

DESIGN CAPACITY AND CAPABILITY: MAPPING DESIGN IN MOTION IN THE UK'S FURNITURE MANUFACTURING SECTOR.

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ABSTRACT:

This paper presents an interim report on research into design capacity. Design capacity is defined as an organisation's proficiency to gather and assimilate knowledge about design. For small and medium sized enterprises (SMEs) in the UK's furniture manufacturing sector, the management of design capacity is now viewed as being an integral element in business success. Key product development issues such as silent design, tacit knowledge and absorptive capacity are focused on. An in-depth case study, which incorporated the use of self-completion design communication logs, is discussed. Initial findings suggest design agency within SME furniture manufacturers relies significantly on the tacit knowledge of employees and covert design activity. The central aim of the research is to develop a design capacity audit model which, in time, could be further developed into a design capacity audit tool.

KEYWORDS: DESIGN CAPACITY, DESIGN KNOWLEDGE, FURNITURE MANUFACTURING

INTRODUCTION

SMEs within the UK's furniture manufacturing industry are experiencing irresistible pressure on several fronts. In particular, the advent of new knowledge economies and cheap foreign imports (FIRA, 2000. FISG, 2005). Several authors believe it is possible to counter these pressures through the effective management and use of design (Press & Cooper, 2003. von Stamm, 2003. Cox, 2005).

The UK furniture manufacturing sector is deceptively large. Its broad and diverse operation is predominately driven by SMEs, with manufacturing sales nearing £9.4 billion per annum and a workforce in the region of 155,000; the industry makes a regular and significant contribution to the UK economy through such things as job creation and regional economic recovery (DTI, 2002). To cope with the challenges of a global market, SME furniture manufacturers involved in design and new product development (NPD), have to rely increasingly on their evolving knowledge base (FISG, 2005). An evolving knowledge base is centered on the skills, experience and the implicit 'understandings' of employees, which is supplemented and improved as new designs and products are developed (Rogers & Clarkson, 1998). As SMEs, unlike large organisations, generally rely on fewer employees, they are more prone to knowledge deficiencies beyond core expertise. Thus, the central research questions include:

- What is the nature of the knowledge used when designing within SME furniture manufacturing?
- How prevalent is the use of silent design (Gorb & Dumas, 1987) and tacit knowledge when developing products?
- What systems are employed within SME manufacturing companies to maintain knowledge used when designing?

This paper describes an investigation into design capacity within SMEs. The analysis of the findings is ongoing and it is envisaged that a final report will be completed in the winter of 2007. The objective of this research is to begin to map *design in motion*, which is characterised by the fluid and unpredictable course of events within design activity, and involves, amongst other things, 'seen' and 'unseen' design input (Dumas, 2000), and the implicit knowledge of employees (Wong & Radcliffe, 2000). This will lead to the development of a design capacity audit model that, in the first instance, will be specific to furniture manufacturing, but in time, could be further developed into an auditing tool that is applicable to other manufacturing sectors. It is envisaged that the design capacity audit model will incorporate features which will highlight the types of implicit knowledge and explicit information used when

developing products, identify locations of design related knowledge and suggest possible methods of maintaining an appropriate and effective design knowledge base within the firm.

Having reviewed selected literature within design and design research, the paper reports on the empirical investigations undertaken. The paper concludes by addressing the main research questions by highlighting a number of initial findings and reflections.

DESIGN AND KNOWLEDGE

Defining design is always a challenging task. Attempting to describe the process of what is not only a confusing, but frequently erratic activity, has for decades, perplexed theorists and practitioners (Cross, 2006. Lawson, 2006). More recently research has focused on what is seen as a critical element in the changing nature of design working, namely design knowledge and its management (Rogers & Clarkson, 1998. Shani, Sena & Olin, 2003).

Design, as a knowledge broker can contribute to innovation within companies (Bertola & Teixeira, 2003). In this respect designing acts primarily as a knowledge agent by collecting, analysing and synthesizing information from various internal and external domains. The various acts of designing generate the knowledge needed to design and the concept mediates the motion (Jerrard, 1998).

Explicit design knowledge is relatively easy to articulate and document and is generally embodied as information. This type of knowledge can be easily transmitted from one person (or system) to another in formal, codified systematic languages (Rogers & Clarkson, 1998). The tacit knowledge used in design on the other hand is less easy to formalise. It has been suggested that such knowledge is at the root of all organisational knowledge (Nonaka & Takeuchi, 1995); yet there is only a nascent understanding of the phenomenon. The concept of tacit knowledge is simple to describe in abstract terms but much more illusive when we try to settle on a concrete definition.

Within this paper, tacit knowledge is viewed as being both experience rich and situation specific. It is often the product of routine and habit, coupled with trial and error. It is made up of hunches, inexplicable 'gut feelings' and intuitive reactions. It is a knowing born out of our interactions with the world and it is an integral element in problem solving, judgment and decision making, the very stuff of design activity. Moreover its implicit, inexpressive nature makes it challenging to capture. To employ Polanyi's (1967) definition, tacit knowledge is, *knowing more than we can tell*. Polanyi further suggests that tacit knowledge is primarily seen through an individual's actions (skills) rather than through what that individual knows. This aligns neatly with Schön's (1983) theory of 'knowing in action', which holds a similar argument to that of Polanyi by proposing, *our knowing is ordinarily tacit, implicit in our pattern*

of action. If we cannot identify the knowledge that has caused a particular achievement, we may say tacit knowledge has been involved (Wong & Radcliffe, 2000). Figure 1 employs the visual metaphor of a Necker cube to illustrate both the transience of design in motion and the duality of design knowledge. The knowledge used when designing is in constant oscillation; at times through the design process tacit knowledge is foremost; at other times explicit knowledge is predominant. As with the visual ambiguity of the Necker cube, knowledge shifts focus as a particular type of is required.

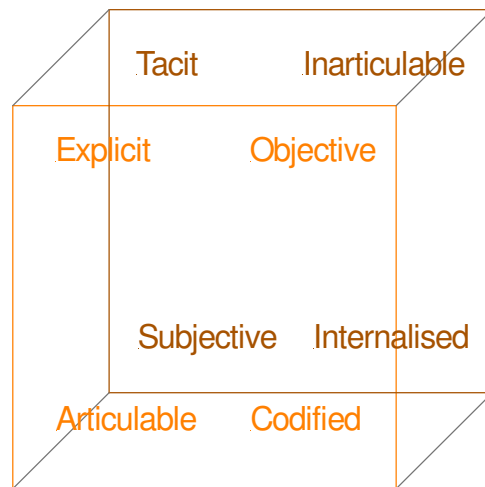


Figure 1. The duality of the knowledge used when designing.

Within organisations, knowledge and in particular, tacit knowledge, is shaped by broad social and institutional contexts; along with expert knowledge, patterns of work organisation and societal institutes (Lam, 2000). To illustrate this Lam has developed a four-fold typology of organisational knowledge (Figure 2) where the distinctions between tacit and explicit knowledge, as well as between individual and collective knowledge, are drawn together. Missing from Lam's typology however is the rich source of accumulated knowledge that is captured and retained in the physical world (King & Spring, 2001). Pile (1979), when discussing the various forms of furniture design and development knowledge available advices, *the most useful references are actual pieces of furniture* (pp, 4). Design knowledge is preserved in past products, drawings, models and the machinery used in production which, through a combination with the tacit and explicit knowledge of employees, results in a knowledge that is unique to an individual organisation.

| | | |
|----------|---|--|
| Explicit | EMBRAINED A priori - 'learning by studying' | ENCODED Information - Can be stored and retained |
| | EMBODIED Action orientated - 'learning by experience' | EMBEDDED Routine and practice - Shared beliefs and understanding |
| | Individual | Collective |

Figure 2: A Four-fold typology of organisational knowledge, based on Lam (2000).

There is a consensus in the literature that, like the tacit aspects of design knowledge, silent design (Gorb & Dumas, 1987) appears to be a key ingredient in successful new product development (NPD). Silent design, described as design input by people who are not designers and are not aware that they are participating in design activity, suggests that design knowledge exists beyond the activities of designers or design managers. Design in *organisational reality* cannot be understood as a specific activity carried out by a particular individual or function; it is better understood as a type of 'umbrella' (Dumas, 2000) (Figure 3).

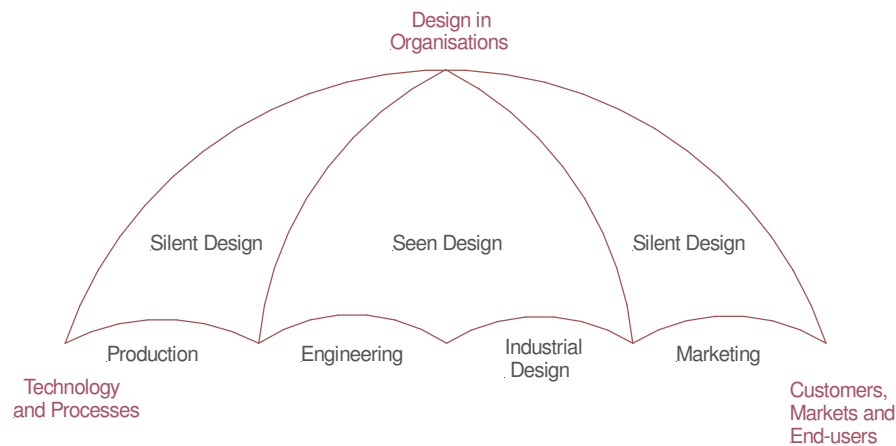


Figure 3. The Design Umbrella illustrating 'seen' and 'silent design' within organisations, after Dumas (2000) with minor modifications by the authors.

In the Dumas model the centre of the umbrella covers the specialised design practices such as industrial and engineering design; as they are generally more obvious, Dumas terms them '*seen design*'. Flanking seen design, but still within the shade of the design umbrella, are the activities of those in marketing and production. Viewed as an overarching practice, design within organisations becomes not simply a single activity in the development of new products but, *the fit of all activities that affect the performance and appearance of the product* (ibid. pp, 8).

There is however a dual paradox within silent design in that while it is important (in some cases, potentially critical) to many businesses involved in product development and manufacturing, it cannot be systematically or formally cultivated and maintained like many other business processes. By its nature silent design is an ephemeral phenomenon; attempts to harvest it may shackle it in formality and render it impotent. Furthermore, the very act of introducing formal design processes into a firm's systems might inadvertently undermine any established and successful silent design activities (Gorb & Dumas, 1987).

If it is acknowledged that some aspects of design are, to some extent, 'silent', then the management of design knowledge can be seen as having to include many activities that occur outside the immediate design environment; as such, it needs to take in knowledge of various types from a range of locations (Jones & Craven, 2001. King & Spring, 2001). The ability of a firm to recognise the value of new external knowledge, assimilate it and apply it to commercial ends, i.e. what Cohen and Levinthal (1990) term 'absorptive capacity', thus is critical to its design and NPD. An organisation's absorptive capacity is largely the function of its level of prior related knowledge. At an elemental level such prior related knowledge includes basic skills, a shared procedural language and knowledge of technical advances.

Organisational absorptive capacity is also the extent to which an organisation has collaborative links to other organisations. In SMEs, network knowledge is a key source of design innovation (Bertola and Teixeira, 2003). A great deal of this knowledge will be found in supply chains and business clusters (Burns, 2006). Described as *geographic concentrations of interconnecting companies, specialised suppliers and firms in related industries* (Porter, 1998), clusters are not only businesses trading between each other, but businesses sharing knowledge and facilities. Firms involved in industrial clusters can increase their capacity for design by diffusing technological knowledge and innovations more rapidly (Trends Business Research, 2001). Indeed, most innovation results from borrowing rather than inventing (Von Hippel, 1988).

A useful example of the value of inter-firm association and collaboration can be seen in the work of the Design Knowledge Network (DKN). Based in the West Midlands of the UK and part-funded by a regional development agency and the European Union, DKN assists design conscious SMEs to

become more innovative through improvements to the product development process, increasing market intelligence and the application of design methods to add value to products (Burns, 2006). A successful outcome of DKN has been the creation of Furniture West Midlands (FWM) which brings together furniture designers, manufacturers and academics in a type of micro-cluster, where knowledge, experiences, contacts and ideas are discussed and partnerships developed. An apposite example of Von Hippel's (1998) notion of borrowing ideas for innovation.

Acquiring information and knowledge has little impact on a company's fortunes if the knowledge is not effectively employed and regularly supplemented with design knowledge generated from such activities as *post-project reviews* (Koners & Goffin, 2005). 'Thinking', innovative organisations do more than make knowledge available, they make a habit of using knowledge creatively. Moreover, such organisations recognise the value of breaking old and out-dated paradigms and replacing them with new and more efficient ones (Basadur & Gelade, 2006). A thinking organisation can both unlearn and invent; as well as having the capability to serially innovate.

RESEARCH DESIGN

There is now a well established view that social research, and by association design research, is better suited to a qualitative investigative approach (Denzin & Lincoln, 1994. Huberman & Miles, 2002). This assumption is effectively demonstrated by the work of Baya (1996), Yen (1998) and McAdam & Keogh (2004), all of whom adopted a qualitative methodology to seek answers to their design research questions in the 'real-world' or as Baya (1996) puts it, embrace a methodological strategy that would, *ground the research in reality*.

The review of literature begins to suggest that design within firms is predominately based on 'fugitive' knowledge that could come from anywhere, at any time (Gorb & Dumas, 1987. Lam, 2000. Dumas, 2000). A key objective of the authors has been to understand the nature of design within companies; as such a case study was developed to capture real events and communications that occur when the company considers and is involved in design. Case study research, more than any other method, is ideally suited to investigate the processes, interactions and culture of a given situation; being immersed in the real world is often cited as being the only way to completely understand what is happening in businesses (Langrish, 1993. Yin, 1994. Stake, 1995).

SELECTION OF CASE STUDY COMPANY

The case study company was selected using the returns from a national postal survey, a ten-point sampling frame and practical and logistical contexts.

COMPANY PROFILE

Having traded successfully for 15 years, CS is a well established furniture manufacturer. The company is located in rural Shropshire in the UK, which is not within any generally recognised furniture manufacturing region or 'cluster'. CS has 85 employees and annual sales in the region of £5 million. The company management structure includes a Design Manager as well as a Technical Manager, both of whom are closely involved in all the design and product development activities within the company. The company's promotional literature states CS are a leading, design led manufacturer of quality British furniture, and that they have a policy of continual investment in design.

CASE STUDY RESEARCH METHODS

While interpretive research is recognised for its value to provide contextual depth, results are often criticised because they are not generalisable. The same criticisms are regularly levelled at findings from single case studies. However, validity results from an integrated approach, involving a combination of specific research methods, to relevant and appropriate standards (Kelliher, 2005). To this end a range of qualitative research methods were adopted, which, as well as supplying an array of textural and visual material, allowed participants to reflect and comment on their knowledge requirements, motives and actions (Travers, 2001).

The case study research methods included non-participant researcher observations, a textural audit of the company's product development literature, a series of semi-structured interviews and a brief questionnaire. However the research mainly used design communication logs. While observations and textural surveys can generate valuable information, they rarely supply the views and 'understandings' of those being studied (Rodriguez & Ryave, 2002). As such there is an awareness among social science researchers of the value of self-completion diaries, journals and logs (Corti, 1993. Rienman, 1993). To gain a 'first person' perspective of the type, manner and value of design communications,

the logs were completed daily, over an eight week period, by five key personnel; all of whom were directly associated with the design activities within the company.

Figure 4 shows an interaction report section from a design communication log. The first part of the incident report identifies the situation and context of the communication; this is followed by an explanation of the nature of the communication, in effect, a description of what was being communicated. The final section asks the participant to both describe and ‘value rate’ the interaction. A value scale of 7-1 was used where a rating of 7 was positive and saw the communication as *very helpful* (problem solved, questions answered, solutions found, action plan developed, real progress), and a value rating of 1 was negative and viewed the communication as a *hindrance* (detrimental to design development, restrictive, drawbacks, reversal of design progress). Analysis of the completed logs enables both quantitative and qualitative information to be reported.

| | | | | |
|---|-----------------------------|---|---|----------------------------|
| Name: <i>A.T.</i> | | Position: <i>Design Manager</i> | | Date: <i>10 October 06</i> |
| Who? <i>T.S. mill supervisor</i> | When? <i>9.00am</i> | Nature of Communication <i>Request for bespoke chair top rail drawing - jig needs to be made to repair one chair</i> | Quality of Interaction (Please describe and rate) <i>2-3 jig should have been kept after last batch of chairs was made (info management!!) - time wasted reprinting drawings and making new jig</i> | |
| Where? <i>mill (Factory)</i> | How? <i>face-to-face</i> | | | |

Figure 4. A sample interaction report from a design communication log.

FINDINGS:

DESIGN PERSPECTIVE AND PRACTICE

Design perspective is defined as how design is understood within the company. Throughout the course of the case study a number of words and phrases became predominant and began to describe the view of design within the firm.

Problem Solving: Although an over simplification of the design process, problem solving was constantly cited as a major element in product development; as a combination, solving problems (or 'solution finding') and developing products, were viewed as the main purpose and activity of design within the company. Indeed, the extremely apt phrase, *problem solving ideas into existence*, used by one of the managers, seems to sum up the importance placed on the problem solving capabilities of the people involved in the design process.

Engineering: Within CS a key feature of developing products was the association with engineering; technical issues such as specifications, measurements, tolerances and material capabilities were constantly part of the 'design vocabulary'. This engineering based view of design links to, and is supportive of, another finding which was generated by an in-house questionnaire. When asked who in the company they would approach if they had a design idea or query, as many employees said they would go to the Technical Manager as said they would contact the Design Manager. As with problem solving, engineering is perceived as a key feature of design which enables products to move through the factory, or as one employee saw it, *changing things ready for production*.

Masculinity: Although a number of the findings in the case study were expected, the notion of the design perspective within CS being predominately 'masculine' came as a surprise. The masculine atmosphere (a sometimes condescending, negative view of artistic creativity and designers) which surrounded the design activity, was often evident in the vocabulary of engineering, machinery and production, and was marked in the manufacturing and sales ethos that underpinned the majority of design thinking within CS. Although not an endeavour stifled by 'machismo', the almost complete lack of femaleness in the product development process within the company, meant the design perspective was dominated by maleness.

The design practice within CS is underpinned by unseen design activity (Dumas, 2000); silent design is prevalent in the company, indeed, initial findings, which reveal the extent to which the development of items of furniture are influenced by 'non-designers' in the company, begins to suggest silent design input could be of major significance in the successful development of products. In SMEs silent design occurs more frequently because of the close interactions of employees and management (Press &

Cooper, 2003). This seems to be case in CS, as the company has developed, by design or consequence, an internal culture of communications which is conducive to ideas generation from its employees and avoids subduing the flow of design information and innovation.

DESIGN KNOWLEDGE

The practices of design and new product development require a company to employ information and knowledge from many sources (Cross, 2006). Within CS much of this information came from technical literature, visual imagery, procedural documentation and furniture products. However, a great deal of what the company needs to know when involved in NPD is bound up in the tacit knowledge of its employees. For businesses, tacit knowledge and its effective use are vital (Nonaka & Takeuchi, 1995); a view constantly expressed by the management in CS. One senior manager expressed it thus, *I think the problem is the amount of people who walk around the factory with knowledge in their heads and never put it down on paper...the things they know are incredible.*

Figure 5 illustrates the components of tacit design knowledge as displayed by the employees in CS. It highlights how their tacit knowledge comprises, among other things, learning processes, involvement with the 'world', and innate, instinctive feelings. The case study findings begin to suggest that many of CS's design activities might in effect, because they are based on the implicit know-how of the work force, be built on foundations of tacit knowledge.

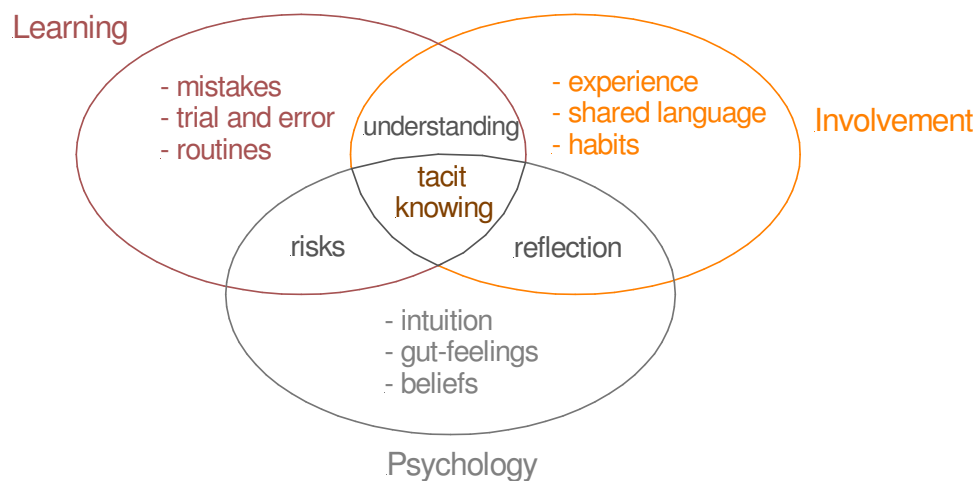


Figure 5: The components of tacit knowledge evident in the employees within CS

As the majority of CS's design practices were found to be informal and reliant on the experience rich, intuition abundant knowledge of the company's design and technical managers, their tacit knowledge has become integral to the success or otherwise of many of the company's products. Their departure from the company would have major implications.

DESIGN COMMUNICATIONS

The case study has revealed that the design and NPD demands engagement with a multiplicity of personnel, ranging from customers, clients and users, through sub-contractors, technicians and assemblers, to transporters, sales and marketing. Likewise the types of communications are numerous, such as verbal, textual and digital. Four years ago CS established a communication practice which they termed the 'core brief'. Throughout the research the core brief (a fortnightly meeting attended by all the managers and employees where information is conveyed through verbal and visual presentations), was cited repeatedly as a positive means of transmitting information, issues and opinion (including specific design and product development information) through the company. Established to counter the 'Chinese whisper' effect that can occur when information is passed down the management structure, the core brief is an opportunity to discuss business issues and pass on customer feed back.

Design communication logs, completed by the Managing Director, Design Manager, Production Manager, Commercial Manager and Technical Manager, asked the participants to describe and value-rate the communications they had about design and NPD. Because the participants were asked to include only what they considered a design communication, the logs, to some extent, begin to suggest what the participants may *not* have considered design related issues. For example, there was never a communication logged regarding packaging or transportation of products; key design issues.

As has been revealed through the other research methods, the logs suggest that design was seen as a predominately technical, engineering based practice, with a strong emphasis on problem solving and finding solutions to production difficulties. Specifications were regularly mentioned, usually in the context of re-engineering or re-designing as were considerations of costs, quality and customer satisfaction. It was surprising to note how few entries commented on aesthetics or styling, or the way a piece of furniture should look. Likewise with market research considerations, only a handful of entries mentioned why furniture products were developing the way they were. The overriding impression given by the logs was the sense that the communications were all based in a tacit understanding of practices, preferences and people. There were no references to a guide, manual, process model or

any other explicit form of NPD or design procedure despite these items being available within the company.

The participants were also asked to log the method of communication and where it took place. Within CS, design was discussed everywhere. The logs showed the highest percentage of the communications (38%) took place in the design office. However 20% of the entries took place on the factory floor, again illustrating the engineering, production led nature of design within CS.

The most frequently used communication value rating was four (*inconsequential, routine, ordinary*) with 39.1% (figure 6). The overall spread of value ratings matched pre-analysis estimates. However, there was a less than expected higher tendency towards the 'positive'. This was evident in the 44 communications (27.3%) which were rated as a five (*interesting, raised awareness, initiated design curiosity*), with 16 (10%) of the communications being judged as a six (*inspiring, thought provoking*).

Closer inspection of the data revealed the variations in ratings by the individual managers. For instance the design manager and the technical manager regularly rated their communications towards the low end of the scale, indicating that the design discussions they were involved in were less than satisfactory (an illustration of the problem solving, solution finding nature of both their jobs). Indeed, many of their remarks mentioned, *re-thinking, re-working, time-wasting, extra work involved and better communications needed*, with regular entries to the effect that the sales staff where not fully aware of design issues.

| MEANS OF COMMUNICATION | | | | |
|------------------------|-------|-----------|--------------|-----|
| | EMAIL | TELEPHONE | FACE TO FACE | FAX |
| AMOUNT (Total: 189) | 6 | 18 | 165 | 0 |
| % | 3.2 | 9.5 | 87.3 | 0 |

| QUALITY RATING OF COMMUNICATION | | | | | | | |
|--|-----------|-----------|---------|-----------------|-------------|-----------|--------------|
| Value rating | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Description | Hindrance | Unhelpful | Mundane | Inconsequential | Interesting | Inspiring | Very helpful |
| AMOUNT (total: 161*) (*28 entries were not value rated) | 9 | 12 | 16 | 63 | 44 | 16 | 1 |
| % | 5.6 | 7.4 | 10.0 | 39.1 | 27.3 | 10.0 | 0.6 |

Figure 6: Totals from the design communication logs, showing means of communication and value ratings of communications.

The logs revealed that the design and technical managers were at the 'coal face' of design and NPD, making things happen and often encountering the frustrations of inadequate information transfer between clients, sub-contactors and other departments (the example log extract in figure 3 begins to give some indication of this). In contrast to the value ratings of the technical and design managers, the Managing Director (MD) constantly scored his communications as *four* or above (he was the only participant to rate an interaction as *seven*, (*very helpful, real progress*). This regular high rating is mirrored in his comments which are constantly positive and encouraging.

The reason for the MD's generally high rating might have been associated with the type of communications he was involved in. Although he was involved with the design process throughout, many of his comments involved what could be termed 'front-end' design issues, where ideas are being considered and specifications are being finalised. These are not necessarily problem solving issues. They are more to do with planning and strategy and as such they probably rely less on the information supplied by other departments.

While the participants completing the communication logs did not always value the same interaction at the same level, they were generally consistent when viewing design related issues. Analysis of the log entries reveals the participants recognised design issues in similar ways. Single events and interactions were regularly logged by all the participants as to do with design and product development, and in doing so, showed they have a similar understanding or concept of what design entails. This is a noteworthy finding as it shows that the managers were generally sharing the company's agenda for design, which in turn helped the flow of design related information throughout the company.

Many of the findings derived from the communication logs were supported by the information gained through the other research. The overwhelming means of communicating design issues inside and outside the company was face to face. This particular form of communication accounted for 87.3% of all communications logged. Design uses a visual vocabulary of sketches, photographs, models, mood boards and samples of materials. It follows that this type of visual language is best employed face to face, directly to clients, designers and fabricators. The intimacy and immediacy of drawings, samples of materials and models is invaluable and can only be effectively expressed 'live'. As one of the managers stated when considering design communications, *you need to be able to communicate face to face; telephones are not good for design communications because it is a very visual process*.

Key incident and communication logs are an effective means of capturing the considered thoughts and feelings of the sample population as they go about their daily activities (Rodriguez & Ryave, 2002), however they do have some drawbacks. For instance, the logs are bounded by time; they represent a relatively small moment in the activities of the business. Such is the nature of a case study research. It

is also likely that many other communications took place but for one reason or another they were not logged.

DISCUSSION

Silent design pervaded CS. Indeed, initial findings begin to suggest it could be essential to the development of new products. Information gathered from the communication logs and interviews revealed the level of covert, unseen design input in the firm, substantiates Gorb & Dumas's (1987) description of silent design as being dispersed, interactive and repeatedly performed by employees who would not appreciate that their jobs involved design. This unformalised and unmanaged phenomenon was perpetual and effective; it was unguided but implicitly welcomed. It was predominately facilitated by a culture of 'openness' within the company that one manager described thus, *you have an opportunity to pass on your views...there are no closed doors...everyone has an opportunity to say what they feel.*

The difficulty of being able to value the intangible nature of tacit knowledge was illustrated throughout the case study. The firm-specific, 'embodiedness' (Lam, 2000) of the company's processes and practices were often inarticulable. When asked to report their actions and decisions, employees engaged in product development, were mostly unable to articulate their reasoning. However, the importance placed on the tacit knowledge of CS's employees was constantly evident. The effective process of design and development of products was frequently commensurate with the level of tacit knowledge of key employees.

Designing is knowledge creation, but not necessarily knowledge maintenance. Throughout the NPD process in CS it would be impossible to calculate how much design knowledge 'evaporated' before being collected, stored and made available for reuse. Observations from the case study suggested a great deal of the knowledge generated when designing was lost. This was due to a combination of an inadequate knowledge management system, the retention of design information by consultant designers and an over reliance on the ability of employees to remember past design decisions and actions. Project files, along with the library of design and production related literature, went some way to capturing design knowledge; but the manner in which they were organised severely restricted their effectiveness. The provision of design support in a computer tool, as suggested by Rodgers & Clarkson (1998), theoretically offers a solution to design knowledge maintenance. However, in the majority of SMEs, because of costs, time implications and a lack of expertise, a formal knowledge management system would be difficult to implement and maintain (Sparrow, 2001). Indeed, the case

study revealed what appeared to be a difficulty (or perhaps a reluctance) for an SME to manage a formal system of information and knowledge management.

The novel use of the design communication logs, through the participants quantitative value rating and qualitative commentary, revealed not only that knowledge about design resided in every part of the firm as well as in a vast range of external locations, but also that the quality of design communications varied considerably. Simply communicating appeared to not be enough. For design interactions to be effective, they have to possess a certain positive value.

Design in the 'real world' of furniture manufacture is a 'messy affair' (FISG, 2005). It can be initiated for various reasons, and once set in motion, is generally unpredictable. It appears rarely as a linear or sequential process. The consequence of 'design in motion' appears to be that the information and knowledge needed in design activity can become sinuous, itinerant and invariably ephemeral. Moreover design is inherently ambiguous and multifaceted; as such it means different things to different people and is rarely practiced by designers or organisations in the same manner. This applies particularly to the majority of SMEs where a single person within the firm might be responsible for several elements of the product development process and as such that individual's personality and perspective will have a significant influence on the eventual form of the product. The real challenge to developing a design capacity audit model is not in understanding how a firm can absorb external design information; it is in knowing how to locate and understand the capricious design knowledge which resides within the firm.

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