A systems approach to design innovation

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Theme: innovation
Keywords: systems, interdisciplinarity, art, science, fiction

To be presented at http://www.cumulusassociation.org/cumulus-conference-paris-2018-to-get-there/

ABSTRACT

How exactly can interdisciplinarity in the field of design be a lever for innovation? Where exactly might innovation be situated in interdisciplinary design? I address these questions by, first, de-constructing the terms 'design' and 'innovation' to expose their roots in science and art. I then identify patterns across science and art which can be applied to an expanded practice of interdisciplinary design, locating innovation in the connections between these disciplines. I then abstract these into design principles focused around practice-based research, providing illustrative case studies. The methodology for addressing the above questions draws from systems thinking combined with artistic research. Key findings emerging from our work include the construction of new ways of using and theorising information in design practice; the importance of embodied, multisensory experience in design processes and outcomes; and new methods of data collection and analysis combining multiple perspectives. These can roughly be grouped under a systems approach. The main contributions of this research are therefore in methodological innovation, and in an emerging set of design principles based on a systems approach.

INTRODUCTION

Interdisciplinary approaches in design education and practice are increasingly given and unquestioned, with 'design' and 'innovation' generally defined as generators of ideas, products, services and value. A broader cultural and historical view reveals important shifts in how these terms have changed, and thereby how critical perspectives are changing what design means and does.

Buchanan (1992) defines design as 'the conception & planning of the artificial'. It is no coincidence that 'art' is in the word 'artificial'—both are rooted in the Latin word related to making, skill and craftsmanship. But while the word 'art' typically refers to the making of something that somehow enriches human experience, 'artificial' usually describes the unnatural or even deceitful. Art is often counterposed against science, which investigates natural phenomena, while technology is typically associated with the artificial. Scientific and artistic approaches often serve as shorthand in people's minds and conversations for rational versus intuitive modes of thought, respectively.[1]

The terms 'design' and 'innovation' arose within American industry, in the 19th century, according to Noble (1977). America's founding thinker Benjamin Franklin regarded science as 'handmaiden to the arts'; a generation after him, the word 'technology' came into general usage to describe the application of science to 'the more conspicuous arts' (*Ibid*. p.2). At the time, according to Noble, scientists held little regard for practical applications or money making, and those in business conversely had little need for lofty scientific theories. But as both science and technology progressed over the 19th Century, a significant shift occurred in which companies increasingly adopted, or co-opted, scientific discoveries and techniques of the 'useful arts'. In particular, advances in electricity and chemistry were absorbed into corporate research and development, and engineering arose as a profession. Science itself became a form of capital—as Marx observed at the time, 'Invention then becomes a branch of business, and the application of science to immediate production aims at determining the inventions at the same time it solicits them' (Marx, 1858:592).

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[1] See Kahnemann (2011). Pirsig (1974) terms these 'classical' v. 'romantic' modes of thought.

Innovation at scale

George Orwell and others saw the dangers of this marriage early in the 20th Century. In particular, wars large and small have tended to boost both technological and economic development (Ruttan, 2006). Conflicts such as wars serve as 'wicked problems' (Rittel and Webber, 1973) to be solved by rational minds and means, and design, as deliberate planning, is so applied to solve them (Buchanan, 1992). Technological tools such as computers—inherently rational by definition—both aid in and help to perpetuate this effort. Yet this results in what Lasch calls 'a productive system efficient in its details but supremely wasteful and irrational in its general tendency' (Lasch, 1977: xii-xiii). He notes, 'Unless accompanied by changes in social relations, technological changes tend to be absorbed into existing social structures; far from revolutionising society, they merely reinforce the existing distribution of power and privilege' (*Ibid*, xi). Mumford (1934) thereby preferred the term 'technics' to 'technology', which envelops technological innovation within the broader interplay of social relations, drawing from the Greek *tekhne*, which encompasses art, skill and dexterity.

In the Middle Ages, the individual craftsman held property, tools, and technical knowledge; all of these were gradually appropriated by capitalists through specialisation and automation.[2] Now, global industries rely on innovation as a variable, but inevitably run into the problem of scale: mass manufacturing and distribution shift the focus from quality to quantity, from individuality to commonality—of people, processes and products. An organisation, when it scales up, can no longer innovate from within, according to the designer Neville Brody (2016), and must import, purchase, or otherwise stimulate bottom-up creative processes.

But there is no conspiracy here. Jerome Weisner warned in the early 1970s that we were approaching Orwell's dark vision of *1984*, but that this was happening 'without specific overt decision or high-level support, and totally independent of malicious intent' (in French, 1979:6).[3] This is the unintended result of collective human action—when individuals, acting in their own self-interest or on increasingly specialised tasks, fail to see the big picture.[4] Following Lasch's argument above, we might observe that technological change is now so rapid that it serves primarily to reinforce existing distributions of power and privilege.

Questioning design and innovation

What then are the contemporary roles of 'design' and 'innovation', both of which emerged squarely within capitalism? Bratton (2016) proposes that many of our current global-scale problems are the product of the field of Design, and that 'the job of Design in the 21st century is to undo (much of) the Design of 20th.' Similarly, 'innovation', closely allied with design as a synonym for profit-making and exploitation, exists almost exclusively within narratives of technical improvement. Could it be turned back against itself to question or design alternatives to 'artificial' products, services or experiences which might be viewed as harmful or exploitive to humans or other natural systems? When and how might the new become a reaction to newness itself?

Our approach is to confront the systems of design, technology and innovation by engaging directly with them, deconstructing them and using their own methods, tools and materials for alternate purposes. This aims to diverge from other critical approaches in its deep investigative approach involving direct engagement and practice; in moving beyond merely questioning and raising awareness to posing alternatives; and in our approach to interdisciplinarity—instead of drawing together teams of specialists to design something new, we aim to be and to train generalists who can work across a range of specialisms, tools, methods and media, drawing not from hybrid areas in the overlaps between disciplines, but rather from the far extremes of artistic and scientific research and practice, including, in our case, quantum physicists, children, nonhuman organisms or machines in the design process.

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[2] The early 20th century Arts & Crafts movement tried to address this alienation by giving control of the means of production back to the craftsperson. According to Morris: "Have no work in your house not useful or beautiful." Unfortunately, it was mostly the rich who could afford it.

[3] Weisner later went on to establish the MIT Media Lab.

[4] This view is most notably espoused by free-market economist Hayek (1991); for an account of how atomic scientists became increasingly specialised and failed to see the eventual outcome of their research, see Else (1981).

RELATED WORK

While much of the following work is grounded in critical theory, particularly around the deconstruction of texts, Marxist-inspired analyses of social relations, or social semiotics, I focus on practical implementations in art, design and technology, not theory.

Design & critique

Garland (1964) and fellow graphic designers critiqued the crass commercialism they saw in advertising, and called on designers to shift their priorities to more socially useful work. Papanek (1971) was even more direct:

> There are professions more harmful than industrial design, but only a very few of them. And possibly only one profession is phonier. Advertising design, in persuading people to buy things they don't need, with money they don't have, in order to impress others who don't care, is probably the phoniest field in existence today. (Papanek, 1971: ix)

Garland's manifesto was updated in 1999 and countersigned by a new generation of designers who hadn't seen much progress from the time of his original. In parallel, Dunne (1998) perhaps unwittingly updated Papanek's critique of industrial design for the digital age in coining the term 'critical design'. Dunne locates its roots in conceptual art and architecture as well as speculative fiction dating back to the 1940s, and it has involved primarily technology-related design concepts and prototypes to stimulate discourse and challenge prevailing assumptions. Its explicit focus on wicked problems, its liberal use of fiction and imagination, collaboration with scientists, and practice of bringing science into the art gallery has some parallels with our approach. Related approaches include Wodiczko's (1999) 'interrogative design', which uses 'critical vehicles' to question the role of the individual within capitalism; 'contestational design' (Hirsch, 2008) and 'adversarial design' (DiSalvo, 2010), both of which use the design of technologies to challenge political issues.

By comparison with the above approaches, we are less focused specifically on technology, politics or advertising, and more broadly on systems in general—both as targets for research and practice, and conversely as a general orientation to design. We focus on the real-world present, aimed at addressing systemic problems, existing and emerging power relations.

Systems & strategy

Systems thinking has long been integrated into design, being integral to any design project or process which goes beyond aesthetics or functionality with regard to a single product or outcome. Systems thinking began to be explicitly integrated in the 1960s by designers such as Papanek, Buckminster Fuller, and Christopher Alexander—all of whom came together in a seminal event in Helsinki in 1968. Helsinki Design Lab later shaped this into what they called 'strategic design', which aimed to move beyond the design of static solutions to the design of decision-making processes, by which the designer would be able to navigate, visualise and implement new relations.[5]

Blauvelt (2008) conceptualised 'relational design' as a performative, process-oriented and participatory practice, linked to the spread of digital systems in the 1990s. Like strategic design, it charted a move from form to content to context. He cites Dunne and Raby (2013) as well as Bourriard (2002) whose identification of the move to 'relational aesthetics' in the art world was similarly influential in that domain. Systems were, as well, at the centre of Blauvelt's approach: '…the nature of design itself has broadened from giving form to discrete objects to the creation of systems and more open-ended frameworks for engagement: designs for making designs.'

Our approach is similarly concerned with systems and the relations between their parts and to other systems. Our work, however, is not commercially oriented as with Helsinki Design Lab, perhaps closer to Blauvelt's but with strong links to domains outside design.

Art & innovation

The art world has a long history of both interdisciplinarity and critical practice. Artists in the late 1950s began to work with emerging digital technologies, for example working with engineers and/or co-opting military computers for the purpose of making artworks (see Bedard, 2009). Conversely, artists including

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[5] See http://1968.helsinkidesignlab.org (accessed 18 Mar 2018).

Yoko Ono, Sol Lewitt and Bridget Riley adopted algorithmic or systems-oriented approaches to making non-digital works. The following two artistic examples are particularly relevant for us.

The Artist Placement Group, which operated from 1966 to 1979 in the UK, sought to relocate artists from the studio and into companies and government, for months or years—not to produce commissioned work but to offer insights such as a management consultant might. In return, the artist might gain access to new materials or produce documentation as new work. The APG had only a subtle form of critique, seeking to change the perception of artists as marginal figures by putting them directly in commercial contexts (Hudek and Sainsbury, 2012). Indeed, APG was criticised by other artists for being apolitical and even subservient to industry, and some APG artists even produced practical, commercial designs during their placements. This nonetheless has echoes in our work, in its regard for artistic knowledge as equally valid as other, seemingly more rational approaches; and in seeking to situate critical practice directly within real-world contexts. Two specific practices of the APG resonate with us: First, the artist was regarded as an 'incidental person' who explored and observed the context before making a proposal; and second, the artist had an open brief in which they received a wage not tied to outputs.

Experiments in Art and Technology (E.A.T.) began in the US at the same time as APG, and united artists, engineers and scientists with the parallel aim of expanding the role of the artist in society through direct engagement with new technologies, in the scientific or commercial contexts in which technologies were being developed. E.A.T. is known primarily for '9 Evenings of Theatre and Engineering' in 1966, but its activities took place around the world, including India, Japan, El Salvador, Sweden and France. Such an international scope, and the bringing together of radically different practitioners, has echoes in our work.

Critical technology practice

Our work diverges from that of E.A.T. in that we engage directly with technologies as a critical practice more often than collaborating with engineers. This has roots in 'physical computing', which, as initiated by Igoe and O'Sullivan (2004), has made electronics accessible to artists. Viewed within the historical perspective detailed above, this locates innovation back in making and craftsmanship. This approach has been shaped into critique in approaches such as 'critical making' by Eric Paulos and others.[6] The open source movement further puts software and hardware specifications into anyone's hands, which also means that companies large and small are free to exploit them for profit.

Critical practice has more recently infused interaction design more broadly, for example in 'material speculation' (Wakkary et al, 2016) and recent research by Bonnie Nardi (2017, 2016). Dunne and Raby (2013) have explored a variety of possible futures with their students and collaborators, in their speculative design work around social engineering and synthetic biology. As computation is increasingly embedded in the physical world in the form of sensing, surveillance, connected objects, and the digital design of everything, some have begun to conceptualise a post-digital world (e.g., Berry and Dieter, 2015), including us[7]. Our approach thus takes in current and future technologies but reaches more widely; I detail this next.

OUR APPROACH

We regard artistic research to be as valid as scientific research in generating new knowledge, and frame our contribution in terms of methodological innovation[8], aiming to redefine design and innovation in the context of critical practice. Our methodology combines and conflates methods from art, design, journalism and the social and physical sciences. As such, we do not make firm distinctions between these fields nor between research and practice. We view ourselves, and aim to train our students as, research-based practitioners or practice-based researchers. Thus while focusing on the post-digital, we also regard our approach as post-disciplinary.

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[6] See Hertz, G. (2012), http://make.berkeley.edu; http://www.paulos.net (accessed 18 Mar 2018)

[7] See https://postdigitalfutures.tumblr.com (accessed 18 Mar 2018)

[8] See https://midas.ioe.ac.uk (accessed 18 Mar 2018)

Our work can be divided into three more specialised initiatives. One, which we call ‘de-computation,’ has been described elsewhere (Walker and Fass, 2015), so this paper focuses on the other two, which have emerged more recently. (I note however that this paper is structured using the steps of de-computation: deconstruction, pattern recognition, abstraction and design.) All these initiatives are characterised by a strategic approach, which to us means going beyond the traditional definition of design as planning, to broader, longer-term thinking. A good strategy maintains some flexibility in the face of randomness and unpredictability, to turn a complex and developing set of affairs to particular advantage—this indeed is a definition of design (See Freedman, 2013).

But strategy is also art—the art of creating power. Thus, in contrast to the approach of Helsinki Design Lab, ours is more overtly political. An artistic strategy applied to design means interrogating and investigating systems of power and persuasion—how they embody, produce and perpetuate particular social and political relations and structures. ‘If power was previously exerted in the disciplinary practices of design at a built and urban scale,’ according to Ericson and Mazé (2011), ‘power is shifting into the codes, programs and archives of telecommunications and network technologies.’

Systems Research Group

A systems perspective is explicitly investigated in our Systems Research Group, led by artist and quantum physicist Libby Heaney and grounded in scientific theories and methods. Information plays a prominent role, in theories from Shannon’s (1948) mathematical theory of communication to Integrated Information Theory (Tononi et al, 2016); and in practice as a material for artistic and design production.

Information is now seen to underlie biology, physics and chemistry as well as computation, and as a focal point it enables a redefinition of design from the perspective of natural systems. Dennett (2015) regards ‘research and development’ as a design process—as innovation which exploits information in the environment to create, maintain, and improve the design of things. This is undertaken by humans as a directed, top-down (strategic) process, but also by evolution as an undirected, bottom-up process. Viewed as a system, any organism or organisation is more powerful than any single element it contains, according to Weiner (1950).

Taking this view, what we refer to as things (microbes, companies, galaxies) are systems and processes—poetically and temporally-bound confluences of other things. Therefore instead of referring to discrete things, it makes more sense to think about how things connect with each other, of causes and effects. As in relational design as described above, meaning is found in the connections. According to Barad, ‘Space and time are phenomenal, that is, they are intra-actively produced in the making of phenomena; neither space nor time exist as determinate givens outside of phenomena” (Barad, 2007, p. 383).

The natural tendency of any system, from the microscopic to the social to the galactic, is to eventually dissolve into entropy—the state where no patterns may be found. If all material and social entities are in a state of constant reconstitution and deterioration, we can hasten this process, or stop time by capturing a momentary glimpse of something—as in a drawing, photo or other representation—during this constant and inevitable transformation. This is a translation of time into space. Or, as with the strategic approach of Helsinki Design Lab or the Artist Placement Group, the process can be the outcome.

A critical perspective is elucidated by Heaney (2017), drawing from quantum information theory as well as literary studies: ‘The act of critical reading means one must decide which questions to ask to probe certain inconsistencies and instabilities in a text.’ This, she says, is not unlike a quantum experiment in which the act of observation biases the outcome one way or another. ‘Deconstruction is not neutral,’ according to Derrida (1981) ‘It intervenes.’

Thus, observation is a key method with regard to systems, along with a recognition that observation can also influence the system under study. Therefore, second-order cybernetics comes into play: developed by the social anthropologist Margaret Mead (1968) and others, this regards the subjective observer as part of the system under study. Zooming in and out to choose appropriate levels of description and action are therefore important.

The paradox about observation, from a quantum perspective, is that when an observation is made, it collapses the multiple possible states of a system into one. In *A measurement (problem) of reality*, our MA

student Maria Euler, reacting to political events in 2016 (the US presidential election, and UK 'Brexit' vote) replicated a quantum experiment in which a laser is deflected in one of two directions, and encased it in a voting booth. The viewer (as active observer) pushes a button which randomly deflects the laser, thereby taking a measurement and initiating one reality over another (fig. 1). Euler worked with quantum physicists throughout her research, but attained sufficient knowledge of the topic to use and apply some of its core ideas as critical practice.

Figure 1. *A measurement problem of reality* by Maria Euler (2017). *Photo by Maria Euler.*

Investigative Design

Whereas a quantum approach views all observed phenomena as systems, we also use narrative methods to take a critical approach to systems. This is common in investigative journalism, which undertakes in-depth research to question systems of power and privilege, in order to produce stories which aim to inform and influence. While journalists typically strive to uncover facts, art (and arguably much of design) is often about fiction and fantasy. Yet both art and journalism are about making visible the things we take for granted. Both can inform, enlighten and provoke. Both can be overtly political. Both usually involve some amount of investigation or research, and result in some kind of output.

Some art embraces investigative approaches and the communication of facts. For example, the placement of artist Ian Breakwell in the UK's Department of Health and Social Security by the Artist Placement Group in 1976 uncovered substandard conditions in mental hospitals; his report was censored by the government, but the details later emerged in Breakwell's film works. Conversely, some journalism embraces elements of fiction, notably the 'new journalism' of Truman Capote and others.

In investigating a topic, both journalists and artists/designers typically recognise and embrace the fact that they are not experts. The journalist finds out whom to talk to, gathers multiple perspectives, digs into books and documents, but importantly does not get lost in research because there is a deadline to be met and a story to file. The artist/designer might also seek out experts as informants or collaborators, but pursues a singular, often critical, vision, perhaps turning a topic against itself or counterposing it against a completely different

one. Our aim with investigative design is to bring together the best of journalistic investigation and artistic instigation, journalistic communication and artistic experimentation.

As in quantum theory, journalism embraces observation as a primary research method. Technology is similarly often used for observation and data collection—for example, cameras or other recording devices. Extended to computational practice, we can also use technologies such as sensors and algorithms to collect and interpret data in journalistic ways (see e.g. Bilton, 2013). The sub-field of data journalism attempts to look for stories in the data, not just collect data for a given story; we draw from this but aim for a broader range of storytelling mechanisms and outputs than printed or screen-based data visualisations.

As in quantum theory, journalism also embraces multiple perspectives, aiming for rigour and objectivity of methods while acknowledging the subjectivity of interpretation. Design practice also uses multiple perspectives, for example at Helsinki Design Lab. While some practitioners of critique fail to go beyond raising awareness or criticism of the phenomenon under study, as detailed in (Walker, 2018) we aim for what Watson (2016) calls 'constructive criticism,' accepting that technology will not go away, and aiming to direct it to particular purposes through design. But investigative design aims at systems more generally, not just technological ones, as the following example illustrates.

To investigate the over-saturated topic of climate change, our MA student Sylvana Lautier interviewed London children about the topic and found them surprisingly positive about its perceived effects on their environment (for example, if London flooded, everyone could travel by boat). She then travelled to Greenland where melting ice was directly affecting local communities, and interviewed children there to create a film in which their voices tell the story. She exhibited this by projecting the film through a mirrored table, onto which viewers could manipulate a block of ice. The content was therefore communicated literally through melting ice, creating a visceral and multisensory means of telling the story (fig. 2).

Figure 2. *Their Voices* by Sylvana Lautier (2017). *Photo by Milan Lautier.*

RESULTS & DISCUSSION

Our approach to interdisciplinarity thereby combines methods from art, science and journalism to expand the realm of design beyond a top-down planning process, with innovation located in the connections between disparate elements, and newness emerging from their collision and the resulting divergent effects. Practitioners of this type of design aim to become generalists, but undertake deep subject-specific investigation, whether artistic, scientific, and/or journalistic, engaging with a wide range of collaborators who may or may not be specialists. We are just beginning to distill our findings into a set of design principles, but here are a few that are emerging:

Direct experience

A post-disciplinary designer aims to gain expert knowledge of a topic, and expertise in any domain comes not through the construction of abstract mental models but through direct, repeated experience, according to Sweller et al (1998). Drawing on scientific as well as journalistic practice, we have found that direct observation and participation in a given topic are the best ways to engage with and communicate it through design.

Constant questioning

I have described the practice of gathering diverse perspectives on a phenomenon. This means asking questions, starting with the journalistic conventions of who, what, why, when, where, how; it also means constantly questioning one's own assumptions and practices, recalling how second-order cybernetics situates the observer as part of the system. Here, such questioning becomes a key feedback mechanism for design.

Dialogue with(in) systems

What Meadows (1995) calls 'dancing with systems' means engaging in a dialogue with the materials and context of the phenomenon under study. A designer in this case should be prepared to cede some control and be led by the material and other human and nonhuman agents in the system. Choosing the right level of detail and description is important. We can distinguish between a level of descriptions (language) and that of actions (practice), following Laurillard (2002) who in turn draws from Pask (1976).

A conversational framework for design, adapted from Laurillard's, is shown in Figure 3. This illustrates design as a system with a subject and object, with two-way feedback mechanisms (what Maturana (1997) calls recursive interactions, or what Barad (2007) calls 'intra-actions') occurring between them and on a level of descriptions (language) and actions. Feedback takes place not only between designer and audience on these levels, but also between the conceptions of the designer and his or her own actions, and the audience's conceptions and actions.

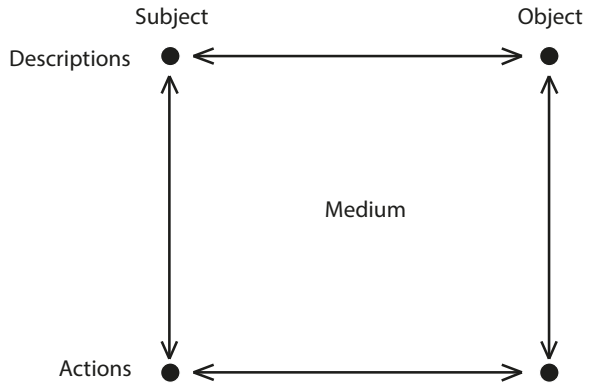

Figure 3. Conversational framework for design, adapted from Laurillard (2002).

In a quantum system, the scientist as subjective observer would be placed on the left, and the object of study on the right, wherein observations are mediated by tools, which indeed are seen to influence the described outcome. An important difference between science and the arts, however, is that science observes existing phenomena in seeking objective truth, whereas art and design exists to create new things in seeking change —in an audience or in broader terms.[9]

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[9] In quantum physics, a scientist observes a quantum system, situated in what is called a 'bath'. See for example https://vimeo.com/95925128

Viewing the designer as subject and the audience as object, design can be located as a mediation between them, in the sense of a designed object or system; drawing a triangle between subject, object and medium links this approach with activity theory (see Kaptelinin, 2011). But the subject could alternately be the designer's audience, whereby the object becomes the object of their attention in a hermeneutic sense. Or, the subject could be the designer and the object as his or her object of study, mediated by cognitive and technological tools. Design can more broadly apply to the entire system, with the designer-as-subject being a part of it, and humans as natural systems being situated in a shared medium or environment.

In all these cases, the value of this model is in separating (but linking) language and action. Journalistic methods of interviews and observation can also be placed on these levels. As an example, analysing Sylvana Lautier's project about climate change detailed above, we can place her audience as subject and the topic of climate change as object of attention, whereby this attention is mediated by language (as feedback between the audience's conceptions about climate change and the language encountered in the film), and actions (for example tactile interactions with the ice block, or more broadly any subsequent actions they might take about climate change).

Taking a systems approach to design is not easy. Scientists train for years to acquire deep subject knowledge and rigorous methods. Investigative journalists cultivate sources for years and undertake deep investigations that are not always possible in design. Artistic experimentation with tools and materials can lead in unexpected directions. Similarly, taking a systems perspective means ceding some control and agency to the system, operating at different levels, and acknowledging the designer's subjective role within a system—not least the technological, social, political and economic systems we live in. But we feel that this is where innovation arises: in the connections and feedback between designer and audience, language and action, information and experience; and between disparate fields of study.

CONCLUSION

In this paper we have detailed a systems approach to design innovation—de-constructing each of these terms historically and across relevant fields; recognising and generating patterns in the form of our methodological approach to systems and narrative investigation; and we have begun to abstract our emerging findings into design principles. We hope to contribute new types of post-disciplinary practice with deeply informed practitioners drawing from the far reaches of relevant theory and practice in the social and physical sciences, conceptual art and design, investigative journalism and communication. We thereby locate 'innovation' in the links between disparate areas of theory and practice, held together with a critical perspective and direct experience of materials and making.

The approaches we have described need further development and articulation. Each can be de-constructed further, and patterns recognised across them. The process of abstracting design principles from each can be extended, and formalised into a design process that maintains some rigour but also the flexibility of a sound strategy, and a critical perspective of constant questioning.

ACKNOWLEDGEMENTS

Thanks to my Information Experience Design staff who have informed this work in theory and practice: Dr Libby Heaney for entangling us all in quantum theory, Dr Dylan Yamada-Rice for helping to develop narrative approaches and highlighting the value of working with children, Angus Main for his work in pattern recognition and interaction design. Thanks to our students, including Maria Euler and Sylvana Lautier, for engaging with important issues and putting into practice some very challenging ideas.

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