How Do Knowledge Processes Support Innovation in the Sportswear Industry?

(Working Paper: This research is a part of ongoing postgraduate studies in KM & innovation in sportswear innovation.)

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Key words: Knowledge creation, Sportswear, innovation, product development process, individual knowledge

Introduction

In today's rapidly changing competitive environment, the pursuit of innovation drives firms for economic rent (Brown and Eisenhardt, 1998; Drucker, 1999). The complexity of problems requires solutions that combine the knowledge, efforts, and abilities of people with diverse perspectives (Brown and Eisenhardt, 1998). One innovation leads to another by bringing about continuous innovations and upgrading via successful knowledge creation (Nonaka and Takeuchi, 1995: 5). Ultimately, however, organisations can gain knowledge from different sources, significantly from exploiting their experiences of past learning and developing new knowledge. Therefore, knowledge can be seen as the resource of innovation.

The paradigm of effective knowledge creation in design firms has become one of predicting the needs and wants of the consumer and responding with innovative, well designed and executed products (Little and Plumlee, 2006). Therefore, it is increasingly important to understand the rationale of strategic knowledge management (KM) in a sportswear design firm in terms of gaining a competitive advantage and for firm survival (Damanpour, 1991).

Many influential studies in the knowledge and innovation literature have focused on the automotive and pharmaceutical industries (Nonaka and Takeuchi, 1995; Von Krogh *et al*.,

2000), whereas other studies have focused on industrial design firms such as 3M, IBM, IDEO and Design Continuum (Hargadon, 2003; Hargadon and Fanelli, 2002; McKinley *et al.*, 1999). However, little previous work has examined product innovation and knowledge creation in the sportswear industry.

Most process innovations happen within the production, logistic practices and IT system developments (e.g. SAP, lean and agile manufacturing); in general, there has been little innovation seen in product development through everyday fashions. According to recent WGSN innovation reviews (2009-2011), most of the cutting edge experiments in the fashion industry were identified in material development, outdoor apparel and sports product developments by utilising old values or knowledge combined with new technological innovation that enhances texture, weight, comfort and durability of the yarn fibre, fabric, appearance, chemical features etc. Some material innovations were significant in multi functional, lightweight, smart fibre developments, electro-conductive materials, eco-friendly, organic and sustainability trends in fibres and fabrics (WGSN, 2011). As an example, Invista™ engineered an extreme performance fabric called Climacool® for the adidas® golf range which incorporates highly breathable ventilation in the critical heat zones of wearer's body, wick and evaporates moisture more quickly than other moisture management materials (Figure 1). Design-wise multifunctional seamless knits, ultrasonically welded and bonded seam free products and body hugging thermal products were highlighted (WGSN, 2011). Speedo's ultrasonically welded seamless swimsuit is a recent example of this kind of innovation (Figure 1).

Intelligent skin
Speedo LZR® Racer
World fastest Swimsuit

Extreme performance
adidas Climacool®
by Invista™

Contemporary Japanese
Textiles by Cara McCarty
and Matilda McQuaid

Inflatable, balloon-like forms
create weightless dimensions

Intimacy dress by Studio Roosegaarde
(clothing made with plastic e-foil to use as
swimwear cover-up)

Figure 01: Innovation review

Source: WGSN 2009-2011 (www.wgsn.com)

Organisational Knowledge

Most influential studies in knowledge management (Spender**,** 1989; Nonaka and Takeuchi, 1995; Nelson and Winter, 1982; Levitt and March, 1998) literature described knowledge as distinct from data and information.Organisational knowledge is the 'shared set of beliefs about casual relationships held by individuals within the group' (Sanchez and Heene, 1997: 5 cited in Hitt et al, 2000). Here, knowledge represents beliefs, commitment, perspectives, intention and action (Nonaka, 1994; Nonaka and Takeuchi,1995) Similarly, knowledge in organisations is viewed as 'dynamic, relational and based on human actions; depend[ing] on the situation and people involved rather than on absolute truth or hard facts' (Von Krogh *et al*., 2000:7).

The resource-based view (RBV) (Grant, 1995; Nonaka and Takeuchi, 1995, Eisenhardt and Santos, 2001) interprets the firm as a unique bundle of idiosyncratic resources built on the linear accumulation of valuable, rare, and non-imitable resources (Barney, 1991) which create sustainable competitive advantages (Barney, 1986, Simonin, 1999). This approach perceives knowledge as predominately strategic 'intangible assets or commodity' (Patriotta, 2003) linked with the materials, structure and performance features of the organisation. In this scenario, sophisticated and innovative products can make significant differences between two competing firms. Intellectual capabilities are identified as more fundamental resources than physical assets (Subramaniam and Venkatraman, 1999). Thus knowledge base competition is based on a firm's superior ability to create and exploit knowledge (Drucker, 1999; Grant, 1995, 1996; Lipman and Rumelt, 1992; Spender, 1996). This is vital in contemporary business.

Wide traditions of knowledge literature reflect the multiple origins of organisational knowledge, with empirical and latent qualities being identified as the main two idiosyncrasies. Empirical researchers (e.g. Nelson and Winter, 1982; Levitt and March, 1998) argue that knowledge exists in the organisation's actions in the form of physical and social artefacts including technologies, routines, procedures, products and processes (Hargadon and Fanelli, 2002: 290). Empirical approaches engage with how individuals and organisations replicate their existing knowledge. By contrast, the latent qualities (Nonaka and Takeuchi, 1995; Kogut and Zander, 1992) of knowledge present the 'possibility for

generating novel organisational artefacts' (Hargadon and Fanelli, 2002: 291). In this context, knowledge is the 'beliefs and values of organisational participants and is context specific' (Hargdon and Fanelli, 2002: 291) and also leads to dynamic knowledge creation activities. Nonaka and Takeuchi, (1995) argue that these duel qualities of knowledge enable organisations' actions by facilitating the innovation, yet at other times they can be a restraint on the firm's growth by obstructing the knowledge enabling processes . As a result, Hargdon and Fanelli (2002) suggest a complementary model, that is to say the best way to understand organisational knowledge is as a process of interaction, or a duality between knowledge of action and knowledge of possibility, which combines the empirical and latent qualities of knowledge and whereby the 'knowledge of possibilities constitutes action and the knowledge of action constitutes possibility' (2002:291).

Dimensions of Knowledge

Nature of Knowledge: Tacit vs. Explicit

Many theorists in the knowledge literature differentiate between types of knowledge at length. James (1950, cited in Spender, 1996) drew ideas from Greek epistemology and discussed two types of human knowledge: 'knowledge about' and 'knowledge of acquaintance'. James' distinctions impacted on Michael Polanyi's work (1967), where he identified a tacit and an explicit dimension of knowledge in organisation. Polanyi claimed that tacit knowledge related to experience is 'knowledge of acquaintance', whereas explicit knowledge is more like 'knowledge about' (Spender, 1996:50). Polanyi added psychological dimensions into James' view and discussed the tacit nature of knowledge in detail. Since then Polanyi's definitions have made a profound contribution to the knowledge literature and have had a great influence on the view of subjective and objective dimensions of knowledge in organisations. Polanyi's work underpins two of the studies that I have drawn on in this review by Nonaka and Takeuchi (1995) and Nelson and Winter (1982).

Nonaka and Takeuchi (1995) classified 'explicit' or codified knowledge as having fundamental 'digital' communication properties (Bateson, 1973 cited in Nonaka, 1994: 17), which can be easily captured, stored and transferred in formal, systematic language. By

contrast, ‘tacit’ knowledge ‘is deeply rooted in action, commitment, and involvement in a specific context’ (Nonaka, 1994: 16) and is said to have ‘analogue’ qualities , which makes it slow and hard to codify, transfer and communicate (Kogut and Zander, 1992). Therefore, transferring and sharing tacit knowledge between organisational members is communicated through ‘analogue’ channels and, as a result, difficult to process and can only be accumulate by the ‘observance of a set of rules’ (Polanyi, 1967:49), through experience or ‘learning by doing’ (Reed and Defillippi, 1990).

Yet, Nonaka proposes that tacit and explicit knowledge is ‘not exclusive, but complementary [and] can be converted from one form to the other’ (2006: 76). Hence, they discussed the cornerstone of knowledge creation in the organisation as being the differentiation between tacit and explicit knowledge and likewise ‘the key to knowledge creating lies in the mobilization and conversion of tacit knowledge’ (Nonaka and Takeuchi, 1995:56). I shall discuss their perspectives of KM at length in section 2.4. Moreover, tacit knowledge has two dimensions. Tacit knowledge that holds informal kinds of craft and personal skills refers to ‘know how’ (technical dimension) while a second set of tacit knowledge (cognitive dimension) refers to ‘beliefs, values, schemata, and mental models which are deep-rooted within humans and organisations (Nonaka and Konno, 1998). Therefore, recognising the value of tacit knowledge and figuring out how to use it is the key challenge in the process of knowledge in innovation (Von Krogh et al., 2000).

Conversely, economic researchers, mainly based on Ryle’s (1949) work, discussed distinctions between ‘knowledge-how’ and ‘knowledge-that’. Other scholars such as Kogut and Zander, 1992 and Conner and Prahalad, 1996 have linked ‘knowledge-how’ and ‘knowledge-that’ to the ‘tacit’ (subjective, knowledge-how) and ‘explicit’ (objective, knowledge-that) qualities in KM.

From an evolutionary theoretical perspective, Nelson and Winter (1982) explicitly argue that social organisations are a combination of collective tacit knowledge shared by it members. Their study took organisations and routines as units of analysis, and presented the notion of knowledge of a firm’s routines being at the heart of understanding a firm’s behavior (ibid. p.128). Similar to Polanyi’s work, Nelson and Winter viewed routines in organisations as comparable to an individual’s tacit knowledge, skills, experiences and memory embodied

within an organisation. Therefore, they argue 'that the skills of individuals are analogous to the routines of organisations' (1982:73). Some of these skills are like capabilities in a choice set; others are 'intimately involved with the act of choosing' (Nelson and Winter, 1982:73). They see 'routines as genes' (organisation behave like human organisms) that explicitly dictate organisational rules and culture.

Source of Knowledge: Individual vs. Collective

Organisation is a combination of individual and collective nouns. Even when we take a firm as a group of people, it is really an amalgamation of collective individuals. Therefore, a difference exists between primary sources of organisational knowledge as distinctions between individual and collective knowledge are identified.

Cognitive scholars (e.g. Cohen and Levinthal, 1990) consider that knowledge in the organisation is 'intimately attached to the knower, an individual who holds it' (Nonaka and Peltokorpi, 2006:76). From this perspective, the prime mover in organisational knowledge creation is identified as an individual. Individual members in an organisation accumulate tacit knowledge through their past experiences, prior knowledge and 'knowledge of experience' (Nonaka, 1994). And therefore the organisation's capacity to generate new knowledge is dependent on the 'absorptive capacity' (Cohen and Levinthal, 1990) of its individual members. Other cognitive theorists see collective knowledge as a collection of individual knowledge.

In contrast, the study of Spender argues that 'collective knowledge, implicit and embedded in organisational practice' (1994:365) is the most powerful resource that drives firms for economic rent. Here, collective knowledge generates internally and is held collectively within an organisation. Spender (1996) divided organisational knowledge into forms of 'individual knowledge' (knowledge that can be wholly understood and retained by an individual) and 'collective knowledge' (knowledge that is shared by a collective such as a team, an organisation, an industry or a society). In this study Spender explained how the distinctive characteristics of knowledge types in organisation lead firm for different types of economic rent: 'While an individual's knowledge is inherently transferable, moving with the

person, giving rise to Pareto rents and the resultant agency problems, the social types of knowledge are either publicly available or collective and embedded in the firm's routines, norms and culture' (Spender, 1994:52).

Component vs. Architectural Knowledge

A third type of dichotomy of knowledge in innovation is component and architectural knowledge; primarily discussed by Henderson and Clark (1990). Following Henderson and Clark, component knowledge exists in the form of a product, process or operation in an organisation, whereas architectural knowledge remains within the organisations' systems. Component knowledge is knowledge about the core design concept and the way each product component is implemented into each other. Architectural knowledge is knowledge about how those components link and integrate into a product as a whole. Component knowledge (tacit or explicit) can be held by individuals or collectives, whilst architectural knowledge is held throughout the whole organisation. Further distinctions between component and architectural innovations will be discussed in the next section.

Knowledge and Innovation

We can distinguish four entities of innovation in an organisation's product, process, administrative and technical levels. Whilst some scholars have focused on patents and intellectual properties as key indicators of organisation innovations (Fleminig and Sorenson, 2001; Hicks et al., 2001), others have put considerable emphasis on identifying organisational characteristics and processes that forerun innovation (Brown and Eisenhardt, 1995; Eisenhardt and Galunic, 2001). Moreover, some researchers have explored how corporate resources reconfigure to create new productive resources for the firm as a new way of deploying existing resources and utilising stock resources to move the firm toward innovation (Eisenhardt and Galunic, 2001; Prahalad and Hamel, 1990; Teece and Pisano, 1997).

Whatever the entity, knowledge creation and learning within an organisation are central for a firm's economics of innovation. When a firm develops new products and processes they are

not random, ‘rather technological innovation is structured and orderly and typically occurs within fairly well defined frameworks’ (Boerner et al, 2003, p.100). Thus, innovation academics always put an emphasis on organisational KM to improve and identify economics of innovation. The purpose of this paper has been focused on design innovation to some extent, while the main scheme is on KM. For further clarification, in the next section I will summarise design innovation theories that can be applicable to product innovation.

Innovation has been defined as a ‘gales of creative destruction’ (Schumpeter, 1934; Abernathy and Clark, 1984). A distinction between the product as a whole and the system (component vs. architectural innovation)—and the product in its parts and the components has a long history in design literature (Marples, 1961; Alexander, 1964 cited in Henderson and Clark, 1990:2). Clark (1985) defines product component as ‘physical distinction portion of the product that embodies a core design concept’ (cited in Henderson and Clark, 1990:2). Henderson and Clark define product architectural innovation as something ‘that change[s] the way in which the components of a product are linked together, while leaving the core design concepts untouched’ (1990:1).

Abernathy and Clark (1984) discussed how architectural innovation should break the grip of prior industries and should stand for a long time in the industry while retaining the durability of the core concept. Here, innovations focus mainly on scientific and technological based industries, such as the automobile industry. Perhaps more importantly, another type of innovation, ‘niche market creations’, uses established technologies to create new products. Abernathy and Clark identified ‘niche market innovation’ as strengthening architectural innovation in a vast variety of industries including consumer electronics (high- tech industries) and fashion apparel (creative industries) production. The apparel innovation discussed in this study is clearly different from what is called ‘advanced technical apparel’ innovation at sportswear design firms in this study. Abernathy and Clark claimed that ‘changes in ornamentation, colour, configuration, fabric and finishes to create profitable’ women’s apparel are market niches and innovative, and this sort represents what Utterback has called as ‘sales maximization’ (1984:10). They identified that niche innovation does not establish long term advantages for organisations and also can be easily copied by competitors. So if an innovation is readily copiable, the significance of a product or technology may be greatly weakened (Abernathy and Clark, 1984). Perhaps, now it seems

more complicated to define innovation in the advanced sporting goods industry for this research.

In order to achieve competitive success through different types of innovation, two types of knowledge were identified as effective sources. 'Resource conversion knowledge', that is firms' ability to create distinctive products through innovations, enables the firm to use similar resources that are also available to competitors, yet design distinctive products. From this perspective, patents, copyrights and trade secrets are the most articulated aspects of a firm's resource conversion knowledge (Fredman *et al*, 1991 cited in Chakravarthy *et al*., 2003). Resource conversion knowledge is firm specific and sources superior performances when attribute to the organisational systems (Chakravarthy et al., 2003). However knowledge about effective resource allocation is not enough to gain competitive success without having a clear understanding about product positioning in the competitive market place. Thus, a firm's ability to understand its customers and market environment is also a form of knowledge that supports its performance. Thus, 'market positioning knowledge' is crucial when the firm and its competitors compete in the same channels of the market with the same type of products.

Incremental Knowledge Creation

As discussed elsewhere, knowledge base competition becomes the most competitive asset that indicates a firm's growth (Grant and Baden Fuller, 1995), and demonstrates when a firm has a sustainable competitive advantage. Product innovations are a key form which illustrates how specific new products are developed through effective knowledge creation processes in the organisation, the way organisations address problems and how new knowledge is dynamically developed to solve them (Nonaka, 1994; Brown and Eisenhardt, 1995). It is rare for one firm to have all its knowledge and resources retained in store for a long time. Therefore, the superior coordinative attributes and their capacity to confer the knowledge process (Nonaka and Peltokorpi, 2006:77), within and in-between firms (Collins and Hitt, 2006), differentiates firms from their competitors. Both individuals and organisations' ability to add new knowledge to existing knowledge depends on its absorptive capacity (Cohen and Levinthal, 1990). When an organisation innovates, it creates new 'knowledge and

information from the inside out, in order to refine both problem and solution and, in the process, to re-create their environment' (Nonaka and Takeuchi, 1995: 56) rather than processing information from the outside in. Therefore more criticality, transfer and diffusion of knowledge is important across individuals and organisations in regards to the creation of new knowledge.

The distinctions between tacit and explicit knowledge drive creation of new knowledge in the organisation (Nonaka and Takeuchi, 1995). According to Nonaka, tacit and explicit knowledge in the organisation exist simultaneously at individual, collective and organisation levels. In essence, two dimensions of knowledge creation in organisation are identified. The 'Ontological' dimension, which restricts knowledge to being 'created only by individuals', is concerned with the level of knowledge creating entities (individual to inter - organisational level) whereas the 'epistemological' dimension (introduced by Polanyi, 1966) identified the distinction between tacit and explicit knowledge in the organisation (Nonaka and Takeuchi, 1995:59). Further, Nonaka's study described organisational knowledge creation is as a 'process in which individual knowledge is amplified and internalized as a part of an organisation's knowledge base and vice versa'.

Ultimately, knowledge creation in the organisation starts at a fundamental level with individuals who acquire and process tacit knowledge. Then new knowledge creation is associated with the extent of social interaction between individuals who share and develop knowledge. The 'knowledge spiral' model illustrates 'continual dialogue or collective reflection' (Nonaka and Takeuchi, 1995:71) between both the 'epistemological' and 'ontological' dimensions of knowledge creation, starting at the individual level and expanding through communities of interaction across the organisation. The spiral model considers the role of individuals in the organisation and their 'commitment' to the knowledge process. This knowledge spiral is driven by enabling factors i.e. organisational intention, autonomy, the effects of fluctuations and chaos and redundancy (see Nonaka and Takeuchi, 1995: 71- 78). The spiral model is based on knowledge conversion and identifies patterns between communications and in which existing knowledge can be 'converted' into new knowledge in the organisation.

Brown and Eisenhardt (1995) categorised the influential studies in product development into three streams of research. In their study, authors discussed successful product development is as the results of 'rational plan, communication web, and disciplined problem solving'. These categories were developed from different sources and focus on different aspects of product development literature. In order to explain factors that enable knowledge creation in product development (PD) of sportswear design, the 'communication web' and 'disciplined problem solving' streams are identified as the most relevant. The 'communication web' stream underlies communication among organisation and team members and with externals arouses the performance of development teams. In the other words, it focuses on information flows and exchanges in development teams based upon information and resource dependence theories. One pioneering study in critical cross team communication inside the firm has proposed 'that various functional departments were tantamount to "thought worlds," each with its own "fund of knowledge"— what members know—and "system of meaning"—how members know' (Dougherty, 1990). Hence, the 'communication web' supports information and knowledge exchanges. 'Disciplined problem solving' is used to explore ideas of new knowledge creation via creative problem solving. This approach focuses on more stable product development in mature stages as well as experiential product design in uncertain settings. Similar to dominant KM studies conducted in the 1990s, this stream laid the groundwork for studies conducted within Japanese product-development practices, for example Quinn, 1985; Nonaka and Takeuchi, 1986 and was supported by ideas such as 'information redundant' (Nonaka, 1995). Furthermore, these studies resulted in strengthened links between wide use of supplier and R&D networks (Clarks and Fujimoto, 1991 cited in Brown and Eisenhardt, 1995); high levels of technology use such as technical integration and accumulation of interaction knowledge (Brown and Eisenhardt, 1995); and cross functional teams with high communication capabilities that finally result in speedy, productive, efficient and high quality development.

Both 'communication web' and 'disciplined problem solving' approach activities related to product development (i.e. process) require resources which the firm needs to make in-house or out–source (Argyres, 1996 cited in Eisenhardt and Santos, 2005). Even though, there is significant variation across industries and countries of sources of new ideas (Arundel et al., 1995; Klevorick et al., 1995 cited in Gann and Salter, 2003), firms primarily source innovative ideas through their internal knowledge base. Secondly, the firm acquires

knowledge from external sources such as competitors, suppliers, universities, conferences, fairs and across a variety of other industries. Thus, knowledge sourcing activities based on similar and existing knowledge are internalised, whilst activities based on different and unelicited knowledge are outsourced (Eisenhardt and Santos, 2005).

In summary, this study has discussed the persistent distinctions of the complex nature of organisational knowledge and identified connections between knowledge and innovation in design and development. Both the empirical and latent origins of organisational knowledge have been discussed; perhaps more importantly relationship between dual qualities of knowledge 'knowledge of action and knowledge of possibility' (Hargdon and Fanelli, 2002) have been identified. Dichotomised views of knowledge (such as individual and collective ,tacit and explicit, architectural and component) that exist in the organisation are very important in terms of identifying different characteristics that will showcase the knowledge processes in product innovation such as ease of knowledge absorbance, sharing, transferring etc. The cornerstone of knowledge creation in the organisation is described as a differentiation between tacit and explicit dimensions of knowledge by Nonaka and Takeuchi (1995). The 'spiral model' (Nonaka and Takeuchi, 1995) of knowledge creation illustrates the relationship between both the 'epistemological' and 'ontological' dimensions of knowledge creation in product development. From this perspective, knowledge creation starts at an individual level and expands through communities of interaction across organisations. The 'communication web' focuses on information flows and exchanges in developmental team members and organisations, whereas 'disciplined problem solving' research discusses the ideas of new knowledge creation through creative problem solving (Brown and Eisenhardt, 1995).

Research Setting

The primary focus of this research is to identify how the organisation creates knowledge to support its innovation and thereby to what extent knowledge is embedded within products and process. In particular, this paper summarises the findings drawn from a postgraduate Master degree research of three design firms, three design firms, (here given the fictitious names Gravity Ltd, Fibrefill International and Tecsystem Ltd) whose work is mostly

concerned with the design, simulation, testing and prototyping of innovative sporting goods in the UK.The methods employed in this research were based on qualitative methods (Miles and Huberman, 1994). The primary source of data was semi-structured interviews with individuals. Interviews were conducted with six informants during 2011 and each lasted approximately an hour. Interviews were audio recorded and transcribed and field notes were taken in some cases. To maximise the results of this research plan, researcher looked at particular development projects retrospectively and conducted project post-mortems by asking a series of 'open-ended' questions. Secondary sources were used, such as company leaflets, videos and websites about the technological artefacts of the firms and their products.

Following Miles and Huberman (1994), this study began with an in-depth analysis of transcribed interviews by using codes in the initial categorising stages to summarise, organise and retrieve data chunks through the lens of the research question. All cases were read independently and treated equally to find patterns emerge from single cases. Following the transcription of the interviews, clear and recurrent patterns became visible (sentences, phrases, words) and so the researcher moved to categorise coded data according to a small number of themes, trends and clusters (Carney, 1990 cited in Miles and Huberman, 1994: 92). The researcher had no priori hypotheses to be tested, thus, the researcher chose to analyse connections between those categorise within individual cases. Then, the researcher moved to cross-case analysis (Miles and Huberman, 1994) to construct a conceptual framework. As patterns emerged, the other two firms developed into case studies. These carefully selected 'multiple cases' (Yin, 1994) follow replication logic that serve each case in a similar or contrasting manner.

Knowledge Creation Process in Product Innovation (Summery of key Findings)

This study built a conceptual framework for understanding how the organisational knowledge creation process supports product innovation. This framework consists of three phases: knowledge searching, knowledge processing and knowledge creating in hard product development. Therefore, designers attempt to: (a) gain access to knowledge from inside and

outside domains in order to identify knowledge about their market, customers, competitors and the feasibility of a new innovation; (b) absorb and apply knowledge into initial design concepts and; (c) convert knowledge into an archetype by generating novel design ideas. Although these process are illustrated in three chronological phases, it is difficult to draw a line between them as they take place in a multi layered, integrated process in practice.

While many organisational theorists have discussed the importance of knowledge creation (Nonaka and Takeuchi, 1995) and the 'absorptive capacity' (Cohen and Levinthal, 1990) that enables knowledge creation, much less attention has been focused on the knowledge process that is access, sharing and application. Therefore, most importantly, the first two phases of this framework discuss how organisations process knowledge while the third phase focuses on how an organisation creates knowledge.

For Fibrefill and Gravity designers, their access to diverse knowledge sources across multiple industries outside the apparel (and fitness industry) enables them to create ideas that drive successful product innovation. These designers search for ideas from several domains and apply them into their own domain to overcome design problems and to create solutions for customer demand. Fibrefill uses an 'informed guess' approach, based on past knowledge and experience, (Handerson, 1998; Levitt and March, 1988; Vincenti, 1990) and innovates through trial and error. However, their 'learning by mistake' approach involves high levels of uncertainty in product innovation as it is associated with fast and low cost PD (Eisenhardt and Tabrizi, 1995). Similarly, Tecsystem designs textile machineries as solutions for their customers' problems and primarily relies on the internal knowledge process. For them, knowledge comes from manufacturing components and learning about textiles and understanding how the machines work. Lots of the products that they manufacture are based on their own experience. In contrast, Gravity, designs and develops products across several industries such as apparel, fitness, outdoors and focuses on extensive literature searches, close observation and direct communications with outside world. Success of innovation at Gravity is largely dependent on two factors: the inventor and the gatekeeper in the company. Together, this research suggests that the knowledge held by experienced individual innovators (designers) in these organisations plays a significant role in innovation, where they make ideas into reality. As the Director of Gravity claims:

> "I don't think you can just hire an inventor. You probably could, but we never try. But mostly you either have the ability to create and solve problems or you don't. Particularly where you're looking at a blank sheet of paper and you come up with a completely new idea. I've never been able to isolate why some people are good at that and why some people are rubbish at it. They can have the same qualifications, same sort of backgrounds and so on; one of them is rubbish and one of them is brilliant. The numbers of people that are brilliant are very scarce." (Director, Gravity, 2011)

Likewise, this study opens discussion on creative individual cognition that holds brilliant design ideas. Nonaka and Takeuchi (1995) assert that tacit knowledge held by individuals is the heart of organisational knowledge creation. Organisations innovate once rich and untapped tacit knowledge resides in individuals and is shared and amplified within organisation. The process of 'socialisation' makes the tacit into the explicit, which enables knowledge sharing capabilities among group of individuals (Nonaka and Takeuchi, 1995). As a result, organisations innovate via successful knowledge creation. This study supports the concept of individual tacit knowledge that foreruns product innovation in relatively small firms (similar to Nonaka and Takeuchi's findings in large organisations).

The findings of this research also question whether the process of knowledge 'socialisation' is essential for organisations to innovate? The development teams in this study show that when the core team consists of a single (or two) inventor(s) who come up with novel design ideas, the rest of the team support them to built an archetype (testing, validating, management and negotiations). As a result, this study found that individual creativity runs and shapes the organisational knowledge creation process and innovation in sports product development.

Knowledge Searching Example

Access to new knowledge is critical to product innovation. This research identified effective ways of searching for knowledge sources and new knowledge that utilises innovation. Since most innovation in sporting product design requires a wide range of engineering and technological solution, designers in research organisations seek access to multiple technological learning. Their activities are primarily organised in a manner that

acknowledges knowledge brokering through multiple industries (Hargadon and sutton 1997). An inventor at Gravity recalled, "We tend to take inspiration from different market sectors, social interest in fitness equipments. We might look at automotive, we might look a medical devices and start getting concepts and ideas…well if something is seen in a car or a medical product, you already know that you can bring that into the fitness category" (Director, Gravity, 2011)

No Idea to First Idea: Knowledge Processing Example

Many failures in problem solving result not from a lack of appropriate knowledge but from the inability to recognise when that knowledge is appropriate to a new solution (Lave 1998, Reeves and Weisgerg, 1994 cited in Hargadon, 2002:45). As the Director at Gravity described, "It is very difficult to pin down, how you go from no idea to the first idea. How you start with nothing and get to something new".

> "So you typically, say, take an existing product and you go through a process of 'what if we substitute one of the elements'. If you take a chair, the chair has got a backrest. It's got three elements. It's got legs. What if, instead of legs, we put it on a spring or instead of legs what about if we put it on a central column and had a base? And then instead of four what if we had three [legs]. So you know what that means? That is a substitution. Instead of four legs we have one central one on a base. So, that is fairly typical of the process of saying 'take what exists and substitute one or two of the elements and see what it becomes'. It becomes something similar but slightly different. So, that's what's known as iterative product development. And that's quite easy." (Director, Gravity, 2011)

Making Ideas into Reality: Knowledge Creation Example

Converting 'tacit' into 'explicit' knowledge (Nonaka, 1995) represents the final phase in knowledge creation in innovation. Here, the knowledge process turns conceptual ideas into something tangible or archetypal. This research identified two types of knowledge creating patterns that occurred within the field data. First, a firm creates new products through adopting an experimental approach i.e. 'learning by doing'. As Nonaka and Takeucthi (1995) claim, the process of converting explicit into tacit ('internalisation') relates to experimental product development. The second mode involves the ontological dimension of knowledge creation [i.e. 'knowledge is created only by individuals' (Nonaka and Takeuchi, 1995:59)] and drives this research towards the tacit dimension of knowledge in organisations. Likewise, this study suggests that individual tacit knowledge is a tremendous resource for innovation. It is fascinating that the findings of this research have unlocked the idea of innovation in design industries as a collective task (Hargadon and Bechky, 2006), especially from a western approach and results in innovation being viewed as a 'genius' of individual innovators (or designers).

Further, this research suggests that implementing ideas into successful innovation comes through 'learning by doing'. At Fibrefill, this means learning by making mistakes, for example after a machine breaks or when something happens accidently like somebody pressing the wrong button. Leonard and Sensiper claimed 'tacit knowing is embodied in physical skills that reside in the body's muscles, nerves and reflexes and is learning through practice i.e trial and error' (1998: 113) and similar tacit knowing is embodied in cognitive skill is unconscious or semiconscious learning comes through an individual 's past experiences. Both physical and tacit skills were evidenced in Fibrefill, as can be seen in the quotes below. One of Fibrefill's innovators in silicon development described:

> "I've learnt by generally making mistakes after a machine breaks or somebody presses the wrong button or something happens by accident. And if you are open to noticing these then that's where lots of ideas come from." (Technical Director, Fibrefill, 2011)

As seen in the Fibrefill example, innovators make 'informed guesses' based on past experience (Henderson, 1998; Vincenti, 1990) and engage in more experiential or

improvisational product design. Sitkin (1992) claimed that nothing can compare with the knowledge and learning that comes from '"small losses" through experimental products that fail or futurists' predictions that do not come true' (cited in Brown and Eisenhardt 1995:21). Interviewee described:

> "We have a lace and the breathable silicon. We only coat solid position. We applied film over the entire lace through big holes. We blew air through the bag and burst the hole and this concept came from trying to coat lace with big holes in it. And sometimes if you get it wrong, the silicone will burst and you will have holes and we have noticed that sometimes the silicone melts through a little bit and then we think "okay, if you get that then glue it a little bit and flock it and glue and when you do that blurs it a more and it clears all the holes and we've got a brand new product which we then patent". So, that's just an example. But we have to do this by watching and learning. We have to stop it and you have to see it or you just could go "oh that's a mistake, throw it in the bin", so you have to be open to…." (Technical Director, Fibrefill, 2011)

"None as Good as Jose"

Such creativity and talents can be easily separated from the organisation because it is assumed that creativity and innovation blooms in isolation (Leonard and Sensiper, 1998). There were many examples that emerged from the data to support that finding. Examples drawn from Gravity illustrate how the creativity and innovation separate from other members in the firm while core innovations focus on a single inventor. The director at Gravity explained, "The team has one practice consistent and that is Jose"; "Jose is definitely the most creative member of our team. Most of the products that we have commercialised or licensed, Jose's invented. Although it's normally a team effort, Jose leads that process". In another place, the director claimed, "None as good as Jose. Jose does everything to some extent, but his main expertise and his main focus is on inventing and developing new concepts." Furthermore, a design engineer confirmed, "Jose was really the guy behind the design". As Simon (1998) argued, 'the reason experts on a given subject can solve a problem more readily than novices is that the, experts have in mind a pattern born of experience,

which they can overlay on a particular problem and use to quickly detect a solution' (cited in Leonard and Sensiper, 1998:114).

Conclusion

The study of knowledge process of these design firms lifts discussions on individual contribution into innovation in product design firms. To a large extent, the literature on collective knowledge creation was not seen in the research findings. By ignoring the perspectives of how knowledge is created and held collectively, organisations learn from social interaction and the shared understanding about problem solving. This study has shed light on the individual level of knowledge creation and presented evidence of single inventors working in sports product development.

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WGSN Innovation Review via WGSN Subscription (2011) available online at: www.wgsn.com (Accessed 20-04-2011)

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