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'A WAY TO UNDERSTAND THINGS BETTER THROUGH DOING': CREATIVE ACTION AND INTRINSIC MEANING IN ENGINEERING DESIGN

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Abstract: This paper argues for the broadening of the field of design creativity research in two main ways. Firstly, if we studied not just *creative ideas*, but also *creative action*, then this would better reflect some aspects of how creative design occurs 'in the wild'. Secondly, if we adopted not just *cognitive psychological* perspectives, but also *sociocultural* approaches then this would broaden our methodological and theoretical base and permit richer descriptions of design creativity. To illustrate these points, we report on the findings of an ethnographic interview study conducted with award-winning engineers and designers. Based on this material, we propose a way of reframing the process of designing as creative action, looking at the role of intrinsic motivation and personal values.

Keywords: *creative design process, creative action, intrinsic motivation, value.*

1. Introduction

Creative design is usually regarded as resulting from human thought. As such, reference is often made to 'creative thinking', 'creative imagination' and 'creative ideas'. However, the outputs of creative work are often tangible, and the activities that lead to such outputs combine practical work alongside cognitive work. This is also the case where prototyping and hacking are employed during design and product development. Usually in research on creative design these practical activities are subsumed and explained within a cognitive framework, where their role is to test and develop ideas. Here we ask what would happen if our unit of analysis was that of action, rather than idea, within a theoretical model for creative action where creativity is defined in sociocultural terms.

This paper reports on the results of a study conducted with exceptionally creative individuals – engineers and designers who were awarded one or more highly prestigious prizes for their innovative work. The research employed ethnographic interviews that addressed all four Ps, or Pillars of Creativity, identified by Rhodes (1961): the Product judged to be novel, the Person who is creative, the Process they are following in their creative work, and the Press, or the context that frames their work. Therefore, while the analytical focus of the paper is on creative design as process, this is addressed through ethnographic descriptions that have also been informed by reflections of creative individuals on how they shape their environments to support their development of novel products.

In our data collection, and the overall research process, we followed the technique advocated by Marcus (2013) of approaching the participants as epistemic partners. This involves developing new hypotheses from the bottom-up, through dialogue with the research participants. The structure of this paper also responds to this approach, as the discussion of our contribution is developed later, in section 4, where we create a dialogue between empirical findings and theoretical work. While this is a typical way of

creating theory in social anthropology, we appreciate that it is less common in engineering design and design research, and we ask for the reader's patience with the unfamiliar structure of this paper.

In the next section, we look at the main approaches employed in creativity research, and we situate problem-solving in relation to design process and to experiments on creativity. This is followed by a section on methodology, where we present the research method we used – ethnographic interviews. In section 4, we develop our discussion of creative action: we reframe the process of designing in relation to the framework developed by Joas (1996) for creative action, looking at the role of intrinsic motivation and of values in creative design. Section 5 presents implications for further studies on creative design.

2. Background

2.1. Creativity research

The field of creativity studies can be divided into two main research traditions: individualist approaches and sociocultural approaches (Sawyer, 2012). The former type of approach focuses on Personal creativity, as something that is new to the individual, while the latter looks at Historical creativity, as something that is new to the world (Boden, 2004). Those researchers adopting an individualist approach usually employ experimental methods and analyse creativity by breaking it into smaller units of thought and behaviour. For example, Amabile (1983) conducted experiments to look at the role of rewards in influencing creativity levels, and found that people who were told that they would be externally evaluated or rewarded for creative work produced less creative outputs. She suggested that creativity levels declined as intrinsic motivation declined, and that a focus on the reward hindered one's concertation on the task and their ability to use their environment for inspiration. The individualist approach to creativity provides many useful insights, such as Amabile's, about the ways in which the performance of a creative task is influenced by factors related to how the task has been framed and presented to the subjects taking part in the experiment. This leads to a better understanding of how to formulate tasks in support of creativity.

On the other hand, sociocultural approaches address real-world creativity by looking at how exceptionally creative practitioners conduct their work and develop creative outputs. The methods employed by researchers following sociocultural approaches can span from life story interviews (Csikszentmihalyi, 1996; Shekerjian, 1991) to case study analysis (Gruber, 1974). For example, Gruber studied the detailed notebooks kept by Charles Darwin to trace the development of his thoughts leading to his proposed theory of evolution by natural selection. He found out that Darwin's theory did not benefit from a single moment of sudden inspiration, but was reached over years of incrementally accumulated knowledge when Darwin was working on many overlapping projects. Gruber termed this way of working on multiple fronts a *network of enterprise*. He suggested that this form of working allowed cross-fertilization of ideas and supported the development of creative outputs. Sociocultural approaches to creativity take wider perspectives in terms of both time and scale, looking at achievements spanning over a lifetime, and paying attention to the role of cultural and institutional contexts of creative work. This leads to a better understanding of how to shape a society that encourages creative individuals' lifetime efforts to develop paradigm-shifting ideas and theories.

While there have been several attempts to bring these independent research traditions together for the further advancement of creativity and innovation scholarship (Basalla, 1988; Sawyer, 2012), there still remain many underexplored opportunities for knowledge exchange between the two. Here we extend this conversation to the field of engineering design, asking what is to be gained by allowing ethnographic research findings on real world design projects to change the focus of creative design research from creative ideas to creative action.

2.2. Design process and problem-solving

Design theory assigns an important role to what is called design process. This process is usually represented as a diagrammatic model of the steps that someone takes (or should take) when designing something. It is hard to reach agreement on a single process model that would fit all forms of design, and the wide range of models that have been proposed differ in scope and type to the point of providing contradictory views (for a recent analysis see Wynn & Clarkson, 2017). These stages usually cover problem identification, idea generation, idea selection, implementation and delivery (Vasconcelos et al 2016). Studies of creativity in design tend to focus on the first few stages, especially idea generation, and it is much less common to focus on the later stages of implementation and delivery (Snider et al., 2016). Although not explicitly stated, it would also seem that design researchers have regarded the earlier design stages (where ideation is thought to occur) to be primarily cognitive, with making and testing left to the later stages. This might explain lack of making and testing in the majority of design creativity studies (but see, for example, Viswanathan et al., 2014).

In the field of engineering design it has been argued that processes of creativity and design are similar and mutually supporting, and so are the theories that account for them (Bila-Deroussy et al., 2015; Howard et al., 2008; Le Masson et al., 2012). The close connection between design and creativity is most apparent when both are viewed from the perspective of problem-solving (Simon, 1969). For example, when creativity researchers employing individualist approaches conduct experimental studies they often look at aptitudes for problem-solving, with the solutions proposed by participants to a given task being evaluated as a marker of creativity. However, problem-solving is just one of the many facets of creativity. The fact that experimental methods facilitate the study of individual aptitudes for problem-solving should not limit the definition of creativity as being solely about solving problems. For example, exceptionally creative individuals working in fields such as art, writing, and architecture are reported to produce creative outputs by stepping into the flow of making and doing, rather than by following specific problems to be solved (Csikszentmihalyi, 1996; Shekerjian, 1991). With the exception of a few early examples (e.g. Cross & Cross, 1996; Roy, 1993) design creativity research has tended to ignore aspects of creativity that are not directly to do with solving problems. This paper addresses this gap by proposing to include creative action, alongside cognitive capacities for problem-solving, into the definitions of creativity that are being employed in engineering design.

3. Methodology

To better understand the role of creative action in engineering design, we are conducting a study with award-winning engineers and designers who have been recognised for their innovative work. The study is ongoing and here we report on data that was collected between January and May 2017. The research method employed was ethnographic interviews, which is a research encounter informed by ethnographic principles, such as building rapport and trust, and giving voice to the research participants. It takes the form of a guided conversation, usually semi-structured, addressing open-ended questions. The ethnographic interview can be regarded as a mini-relationship (Rapport, 2013) – an event that is distinct from routine social interactions and that invites heightened levels of self-reflection. Based on work with creative professionals, Wulff (2013) suggests that ethnographic interviews can trigger instances of inspiration that are beneficial for the researcher's work as well as for the participant's, in the form of novel personal or professional insights.

The participants were selected from recent cohorts of prize-winners of the two largest professional associations of engineering based in the UK. They were contacted either through the intermediary of the award giving body, or directly by the researchers. So far, a total of 12 prize-winners have been contacted, out of which four have responded and have taken part in the research. In most cases, the first author travelled to conduct the interviews at the participants' workplace; in one case, the interview was conducted remotely, over a two-way video link. The interview questions were grouped into four topics: the awarded project; the personal story of the participant; their approaches to engineering design; and the future of their field. Each of the participants was interviewed individually, for between 80 and 120 minutes. With the participants' consent, all interviews were audio recorded. The interviews were transcribed verbatim, totalling 48,000 words. The two authors independently reviewed the transcripts to identify themes of interest. The research participants agreed to participate in the study on the basis

that the reporting would be anonymous. Therefore, throughout this paper, we use pseudonyms when referring to the participants, followed by an indication of their main design field. Other details that might make them identifiable have been omitted.

4. Creative action: ethnographic and theoretical considerations

All of the participants in the study talked about action as a mode of inquiry that led to particularly creative results. This realisation did not come from their formal education in engineering or sciences, but it developed later in life, from their work experience. The participants reported that the ability to engage in the more exploratory modes of thought allowed by action, such as when making or hacking, was an important part of what distinguished their work from the rest and contributed to their success.

> 'Hacking a ladder and turning it into a towel rail, or something like that, actually puts your mind in a different angle, I think. So you can start thinking: if I have a broken printer, what could I do with it? Well, I could take the motors out and I could build this, and that stimulates a different kind of thinking.' (Andy, Electrical Engineering)

> 'That live, spontaneous reaction in the immediate moment, with full attention, makes people merge into the problem, and from that comes creativity. Solution comes from the problem. Solution doesn't emerge like a lightbulb in your head. Solution actually arises from where the work is taking place, and that's creativity.' (Sam, Biomedical Engineering)

> 'We do things and in the act of doing, we learn more things, and that helps us refine what we want to do. This would be quite distinct from where you identify a problem, you go read the literature, and you start in a systematic and methodical way: what is out there, and what you want to do that's new, or better. In that sense, I would say that is very hypothesis-based or Descartes-based. Whereas this is activity-based, like, the only way for me to learn is by doing, and that would be – I think Heidegger or Nietzsche would represent this kind of philosophical thinking. I don't think anyone can learn to swim by reading a book, and I strongly believe the best way to learn to swim is by just jumping in the water.' (Tom, Human-Computer Interaction)

The above quotes refer to ways of thinking that emerge in action. Tom goes further, mentioning two sets of opposing philosophical ideas. While Descartes argued that knowledge is advanced through deductive reasoning applied to solving problems, Heidegger emphasized the role of perception and experience in generating knowledge. The former model assumes that problems are solved through thinking alone and by following a specific set of steps of reasoning, in a linear process. The latter model, known as Being-in-the-world, suggests that action, perception and reflection are interlinked and they feed into each other; there are no pre-established steps of reasoning, and knowledge is generated through one's acceptance and immersion into this mode of experiencing the world. This relates to what Csikszentmihalyi (1996) calls 'flow', and to what Ingold & Hallam (2007) call 'improvisation'.

This distinction between two main sets of ideas about processes of knowledge-production can also be employed when looking at models of human action. Hans Joas (1996) is the social theorist who first developed an integrated theoretical framework for addressing the creativity of human action. In reviewing existing theories of human action Joas discovered that the model of rational action was taken for granted in a range of fields as the main way for describing any form of action. According to this model, rational actors start by setting a goal, and then choose the most appropriate means to achieve it. This model is aligned to how Descartes described the process of knowledge-production based on deductive reasoning, and is usually followed in sciences education, for example in the ways in which students are trained to solve maths problems. This model also informs certain approaches to research, such as some of the standard experiments that address creativity as problem-solving.

Joas questioned the assumptions behind this approach, especially the fact that it proposed a means-ends schema as the basis for any form of action. He argues that 'concealed behind the notion that an act of goal-setting must precede action is the assumption that human cognition is independent of action or that it could and should be made independent of action' (1996, p.157). Such a view cannot account for creative acts where the output emerges from doing, such as art-making and many other inductive

exploratory practices. Joas suggests that a different theoretical framework is needed in order to account for the creativity of human action. The alternative approach that he proposes builds upon the work of the American pragmatist John Dewey. We will discuss this approach in relation to a more detailed ethnographic case. In the next sections, we present the development story of an award-winning project by Ishan, one of our participants; we then introduce Dewey's ideas on creativity and the framework for creative action proposed by Joas, followed by a discussion of the role of values in creative activity.

4.1. The development of a Tech for Good project

At the time of our interview, Ishan had been a designer for about 16 years. After a degree in graphic design, he worked in animation and web design, then moved to product design, user experience, and later to digital product design. When we met he was the co-founder and CEO of a Tech for Good organisation that had been awarded numerous prizes for innovation. The way the organisation came to be was an unusual story. Ishan had been working for a digital product studio for three or four years when the company let him set up a new program of work, which he describes as a 'think and do' tank. The purpose of the program was to look at how to use technology to improve people's daily lives. For this, colleagues were taken out of regular client work and enrolled in this exploratory program for six weeks: 'This allowed people who were on long-term projects to cycle in and be refreshed. We tried new methodologies, new techniques and new ways of working. Without having the pressure of client delivery within that, there is personal development.'

Without the pressure of set outcomes, the designers involved in the think and do tank were able to try new ways of working and to generate and test ideas at their own pace. One of the ideas that Ishan wanted to unpack was how to use technology to help visually impaired people. This thought first emerged as a New Year's resolution that he had set together with his wife, who is an optometrist. During the think and do program, he was then able to research this topic and to explore several avenues. At that time, as a digital product designer, he was interested in distributed interfaces and in ways of interacting with computers that do not require a screen. Another interest was with emerging sensors and iBeacons: 'These two things overlapped across my design journey. Then it all culminated around a purpose, which was when I read the manifesto of the Royal Society of Blind Children (RSBC).'

At the end of the six weeks of the think and do program, several Tech for Good products were implemented. Out of these, Ishan's project got traction and attracted external funding. He set up the project as a not-for-profit organisation affiliated to the design company he had been working for, and he moved to developing this idea full time. He now knew that he wanted to make a product that would help blind people navigate indoor environments, such as the underground system. He says that once he knew *what* he wanted to do, 'another eureka moment was about *how* to do it'. The 'how' referred both to the shape of the final output, and to the process of achieving it. The team started by working with the RSBC's youth forum, running co-creation sessions and doing customer journey maps to establish the needs of the community and to spot opportunities for design. This led to the idea of building an app, before they discovered that there were already some navigation apps for a few specific locations. The problem was that the existing apps used different syntaxes, which made it very confusing for the user to change between them.

> 'We realised very quickly that without the infrastructure in place for these apps to be able to bring a consistent user experience, we weren't going to get anywhere, and the market wouldn't get anywhere. Vision impaired people wouldn't get what they needed, so we pivoted. Our vision was to empower vision-impaired people to navigate the world independently. We pivoted from making an app to making an open standard, but our vision stayed the same.'

The move to developing a standard was based on research regarding trends in the emerging indoor navigation market. It was also supported by Ishan's experience in the software industry. He knew that in software development, addressing accessibility concerns was often left until the end, and he wanted to change that. By publishing a standard that has 'accessibility woven into it', when the infrastructure for indoor navigation is eventually ready it will be easy for organisations to adopt the standard in an inclusive way. The process of making the standard turned out to have an important organisational design

component. They brought together stakeholders from multiple domains, such as charities for vision impaired people, indoor positioning hardware and software companies, app developers, and research institutions. With their combined expertise, they then developed the software, testing through lab trials and live trials at every step. One of the main challenges in this process was to find a pace and a way of working that allowed all the stakeholders – coming from different types of organisations – to stay involved.

> 'Software moves fast, and design moves fast. The processes and tools that we use, such as the lean methodology, move fast. However, charities don't move fast. Infrastructure owners don't move fast. Policy makers don't move fast. The challenge here is how you adjust your pace of development with the pace of the others. We can move as quickly as we want, and we need to do that because we have limited time and limited money. How do you find an average pace that allows you to still stay ahead of the curve, but keep them part of the conversation?'

The resulting standard was published and recognised by the International Telecommunications Union, one of the main standards bodies for the ICT industry. It is an open standard consisting of two components: a set of guidelines for the syntax of the instructions to be given through the navigation app; and an open source app, which is the software they had developed and tested with the stakeholders.

4.2. Creative action and the process of designing

In this case, the journey from concept to implementation was unexpected even for Ishan. He had never designed a standard before, nor set up a not-for-profit organisation. The result was a surprise, in the sense that Ishan did not envision it when he first set the New Year's resolution together with his wife. To reach it, he had to move between design fields, some of which he was not necessarily familiar with. The reason why he did not find the journey daunting is that he focused on action rather than on a pre-established output.

> 'I find my purpose in action. Rather than sitting there and just theoretically thinking about stuff, actually going away and doing it. We could sit there, get all the experts in a room and write a standard. For me, that is not the way I can validate it to myself, so we do live trials and lab trials as well.'

He says that, for him, the most challenging and at the same time, the most rewarding stage in a design process is moving from idea to execution.

> 'Having an idea and then actually getting off your butt to go and do the first small step. You always want to do the big step, you have an idea and you want to get to the big step. Actually, all of the smaller steps are so boring that they kind of put you off. If you can get through them, you get to the bigger step. Organisations can generate loads of ideas and concepts. To actually get your finger out and do it takes discipline and takes an approach.'

In Ishan's account, the process of designing emerges as an activity that is unpredictable and immersive. The designer has to accept the fact that they cannot control this process, and that there are no fixed or pre-established outcomes to it. On the contrary, when embarking upon a design journey they need to let go of expectations and to accept, rather than avoid, every micro-challenge that arises. Through prototyping, hacking and testing, challenges become clues that tell them what the next step in the design journey is. This description of the process of designing can be situated theoretically by employing the work of Hans Joas (1996) on the creativity of action. As we mentioned earlier, Joas challenges the assumptions behind the model of rational action, and he employs the work of the American pragmatist John Dewey to propose a framework for human action that takes creativity as a starting point.

In his reflections on creativity and education, Dewey (1916) emphasizes the contrast between action in pursuit of external and predetermined goals, and action infused with intrinsic meaning. The former type of action refers to situations when the goal is set in advance by an external entity and it does not reflect the interests of the actor. The latter type of action refers to situations when the actor has, or gains, interest in the task, and it is possible for them to change the goal during the action, as they find out more about what they want and can do. To stay within the realm of education, an example of action in pursuit

of a predetermined goal might be when a student is asked to design something that they do not have any particular interest in, as part of their coursework or as an exam question. An example of action infused with intrinsic meaning might be when the student is asked to choose a topic that they are interested in and to research it. Only the latter type of action can be deemed creative, in Dewey's terms. This is because when the actor is personally invested, they not only perform a task, but they are able to redefine the goals of the action as they discover new means. For example, the student might start with a general view on the topic of their interest, and during their research discover a perspective that they did not know about, and that they would then choose to focus on instead. Thus, in order to engage in creative action, the actor needs to be free to follow the goals 'which emerge in the course of the action itself but which can also be revised or abandoned' (Joas, 1996, p.156).

The story of the Tech for Good organisation set up by Ishan is very telling in this respect. He first embarked on this project when the company he was working for allowed for a group of employees to take time to follow their individual interests, under the general theme of finding ways of using technology to help people. During this program, they were able to experiment with new methodologies without the pressure of the fixed deadlines or defined outcomes that are often associated with designing for an external client. With no pre-established output, they could revise the goals at any point in the process. Ishan took the opportunity of the think and do program to explore his interest of helping people with sight loss. This brought intrinsic meaning to his process of designing.

4.3. Intrinsic meaning and values

In Dewey's understanding, the intrinsic meaning that permeates creative action comes from the values and the ideals followed by the actor (Joas 1996, p.143). Values are culturally determined, in the sense that they differ with the social and historical context where one lives. However, they have an important subjective dimension: individuals can often choose the values that are most important for them and that they want to focus on, as well as switch between values within any given project or across their lifetime.

In our interviews, we wanted to find out about the values that the research participants followed in their work, and so we asked what good design, or good engineering was for them. In his response, Ishan started with inclusivity: 'Good design for me is inclusive. Good design is trustworthy, you can trust it. Good design is delightful. Good design dissolves into everything that you do.' He then referred to one of his favourite designers, Naoto Fukasawa, and to his approach of making products that are flawless and intuitive to use. He mentioned several other designers that he admired – what he called his 'heroes' – such as John Maeda, who moved from a design and computer science interdisciplinary academic environment to developing the inclusivity of one of the most well-known open software platforms. He also referred to the ethos of the Eameses as an important source of inspiration for his work: 'The objective is the simple thing of getting the best to the greatest amount of people for the least'.

Ishan's approach to design is guided by values such as inclusivity, trustworthiness, beauty, flawlessness and affordability. These values, between others, are collective and shared across the discipline of design, as shown through Ishan's examples of famous designers who chose one, or several, as guiding principles for their work. Ishan is able to pick and mix the values that drive him and represent him as an individual designer. This is part of what differentiates him from other designers, who display other combinations of values in their design approaches. Intrinsic meaning comes from finding the combination of values that they want to follow in their work and from expressing these values in actions of designing.

5. Implications

We have shown that the creativity of action is an important aspect of designing for expert practitioners. Hacking and making are ways of immersing into, and of conversing with what needs to be designed; they require full attention, which could lead to creativity emerging as a 'live, spontaneous reaction in the immediate moment', in Sam's words. We argue that it is important to address this facet of creativity in studies of creative design, alongside studies on ideation, in order to gain a better understanding of all the factors that influence the development of novel products and paradigms. The main case study discussed here showed some of the ways in which the context where a project is conducted influences

the creative outcomes. Ishan found an auspicious environment for his network of enterprise (in Gruber's terms), when his employer created a space for experimentation, outside regular client work. In this environment, Ishan's separate interests, together with the values he followed in his design work, came together leading to the successful development of an award-winning Tech for Good organisation and set of products. This journey did not follow a pre-established path, but it unfolded with each creative action undertaken by Ishan. Our findings about the role of intrinsic meaning in creative action extend Amabile's (1983) argument that intrinsic motivation drives creativity while extrinsic orientation might inhibit it. We suggest that as well as motivation, the intrinsic meaning that designers attribute to their actions of designing reflects their subjectivity and reinforces their passion for their job as designer. The fact that we were able to explore this case in detail through ethnographic description provided the opportunity to question established theoretical approaches to design process, suggesting that this process consists of a bundle of actions that cannot be predicted and planned, but that arise when one is immersed in activity. At the moment, such similarly detailed studies are missing from the literature on creative design, and with this paper we propose to take a step further in reviving the interest for sociocultural approaches to creativity in design research.

References

Amabile,T. (1983). *The Social Psychology of Creativity.* New York: Springer-Verlag.

Basalla, G. (1988). *The Evolution of Technology*. Cambridge: Cambridge University Press.

Bila-Deroussy, P., Bouchard, C. & Diakite Kaba, S. (2015). A systemic model of creativity to address complexity in design: The state of the art and perspectives. *The Third International Conference on Design Creativity (ICDC 2015)* (pp. 72-79). Bangalore, India: Design Society.

Boden, M.A. (2004). *The Creative Mind: Myths and Mechanisms*. New York: Routledge.

Cross, N., & Cross, A. C. (1996). Winning by design: the methods of Gordon Murray, racing car designer. *Design Studies*, *17*(1), 91–107.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the Psychology of Discovery and Invention*. New York: Harper Perennial.

Dewey, J. (1916). *Democracy and Education.* New York: Macmillan.

Gruber. H.E. (1974). *Darwin on Man: A Psychological Study of Scientific Creativity.* Chicago: Univ. of Chicago.

Howard, T.J., Culley, S.J. & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies*, 29: 160-180.

Ingold, T. & Hallam, E. (2007). Creativity and cultural improvisation: An introduction. In Hallam, E. & Ingold, T. (eds). *Creativity and Cultural Improvisation.* Oxford and NY: Berg.

Joas, H. (1996). *The Creativity of Action.* Cambridge: Polity Press.

Le Masson, P., Hatchuel, A. & Wei, B. (2012). How design theories support creativity: An historical perspective. *The Second International Conference on Design Creativity (ICDC 2012)* (pp. 273-284). Glasgow, UK: Design Society.

Marcus, George. (2013). Prototyping and Contemporary Anthropological Experiments With Ethnographic Method. *Journal of Cultural Economy*, 7(4):399–410.

Rapport, N. (2013). The interview as a form of talking-partnership: Dialectical, Focussed, Ambiguous, Special. In Skinner, J. (ed.) *The Interview: An Ethnographic Approach.* London and NY: Berg.

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan*, 42(7): 305-310.

Roy, R. (1993). Case studies of creativity in innovative product development. *Design Studies*, *14*(4), 423–443.

Sawyer, R.K. (2012). *Explaining Creativity: The Science of Human Innovation*. New York: Oxford Univ. Press.

Simon, H.A. (1969). *The Sciences of the Artificial.* Cambridge, Mass.: MIT Press.

Shekerjian, D. (1991). *Uncommon Genius: How Great Ideas Are Born*. New York: Penguin Books.

Snider, C., Dekoninck, E. & Culley, S. (2016). Beyond the concept: characterisation of later-stage creative behaviour in design. *Research in Engineering Design*, 27: 265-289.

Vasconcelos, L. A., Crilly, N., Chen, C.-C., Campos, F., & Kelner, J. (2016). What's the benefit of problem exploration? In *DS 84: Proceedings of the DESIGN 2016 14th International Design Conference* (pp. 89–98). Cavtat, Dubrovnik, Croatia: The Design Society.

Viswanathan, V., Atilola, O., Esposito, N., & Linsey, J. (2014). A study on the role of physical models in the mitigation of design fixation. Journal of Engineering Design, 25(1–3), 25–43.

Wulff, H. (2013). Instances of inspiration: Interviewing dancers and writers. In Skinner, J. (ed.) *The Interview: An Ethnographic Approach.* London and NY: Berg.

Wynn, D.C. & Clarkson, P.J. (2017). Process models in design and development. *Research in Engineering Design*, published online 12 July 2017, https://link.springer.com/article/10.1007/s00163-017-0262-7.