio, M., & Lovallo, D. (2016). Generative sensing in design evaluation. *Design Studies* *45*, 68-91.

Dong, A., Kleinsmann, M., & Snelders, D. (2017). A Design-based Theory of the Firm. Unpublished manuscript.

Dong, A., Lovallo, D., & Mounarath, R. (2015). The effect of abductive reasoning on concept selection decisions. *Design Studies* *37*, 37-58.

Dorst, K. (2011). The core of ‘design thinking’ and its application. *Design Studies* 32(6), 521-532.

Fallman, D. (2008). The interaction design research triangle of design practice, design studies, and design exploration. *Design Issues* 24(3), 4-18.

Eris, O. (2004). *Effective Inquiry for Innovative Engineering Design*. Dordrecht: Kluwer Academic Publishers.

French, T., & Teal, G. (2015). Co-designing a digital directory of services*. Procedia Computer Science*, 63, 445-450.

Finger, S., & Dixon, J. R. (1989). A Review of Research in Mechanical Engineering Design. Part I: Descriptive, prescriptive, and computer-based models of design processes. *Research in Engineering Design*, 1(1), 51-67.

Friedman, K. (2003). Theory Construction in Design Research: Criteria: Approaches, and Methods. *Design Studies* 24(6), 507–522.

Galle, P. (1996). Design rationalization and the logic of design: a case study. *Design Studies* 17(3), 253-275.

Galle, P., & Kovács, L.B. (1996). Replication protocol analysis: a method for the study of real-world design thinking. *Design Studies* *17*(2), 181-200.

Gero, J. S., & Kannengiesser, U. (2004). The situated function–behaviour–structure framework. *Design Studies*, 25(4), 373-391.

GSA. (2013). Digital Health Institute [PDF]. URL http://www.gsa.ac.uk/media/782330/the-dhi.pdf

Jonas, W. (2012). Exploring the swampy ground. In S. Grand & W. Jonas (Eds.), *Mapping Design Research* (pp. 11-41). Basel: Birkhäuser.

Jonas, W. (2015). A cybernetic model of design research: towards a trans-domain of knowing. In P. Rodgers & J. Yee (Ed.), *The Routledge Companion to Design Research* (pp. 23-37). Abingdon, Oxon: Routledge.

Kolko, J. (2010). Abductive Thinking and Sensemaking: The Drivers of Design Synthesis. *Design Issues*, 26(1), 15-28.

Koskela, L., Paavola, S., & Kroll, E. (2018). The Role of Abduction in Production of New Ideas in Design. In P. Vermaas, & S. Vial (Eds.), *Advancements in the Philosophy of Design* (pp. 153-183). Cham: Springer.

Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2011). *Design Research Through Practice: From the Lab, Field, and Showroom*. Amsterdam: Elsevier.

March, L. (1976). The logic of design and the question of value. In L. March (Ed.) *The Architecture of Form* (pp. 1-40). Cambridge, UK: Cambridge University Press.

March, L. (1984). The Logic of Design. In N. Cross (Ed*.) Developments in Design Methodology* (pp. 256-276). Chichester: John Wiley & Sons.

Matthews, B., & Brereton, M. (2015). Navigating the methodological mire: practical epistemology in design research. In P. Rodgers & J. Yee (Eds.), *The Routledge Companion to Design Research* (pp. 151-162). Abingdon, Oxon: Routledge.

Melles, G. (2008). New pragmatism and the vocabulary and metaphors of scholarly design research. Design Issues, 24(4), 88-101.

Nguyen, T. A., & Zeng, Y. (2012). A Theoretical Model of Design Creativity: Nonlinear design dynamics and mental stress-creativity relation. *Journal of Integrated Design and Process Science*, 16(3), 65-88.

Peirce, C. S. (1992). The Essential Peirce, Volume 1 (1867-1893). Bloomington IN: Indiana University Press.

Peirce, C. S. (1998). The Essential Peirce, Volume 1 (1893-1913). Bloomington IN: Indiana University Press.

Rodgers, P., & Yee, J. (Eds.) (2015). *The Routledge Companion to Design Research*. Abingdon, Oxon: Routledge.

Roozenburg, N. F. M. (1993). On the pattern of reasoning in innovative design. *Design Studies* 14(1), 4-18.

Roozenburg, N. F. M., & Eekels, J. (Eds.) (1995). *Product design: Fundamentals and methods.* New York: John Wiley and Sons.

Schön DA (1983) The Reflective Practitioner. New York: Basic Books.

Shook, J. R. (2000). *Dewey’s Empirical Theory of Knowledge and Reality*. Nashville, TN: Vanderbilt University Press.

Sleeper, R. W. (1986*). The Necessity of Pragmatism: John Dewey’s conception of philosophy*. New Haven: Yale University Press.

Steen, M. (2013). Co-Design as a Process of Joint Inquiry and imagination. *Design Issues* 29(2), 16-28.

Stumpf, S. C., & McDonnell, J. T. (2002). Talking about Team Framing: using argumentation to analyse and support experiential learning in early design episodes. *Design Studies*, 23(1), 5-23.

Teal, G. (2018). The Modern Outpatient [WWW page]. URL https://futurehealthandwellbeing.org/modern-outpatients

Teal, G., French, T., Hepburn, L. A., & Raman, S. (2016). Fostering Engagement Through Creative Collaboration. Paper presented at *Cumulus Hong Kong 2016: Open Design for E-very-thing*, Hong Kong, China.

Vaughan, L. (Ed.). (2017). *Practice-based Design Research*. London: Bloomsbury.

Wan, T. T. H. (2002). Evidence-Based Health Care Management: Multivariate Modelling Approaches. Dordrecht: Kluwer Academic Publishers.

Zeng, Y. (2015). Environment-based design (EBD): A methodology for transdisciplinary design+. *Journal of Integrated Design and Process Science*, 19(1), 5-24.

Zeng, Y., & Cheng, G. D. (1991) On the logic of design. Design Studies 12(3), pp. 137-141.

Zimmerman, J., & Forlizzi, J. (2008). The role of design artifacts in design theory construction. *Artifact: Journal of Design Practice* *2*(1), 41-45.

1. On the common conception, the deduction is used to and the induction allows for the inference of a general truth from many particular cases. [↑](#endnote-ref-1)
2. The latter contribution is complimented by a descriptive theory of design which aims to outline the productive interrelationship between design’s supposed recursivity and a designers’ cognitive stress and extent to which this may be seen to support creativity (see Nguyen and Zeng 2012). [↑](#endnote-ref-2)
3. Intriguingly, in the context of the present article, Gero and Kannengiesser attributes the origin of the concept to John Dewey’s work in early psychology (Gero and Kannengiesser 2004, p. 376). [↑](#endnote-ref-3)
4. The initial approach was grounded in a wider DHI model referred to as ‘Explore-Experience-Exploit’ (GSA, 2013). Within this, the ‘Explore’ stage related to opportunity-identification; the ‘Experience’ stage, which enfolded the Labs, related to concept generation and testing; while, lastly, the ‘Exploit’ stage related to implementation. [↑](#endnote-ref-4)