Title:
A Framework for Understanding the Impact of Culture on Tacit Knowledge Sharing in Design Automation Teams

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Introduction:
While developing new ideas and products, design engineers generate massive amounts of knowledge which is stockpiled in databases, manuals and technical reports. The robustness and profitability of product designs depend largely on how efficient the design team accesses and uses knowledge. Also, most organizations involved in product development are struggling to survive with the rapid rate of technology development, change of customer needs, and shortened product life-cycles (Corallo et al., 2009). However, during the primary design phases for complex product, detail about the product must be kept and repeatedly updated as the design advances (Corallo et al., 2009).

Among the new technologies offering support to the engineer for the development of new products involving geometry-related design is Knowledge Based Engineering (KBE) which embodies possibly the most important tool to date (Oldham et al., 1998; Mohammed et al., 2008; Chapman and Pinfold, 1999). According to Mohammed et al. (2008), KBE permits design engineers to preserve valuable engineering and design knowledge. Oldham et al (1998) pointed out that KBE is a computer system that facilitates the formation of an entirely engineered product design built on best practice by keeping the knowledge of geometry and data that relate to a product family.

Knowledge management techniques in the design automation team permit the capture, storage and reuse of the enterprises intellectual property and decrease time to construct and capture company product and process knowledge and, more notably, the use of that knowledge in automated or semi-automated KBE applications (Morali and Et, 2006; Chapman and Pinfold, 1999; Chapman et al., 2007). The goal of a KBE system should be to capture the best design practices and engineering expertise in automating design engineering into a shared corporate knowledge base, in order to reduce the design cycle and improve product quality (Bermell-Garcia, 2007).

According to Sainter et al. (2000) design engineers gain a lot from KBE systems. However in the haste to attain these gains, various design organizations have generated applications in an ad hoc manner, thereby giving the organization the short term gains of KBE, but generating longer-term complications. KBE implementation has achieved these benefits in many industrial cases, however, research work in KBE has identified that in several of these cases the gains are only benefits in the short-term instead of in the long-term (Bermell-Garcialp and Fan, 2002; Sainter et al, 2000).
According to Sainter et al. (2000) the effective deployment of KBE systems depends on the design team having an accommodating culture in terms of human and organisational aspects. On the human side during the development and use of KBE systems, there needs to be a close link between the application experts, knowledge engineers and end users. If these links fail, the gains of the KBE system

are reduced. Organizations which have deployed KBE systems productively have acknowledged the need for culturally educated design teams in terms of the benefits of KBE systems. Without culture education, design engineers will develop a negative culture and perceive that sharing will make them vulnerable to redundancy, or they may resent a perceived role of being told what to do by the KBE system (Sainter et al., 2000).

Main Sections:

The conceptual phase of design is very important, because the main life-cycle costs and whole superiority of the design are determined during this phase process (Calkins et al., 1999). Early decisions can determine almost 80% of the product costs at a stage where knowledge about the product and the processes involved is low or vague, and the actual development costs are low (Chapman and Pinfold, 1999). At this phase information is very uncertain and incomplete, which makes the design process fairly difficult. It also presents a challenge for representing the designed product. How to capture user's intent at this stage is difficult for the application of KBE tools (Wang et al., 2002). KBE has been used comprehensively in areas such as simulations, analysis, and optimization, but there are comparatively few uses at the conceptual design stage. The knowledge of the design requirements and constraints during this early phase of a product's life cycle is typically indefinite and inadequate, making it demanding to employ computer-based systems (Wang et al., 2002).

According to Lasson (2003) design collaboration is framed by the social world, and it is therefore impossible to independently interpret and share the nature of design specifications and artifact descriptions without understanding the social situation in which they were created. With reference to design as being a social activity, successful collaboration requires the establishment of a shared understanding, or common ground, between team members. The success of design teams relies heavily on the ability of design engineers to "negotiate different design perspectives and specialties", and "similarities in voice" which are of particular importance when team members come from different disciplines and backgrounds especially at conceptual stage. In a study of industrial designers making concept design sketches, Pan et al. (2002) cited by Lasson (2003) argue that the designers used verbal language to describe the form of design in very individual ways; language that was not clear, consistent or commonly understood by co- designers. Designers have a "creative vocabulary, which has rich meanings in design communication. Where verbal language was not enough, they used gestures, chairs, sketches, prototypes and all possible types of objects to visualize and describe what they wanted to 'say'. The negotiation of meaning also involved the telling of stories and an extensive use of indexical representations, which implied that knowledge of the context of work was extremely important for common ground to be achieved (Larsson, 2003).

Although advances in KBE show promising results there is still an immense potential for improvement when it comes to designing at the conceptual phase where design teams can collaborate in more 'natural' ways than existing distributed environments allow. Many design engineers are also realizing that the actual value in knowledge management is in sharing ideas and insights that are not documented and hard to articulate. This undocumented, hard-to-articulate knowledge is what is known as tacit knowledge (Ardichvili et al., 2006). This tacit knowledge is embedded and encultured in the practices and communications of individual members of the design team (Fahey and Prusak, 1998). Hence there is a need to investigate how this tacit knowledge can be shared among design teams across multinational organizations with different cultural backgrounds to compliment knowledge shared by KBE.

According to Schein (2000) the importance of culture cannot be underestimated in any team. The success of any company depends in part on the match between individual design engineers and the culture of the team. The impact of culture is so natural and embedded that its influence on behavior is hardly ever noted. Yet, the culture offers order, direction, and guidance to design teams in all phases of human problem solving. Schein (2000) argues that the term "culture" should be set aside for "the deeper level of basic assumptions and beliefs that are shared by members of an organization, that operate unconsciously, and that define in a basic 'taken-for-granted' fashion an organization's view of it and its environment". Schein characterized team culture as a pattern of basic assumptions; invented,

discovered, or developed by a given design team; as it learns to deal with its problems of external adaptation and internal integration. Schein went on to say that , it contains a body of solutions to external and internal problems that has worked consistently for a design team and that is therefore taught to new members as the correct way to perceive, think about and feel in relation to those problem. Culture is dynamic, and gradually and continually evolves to meet the needs of the team; hence the research will be scoped around the Schein culture model. The Schein model was chosen in the context of this research because it has specific dimensions which are definable and measurable.

Fiske (1992) cited in Boer and Berends (2003) argues for the existence of four fundamental forms of human relationships knowledge sharing : (1) communal sharing; (2) authority ranking; (3) equality matching; and (4) market pricing. Boer et al. (2002) have argued that these four forms do also apply for design knowledge sharing. Each of the relational models have their own implications for understanding and supporting the design knowledge sharing process and how these models are influenced by cultural implementation rules.
Within communal sharing relations, design knowledge is freely being shared among design engineers belonging to the same team; design knowledge sharing according to authority ranking principles is knowledge being shared between a superior and a subordinate or between an expert and a layman. Within equality matching relations design engineers share design knowledge since they expect to receive similar design knowledge in return in future. Finally, in market pricing relationships, design engineers reduce all relevant features and components under consideration to a single value, frequently money, within market pricing relations design knowledge is being shared when the perceived financially reward is high enough.
Interestingly, four Fiske's forms correspond to different theories on the relational dimension of design knowledge sharing .The communities-of-practice literature describes design knowledge sharing based on communal sharing relationships (Lave and Wenger, 1998; Brown and Duguid, 1991). Members of communities of practice share their identity. They interact with each other on the basis of this shared identity and show themselves in these interactions.

There is an increasing body of work that investigates the relationship between organizational culture and knowledge management (López et al., 2004; Moh'd Al-adaileh, 2011; Paroutis and Al Saleh, 2009; Mukherjee, 2007; Rosen et al., 2007; Cheng, 1994). According Moh'd Al-Adaileh and Al-Atawi (2011), whereas investigation has revealed that culture impacts knowledge management and, in particular, knowledge sharing, there is little exploration of the wider aspects of the nature and means through which organizational culture impacts the whole approach taken to knowledge management in design automation teams. Saeed (2010) and Oliver and Kandadi (2006) went further to say that there is a lack of empirical evidence about the actual cultural variables that enhance knowledge management processes and it is for this purpose that this research seeks to investigate the impact of culture on knowledge sharing in design automation teams in the UK.

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