Craft as a Tool for Multidisciplinary Collaboration and Design Practice

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Keywords: craft thinking, knowledge management, multidisciplinary practice

This research investigates how craft, as a way of thinking, can facilitate the successful integration of knowledge in multidisciplinary design teams. A review of the process of design thinking and design management elicits the challenges arising from the recognition of its complexities. In this context, craft is introduced as new way of addressing this complexity. Relevant knowledge management theories serve to explain the role of craft within design management. Two case studies are used to illustrate the benefit of craft thinking within the management of multidisciplinary design teams.

INTRODUCTION

This research investigates how craft, as a way of thinking and working, can support multidisciplinary design teams by facilitating the successful integration of knowledge from different disciplines or knowledge fields. The idea of craft has recently become an issue of increasing academic (Sennett 2008, Crawford 2009; Frayling 2011) and political interest, for example, through recent UK government policies and the creation of apprenticeships.

Traditionally craft is often seen as the poor relation of design or art, being perceived as inferior in status either due to its economic value (Greenhalgh 2002: 6) or lack of intellectual rigour (Dormer 1997: 19). However, new approaches to craft (e.g. Sennett 2008, Crawford 2009, Niedderer 2009, Niedderer and Townsend 2010; Niedderer and Townsend 2011) contend that craft plays an important role in our everyday lives and that it enables engagement with human values and the combination and exploration of concepts not otherwise questioned.

The importance of craft has been acknowledged as contributing to the pre-industrialised (Epstein, 1998) and industrialised economies, both corporately (Graham and Shuldiner 2001) and sectorally (Freeman and Soete 1997). For example, recent research has shown the concept of craft being applied to problem solving within the knowledge-based enterprise, where non-standardised working practices encourage its adoption (Miles 2008).

Due to its affinity to human values (Sennett 2008; Crawford 2009) and its exploratory potential (Niedderer 2009), we propose that craft can function as a tool for knowledge integration within multidisciplinary collaboration and practice and thus as a tool for supporting design-related management processes. We propose further that this is useful in bridging micro (design teams) and macro levels (firms) of management processes.

In order to demonstrate these two propositions, we review the recent developments of design and design management. Parallels between developments in design thinking and design management reveal the complexities of the relationship of micro and macro level processes on individual, social and organisational levels. We introduce the concept of craft as a way of managing this complexity and explain how it can be beneficial using relevant knowledge management theories. Two case studies are used to illustrate the benefit of craft thinking within the management of multidisciplinary design teams.

THE CHALLENGES OF MANAGING MULTIDISCIPLINARY DESIGN TEAMS

This section discusses recent changes in design thinking and how these have influenced developments and current frameworks used in design management. This analysis highlights the current challenges arising from the recognition of complexity in design management.

How designers work

Designing is an activity and process, the understanding of which has undergone significant changes over the last decades. In 1965 and 1970 respectively, Bruce Archer and John Chris Jones established, perhaps for the first time, clear guidelines for design, which provided a milestone in defining the design profession and its processes. With *Systematic Methods for Designers* (Archer 1965) and *Design Methods* (Jones 1970), they laid down a canon of rules that developed into what is now known as systems design. Systems design regards designing as a linear and highly structured activity, being generally favoured by engineering designers (e.g. Stewart 1981).

However, recent research into the design process has revealed that systems design is not representative of the actual design process as understood by practicing designers. For example, Cross (2011) found that professional designers are happy to work with uncertainties where solution and problem evolve in response to each other, where the end product is not clearly defined from the beginning, and where different options are kept open as long as possible before making final decisions (p.11-12). This confirms the findings of Durling's

(1996) study of designers' personalities. Using the Myers-Briggs Type Indicator, Durling established that designers exhibit certain personality types. For example, designers are largely intuitive and tend to prefer partly personal values, partly 'hard logic' (p.49, 54), while mechanical engineers (or indeed business managers) predominantly exhibit preferences for fact-based reasoning and hard logic (p.50).

This highlights two challenges for multidisciplinary collaborations within design. Firstly, designers are comfortable with situations of uncertainty and risk, which organisational management generally tries to minimise. For example, in spite of the recognised benefits of creativity and design, they are traditionally subordinate to marketing and market research, both of which aim for certainty (Burns and Ingram 2008: p.2). Secondly, design is an inherently multidisciplinary activity because it deals with materials, processes, and people from different disciplines such as material science, engineering, ergonomics/health, sociology, psychology, and many more. According to Cross,

> Large projects demand […] reconciling the variety of interests […] that inevitably have to coalesce around a major project. In these cases, designing becomes not just a personal cognitive process, but a shared, social process. (Cross 2011: p.19)

This means that different personality types, experiences and knowledge areas need to be negotiated to establish a common language or means of communication between different parties for the effective management of the design process.

Design management in organisations

As with design, design management in the 1980s was represented, both visually and metaphorically, as a linear process (see Lawson, 1980; Rothwell and Gardiner, 1983). At macro level, these chronological models describe the major actors in the environment such as science, manufacturing and sales. At micro level, they depict the process as a series of stage-gated activities with minimal interaction between the actors and with it occurring at the boundaries of those activities (Cooper, 2000). Design management is presented as a logical, sequential process that is and can be managed. This orthodox view still persists in some elements of practice (Clark and Smith, 2008).

As the general paradigm of management shifted to incorporate advances from different schools of thought such as design, interactive systems, network and complexity theory, so design management has flexed successively to adopt these changes. Lester, Piore and Malek (1998) present two contrasting approaches to design management as being analytical and interpretive. For the former, design is viewed as part of a contribution to a project that is "essentially an engineering challenge – a problem that must be solved" (Lester et al. 1998: 88). The interpretive approach, on the other hand, presents the project management process as an open-ended process with design used to facilitate and mediate within it. It recognises that markets are dynamic, that users find it difficult to articulate their needs, and that there might be multiple future possibilities. Hargadon (2005) further argues that design needs to integrate the competing needs of markets, technologies and businesses. He presents the core practices

of discovery, synthesis and delivery as being fundamental to design to achieve this, including the significant role of prototyping as an operating principle.

Definitions of what comprises good design management are varied (Bachman, 1998), but various authors have argued that it includes: understanding organisational structures and decision-making processes at a strategic level, the management and leadership of people, teams and processes at an operational level, the facilitation of creativity, ideation and innovation, including collaboration and conflict resolution, at a tactical or project level, as well as understanding the role and importance of design in itself within the organisation (Cooper and Press, 1995; Borja de Mozota, 2003). Borja de Mozota (2008) further advocates the adoption of Kaplan and Norton's (1996) Balanced Scorecard model within design management so that the complexity of the company can be captured and the contribution of design – both to processes and organisational knowledge – can be recognised financially through this. In doing so, it also positions design management as contributing to a company's capabilities as a core competence and elevates it from a project-based restriction to potentially multidisciplinary adoption.

Addressing the changes

The different approaches to design show that the understanding of the design process has changed over the last four decades from that of a linear, orderly, systemic process to one that is complex and intuitive, which draws on, and brings together, various aspects of different disciplines, their knowledge and procedures. The understanding of design management has changed accordingly and is facing a point of inflection both at strategic and operational level. In particular, there is a need to acknowledge its complexity and to bridge the macro and micro levels of management.

Recently, craft has been recognised as a process and a way of thinking to which complexity is intrinsic because of the holistic nature of the process. Applied to design, it represents a more unified approach to experimentation and prototyping combined with the simultaneous tighter integration of clients, designers and users (e.g. Woolley 2011). This is similar to the change that has occurred in software development, where the sequential approach to design and development – the waterfall model, characterised by hierarchical, process-oriented micromanagement (Royce 1970) – has been replaced by adaptive approaches incorporating rapid iterative design and prototyping, collectively referred to as agile methodologies, which stress collective self-management and an emphasis on outcomes.

In the following section, we analyse the idea of craft as a way of thinking and draw parallels with the knowledge management process to propose ways of sharing knowledge and expertise, and to negotiate different approaches within the design management process.

INTRODUCING CRAFT THINKING IN DESIGN MANAGEMENT

This section looks at craft as a unified process of thinking and working, and draws on the concept of 'tacit knowing' (Polanyi, 1961, 1969), in order to provide a holistic approach to multidisciplinary collaboration, which can be useful to design management. First, the concept of craft is introduced and related to ideas of tacit knowing through Polanyi's (1961) notion of 'physiognomy'. From this a proposal is developed for the integration of knowledge and understanding from different disciplines.

Understanding craft as a way of thinking

Craft is an elusive concept (Greenhalgh 2002: 4, Niedderer and Townsened 2010), which is variously used to denote a discipline or practice, or which has been used interchangeably with 'skill'. More recently, craft has been viewed in a new way as an activity or way of thinking (e.g. Sennett 2008, Crawford 2009) to which complexity is intrinsic because of the holistic nature of the process. We propose that this way of thinking can be beneficial in dealing with the complexity of design management at micro (design teams) and macro (firms) level.

At the heart of this new understanding of craft is its capacity to engender complex thinking (Crawford 2009: 23ff), based on the combination of cognitive and experiential knowing. This arises from the link between hand and mind which is created within craft activity, and which enables a unique state of openness, engagement and comprehension (Sennett 2008: 26, 126-7, 144-6, 237-8). Crawford distinguishes between three benefits of complex thinking: these are the concretisation of a matter or task at hand, the reflection on, and questioning of its qualities, and the expansion of its sense (Crawford 2009: 23ff).

The benefits of craft to the design process have been recognised by Woolley (2011) who explains the "strategic role for the crafts in relation to contemporary industry" (p.11) based on the idea of a 'pervasive craft ethos (or influence)' which is "a conflation of values, beliefs, culture and aspirations, underpinned by developing technologies" (p.16). Woolley describes the benefits of craft for design:

> First, as a pervasive craft influence that stimulates new design thinking, markets and values within appropriate industrial contexts; and second, as a series of hands-on craft interventions that directly affect the quality and aesthetics and enhance the value of the product. (p.30)

These two roles of craft can be seen respectively to pertain to the macro and micro levels of the design management process. While Woolley concentrates on the design process or micro stage of design management, design is a social activity, which can only succeed when understood as "a shared social process" (Cross 2011: 19).

Focusing on the social aspect of design and design management, we propose that craft can offer a number of supporting insights concerning sharing knowledge and negotiating different approaches. Firstly, complex thinking engendered by craft knowledge can benefit knowledge

exchange and shared understanding based on human values. Secondly, the integration of complex thinking can increase the ability and motivation to share and negotiate different approaches promoting experimentation. In order to understand how craft thinking can become a supporting factor in design management, it is useful to look at some of the underpinning mechanisms as explained within knowledge management.

Managing different ways of knowing

The idea of complex thinking is based on Polanyi's notion of tacit knowing (1961, 1969) to accentuate the inseparability of knowledge and action. Polanyi (1961: 460) argues that an expert can describe the particulars of a skill (explicit knowledge) and 'integrate' those particulars to make a general understanding of the particular entities through a process of 'tacit knowing'. Thus, experts have the ability to analyse and integrate, which are complementary endeavours (pp. 260-262). He terms this 'physiognomy', which for example, explains how a wine expert not only can describe the characteristics of a good wine but can also integrate those rules to differentiate between wines. In our debate, physiognomy can explain how individual experts in a design team know (and can explain) the rules of their skills/expertise, but cannot describe to others how they apply those rules. In that sense, the concept of physiognomy reveals the limits of an individual's ability to explain to other team members 'how' she applies her expertise.

Some knowledge management (KM) scholars argue that tacit and explicit knowledge can be converted into each other, and tacit knowledge can be largely explicated and codified allowing it to be shared in different contexts (see Nonaka & Takeuchi, 1995; Nonaka et al, 2000). Others argue that tacit knowing (embodied knowledge) can only be known through its expression in action hence it cannot be explicated or codified (e.g., Gourlay, 2004; Tsoukas, 2005; Ray, 2007). A mediating approach by the 'knowledge integrationists' argues that, whilst explicit knowledge is inherently communicable, tacit knowledge cannot be shared, converted or transferred in collaboration between experts in multidisciplinary teams, but that it requires integration (Grant, 1996: 379, 2002). Grant (1996) identifies common knowledge as critical in knowledge integration in multidisciplinary teams and argues that the efficiency of communication depends on "the commonality of vocabulary, conceptual knowledge and experience between specialists" (p. 380). Knowledge integration, according to Grant, could benefit from mechanisms such as directions and routines.

Collins (2004) offers further insights into how knowledge integration works in practice. He argues that experts learn from experience of their own domain (contributory expertise) and by communication (interactional expertise) with other experts from different domains. He suggests that contributory expertise comes about as the result of an expert being fully immersed in a domain (p. 127) while interactional expertise is:

> The ability to converse expertly about a practical skill or expertise, but without being able to practice it, learned through linguistic socialisation among practitioners. (Collins 2004:125)

Thus, interactional expertise is acquired by an expert being immersed in the linguistic culture of a domain other than her own (ibid.). Interactional expertise can explain how different experts in multidisciplinary teams can learn not just a common knowledge but an expertise valuable in understanding other experts' domains.

Brown and Duguid (1998) suggest three methods of facilitating knowledge integration between different groups (communities) of experts. These are translation (carried out by people with knowledge of different domains), knowledge brokering (carried out by those who participate in the practices of several communities), and boundary objects (objects of common interest, e.g., contacts, blueprints, techniques, technologies, etc.) (pp. 103-104) Although Brown and Duguid's debate is about enhancing the effectiveness of knowledge sharing between communities of experts (macro level), it offers useful insights for multidisciplinary design teams (micro level).

In summary, physiognomic expertise of an expert is manifest in the characteristics that an expert can describe and their application that s/he cannot describe. The concept of contributory and interactional expertise can explain how individual expertise may extend beyond a 'native' domain and how interactions between experts in multidisciplinary teams can result in secondary expertise that goes beyond common knowledge.

Adapting the notion of craft thinking for multidisciplinary design teams

Looking closely, it becomes apparent how different stages and methods of knowledge management match and explain the craft processes of complex thinking/knowing described by Sennett (2008) and Crawford (2009), and how craft can function as a tool for sharing knowledge and expertise, and negotiating different approaches within multidisciplinary collaboration and practice (Table 1).

Polanyi's concept of physiognomy can be seen to match Crawford's observation of complex thinking in generating expert knowledge. Extended by Brown and Duguid's (1998) methods it enables knowledge sharing on three levels. For example, the use of boundary objects has been adopted by Ehn & Kyng (1991) and is widely used by craft based design companies, such as Alessi. Ehn and Kyng (1991) showed that simple cardboard models were used effectively to stimulate users' imagination of how they think a product should work. Such working methods are helpful because they draw on people's experiential/tacit knowing and create shared meanings, following Sennett's (2008) principle of the *concretisation of matter, reflection and expansion.*

In many ways, the use of boundary objects can be seen as the basis of the other two methods of knowledge translation and brokering, where experts (who have contributory expertise) or brokers (who have interactional expertise which they have developed through interaction with other experts) translate knowledge from one area of knowledge into another area, using matching examples or analogies that can provide non-experts with the appropriate experiential knowledge. This ability of translation, which is based on somatic experience (Shusterman 2011: 155), is commonly known as empathy where it relates to people, or

transferable skill where it relates to material/technical experience, and may be seen as *reflection and expansion* 'by proxy' (because of the lack of direct experience).

Finally, craft thinking offers a further benefit, which is essential for successful knowledge sharing. This is the motivation to share: Craft is an activity which instils individuals with a sense of pride and confidence (Crawford 2009: 20, Sennett 2008: 21). Both pride and confidence motivate people to share their knowledge which, if missing, can be detrimental to knowledge management (Lin, Lee & Wang 2009).

Having discussed craft as an integrative process that can be beneficial to design management, in the following section, we discuss two case studies to support the theoretical discussion. The first case study looks at knowledge sharing within the craft process, the second looks at knowledge sharing in a multidisciplinary team.

Table 1- extending craft thinking

<table>
<tr><th>Analysis Level</th><th>Craft thinking/processes</th><th colspan="2">KM and Complexity Theories</th></tr>
<tr><td>Individual</td><td>Complex thinking (Crawford 2009:25) - based on the combination of cognitive and experiential knowing. This arises from the link between hand and mind which is created within craft activity. It enables a concretisation of matter, reflection and expansion of sense of task leading to openness, engagement and comprehension</td><td colspan="2">Physiognomy (Polanyi 1961)
Explicates how 'individual' experts draw on their tacit knowing (analyse and integrate) and act/decide without being able to explicate it to others
Limitation: cannot explain how a team of different experts can work together.</td></tr>
<tr><td>Social (including micro level/ design team; macro level/ design firm)</td><td>Craft encourages pride and confidence (Crawford 2009) and motivates individuals to share their knowledge (Lin et al 2009).

Application of the concept of craft to problem solving to encourage non-standardised working practices in knowledge-based firms (Miles, 2008).

a. Artefacts such as sketches, customer drawings, models and prototypes are commonly used (Ehn & Kyng 1991) to create shared meanings.

b. & c. Matching examples or analogies are used to translate knowledge from one area into another to provide non-experts with the appropriate experiential images to evoke shared knowledge.</td><td>Knowledge integration (Grant 1996, 2002) -team members with different discipline-based expertise 'integrate' their knowledge using a common language. Two mechanisms effective for knowledge integration:

Contributory expertise: where an expert is fully immersed in a domain with being able to practice it (Collins 2004). (Shared) Routines can be useful to create a common knowledge basis. (Grant 1996)

Interactional expertise: ability to converse expertly about a practical skill or expertise without being able to practice it. (Collins 2004)
Directions such as the description of clear goals and responsibilities can help to acquire new knowledge (Grant 1996).</td><td>Three methods of knowledge integration (Brown and Duguid 1998)

a. Boundary objects: objects of common interest used to aid understanding;

b. Translation: carried out by people with knowledge of different domains

c. Knowledge brokering: carried out by those who participate in the practices of several communities.</td></tr>
</table>

CASE STUDIES OF INTERDISCIPLINARY COLLABORATIONS

This section discusses two case studies as examples of multidisciplinary work, based on the principles of negotiation and knowledge sharing in the crafts as developed through the theoretical discussion. We draw on one case study from craft itself in order to demonstrate the principles developed from 'within'. The second case study looks at negotiation and knowledge sharing within the context of a multidisciplinary team dealing with Research and Development (R&D) in engineering and new technologies.

Case study One

This case study discusses the commission of master goldsmith Martin Pugh to make a golden jug, and how he managed the design, research, innovation and skilled contributions of other makers in realising the commission. The description is based on an account by Carey (2010) and a presentation by Carey and Pugh, 26 January 2011, 5pm, School of Jewellery, Birmingham City University.

Description: Pugh was invited to produce a 36cm tall jug out of pure gold. According to Pugh "[t]he original request for a pure gold claret jug was initially and immediately dismissed […] as technically unrealistic–pure gold being too soft" (Carey 2010: p.1). When asked again, Pugh explored metallurgical developments in high karat gold alloys with positive results. In discussion with metallurgists, he determined the most suitable alloy(s), although there was some risk in how the alloy would perform under workshop conditions.

In terms of project management, Pugh first had to negotiate with the client about the risk. Second, he had to contend with scientific and technical problems of choosing a suitable alloy and getting it produced in form of sheet metal in the required dimensions, which entailed research and negotiations with metallurgists and relevant companies who produce fine metal sheet. Third, the jug had to be made including several different processes, including spinning, casting, laser welding and polishing, for which he employed specialists. According to Carey,

> Pugh consulted a number of leading specialists and brought together a skilled team willing to impart their knowledge and share the challenges of such a project. It involved a wide spectrum of knowledge, the convergence of new and old techniques, and the reassessment of workshop practice with respect to the characteristics of an unfamiliar material. (p.1)

This means, Pugh (the expert) was in direct negotiation with a number of other parties. Some of whom were experts in the same area (jewellery) with whom he could share 'common knowledge' directly (e.g. caster, spinner, polisher). Others were experts in another area (e.g. metallurgists) or non-experts (e.g. client) with whom Pugh had to communicate through contributory and interactional expertise, variably using boundary objects (e.g. design drawings, scientific figures, alloy samples) or translation to achieve his aims.

Case study Two

Project two is taken from a research and development project situated within the academe in collaboration with several external partners. As before, this project was initiated by one person (Dr Niedderer) who has a crafts background as a silversmith, but in contrast, this developed as a collaborative project where leadership and responsibility rest with different partners at different stages.

Description: Based on previous research with Argentium© silver (AS) and laser welding, Niedderer conjectured that it should be possible to use AS with Direct Metal Laser Sintering (DMLS), because this is a process essentially based on laser welding. This represents the process of complex thinking (Crawford 2009: 23ff) which emerged from the direct involvement with the material/craft process and includes a concretisation, reflection and expansion of thinking.

The first challenge was to convince the potential partners from the mechanical engineering team of the potential of the project and its feasibility. This involved negotiation on technical/operational and conceptual/strategic level, requiring knowledge brokering and translation to establish a common language. Niedderer switched to using scientific data commonly used in engineering to demonstrate the potential technical feasibility (knowledge brokering); when presented with a DMLS sample (boundary object) demonstrating the potential technical difficulties (accuracy in building in a soft metal), Niedderer explained the aesthetics that can arise from these inaccuracies (knowledge translation), thus negotiating different perspectives on a particular subject.

In the further process of the project, similar negotiations occurred between the other partners where either knowledge brokering or mutual attempts of translation on the basis described above were employed. The different areas of negotiation in the project included:

- Engineers (process) and engineers (equipment) negotiated about adaptations of the equipment to facilitate the process. Here common language was pre-existent.
- Engineers (process) and metallurgists had to negotiate about the composition, format (powder) and characteristics of the alloy. Here mutual attempts at translation were required, describing phenomena encountered to elicit conjectures about possible changes leading to improvements in the results.
- Engineers involved in the process negotiated about the DMLS scan process in relation to the characteristics of the alloy. Here too, common language was pre-existent.
- Engineers (process) and crafts people negotiate about the quality and potential of the outcomes using knowledge brokering or mutual attempts of translation.

Case study two shows that there existed a common language between some parts of the project on operational level while common language between others had to be developed. In particular, there was a need to negotiate on strategic level, and between strategic and operational, to create the level of motivation necessary to take the risk that this speculative project posed in terms of investment of money, time and resources (equipment and material).

Discussion

Case study one demonstrates the craft way of working. It was led by one central person (craftsman) who took responsibility for the entire project. In contrast, case study two presents an example where responsibilities are devolved, mirroring more closely the structures of a design firm. While it was still initiated by one person, this project developed in a non-linear way where leadership and responsibility were shared by different partners at different stages, sometimes in independently and in parallel. The craft motivation that had initiated the project was adopted by the project partners to drive the project despite the high risk and no immediate expectation of return.

This demonstrates how craft thinking can be beneficial in the initiation and negotiation of new and high-risk projects. Other examples of such working can be seen in companies, which are research intensive, such as Alessi or Phillips (e.g. knitters were recruited to explore high performance steel yarn). The framework presented here will provide the basis for further theory development and testing in projects mentioned above. Due to the limited space of this paper, it was not possible to explore these further examples here, which will form the next stage of this research.

CONCLUSION

This paper makes a contribution to both theory and practice. Theoretically, the paper makes a contribution to the literature on multidisciplinary collaboration and decision making, drawing together literature from craft, design management, philosophy and organisational studies. More specifically, we have consolidated and developed the concept of craft thinking as a useful tool in multidisciplinary design teams. We have further developed the critical understanding of how expertise and knowledge could effectively converge in such teams to help negotiate and manage different approaches (e.g. risk taking) and engender motivation for new design developments. In our contribution to practice, we have identified and explicated some enablers and barriers in managing multidisciplinary design teams and their interactions, and demonstrate them in our case studies.

The outcomes and benefit of this research is an enhanced understanding of the role and importance of craft and its underlying principles, including the use of tacit knowing, as a tool for integrating different knowledge bases within the operational and strategic processes of design management. In summary, this research found that

- Conceptualising the processes of multidisciplinary collaboration and practice as ‘craft’ is useful in explaining how shared meaning and common understanding emerge in the process of integrating different knowledge bases and skills;
- The analysis and comparison of case studies has provided new insights with regard to multidisciplinary design collaboration, in particular in relation to knowledge sharing, motivation and risk taking.

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