International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 03, March 2017
www.ijates.com
ijates
ISSN 2348 - 7550

DESIGN INNOVATION AND CREATIVITY

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ABSTRACT

In this paper we have tried to differentiate between design innovation and creativity in engineering context, we have also tried to bring them together to achieve successful design. Further we have discussed various methods of creativity and how it can be developed in an individual to achieve institutional success, also we have tried to throw some light on innovation and how to harbour innovation for design management and what are the difficulties which we face during doing so, also there are methods to overcome those barriers.

Keywords : Design, Innovation, Creativity, Creative Confidence, Harbouring Innovation.

I INTRODUCTION

The purpose of this critical review is to examine the current status of design innovation and creativity. A number of different areas of the subject are investigated in order to provide a summary of the topic and determine what further research should be conducted. First, the key concepts of design, innovation and creativity are introduced. The place of creativity in design innovation is then investigated. Research was conducted into creative confidence and barriers to creativity in industry, and the results are presented. Finally, methods for successfully harbouring creativity in businesses are discussed before conclusions are drawn on the research findings, and suggestions for future research are made.

II DESIGN

What exactly does the word design stand for? The first association often goes into an *artsy* direction. Designers being creative and developing ornamental *things*. This derives from the circumstance that in some cases direct construction of objects is considered as design. This does not only show how closely related the different terms in our topic are but also how necessary a clear definition and differentiation is.

Design has different connotations in different fields. According to von Stamm (2008)[1] “design is the conscious decision-making process by which information (an idea) is transformed into an outcome, be it tangible (product) or intangible (service)”. Comparing this with Pahl and Beitz (1988)[2] design is a process which is plan driven and is understood in terms of discrete stages. This leads to the assumption that it basically is a plan for the construction of an outcome. Designing considers the aesthetic dimension, functional dimension, economic dimension and socio political dimension of an object. Simon (1996)[3] states that “design is informed research and knowledge in a predictable and controlled manner”. This controlled manner is vital for an application in a practical environment in a business. According to von Stamm (2008)[1] organisations have increased the interest in both innovation and design over the last few decades. Therefore, viewed in a context of innovation and creativity, she continues to state that designing stands for creative activities and eventually a

procedure of information transfer with the goal of a definite output. This leads to the term engineering design. Engineering design is a process which involves several steps to generate a solution to a problem where, in essence, the solution is the designing of a product which is required to meet certain specifications and perform specific tasks (Ertas & Jones 1996)[4].

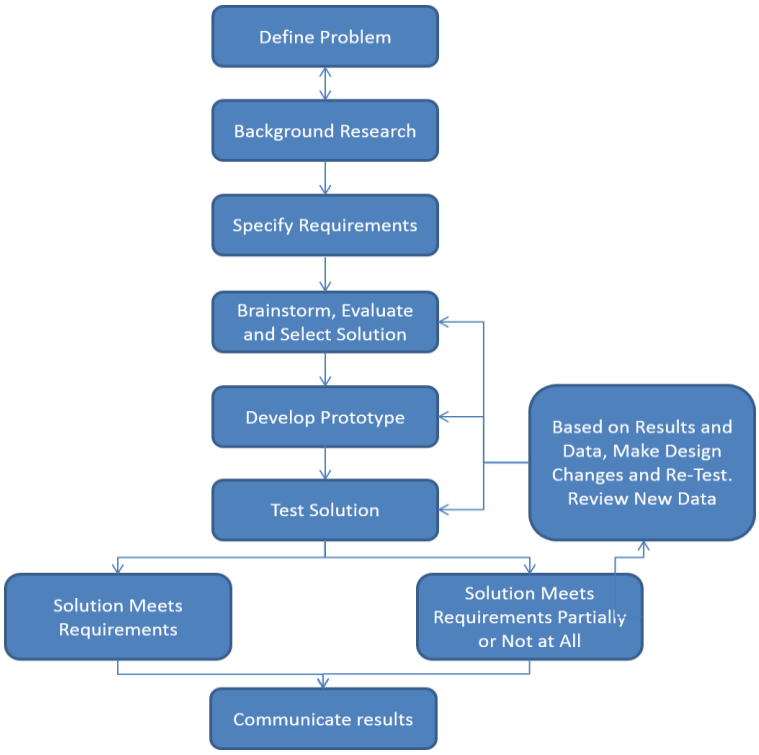

Figure 1: Ertas & Jones (1996)[4] - the engineering design process

This process is visible in figure 1. It shows the mentioned series of steps that lead to a desired goal or result. Consulting von Stamm (2008)[1] it is about executing those steps consciously because "it is about comparing alternatives to select the best possible solution, it is about exploring and experimenting". And that is exactly the substance of innovation.

III INNOVATION

The word innovation is used so frequently and in so many contexts that its value has diminished (Keeley et al. 2013)[5]. The definition has been discussed, refined, and redefined on numerous occasions throughout the paper.

However, we would like to begin by stating it in simple, unambiguous terms - innovation is the process of building upon prior art and giving new meaning to existing ideas. "Newness", itself, is not enough, the end product of the innovation process must be a successful product, process or organisation (Fagerberg et al. 2012)[6].

The early definition, presented by Schumpeter (1934)[7] remains valid to this day – innovation is new combinations of knowledge, technology and resources. Solow (1957)[8] added the ideas of introducing new products, improvements in quality and new methods of production. According to Hagedoorn (1996)[9]

innovation is the stage that follows invention – invention that has successfully achieved economic and social impact.

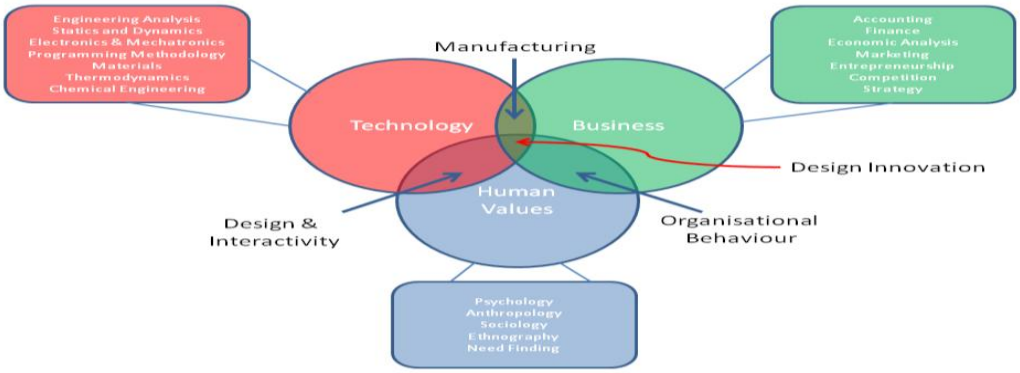

Figure 2: Innovation from design workshop on user-centred design, Ireland 2007

As seen in figure 2, innovation in design can be come about when a number of factors and influences cooperate. "Only when you a*ct*, when you *implement*, do you truly innovate" (Kelley & Littman 2006)[10]. Only by taking control of acting differently when it comes to the implementation of the visible elements, innovation can be stimulated. This is the reason why the definition of innovation often gets associated with a "frame of mind" (Von Stamm 2008)[1].

Designers and engineers have attempted for a number of years to bring the core concept of innovation into their business models and working structures. Researchers have analysed processes and generated models of how innovation is and can be used in businesses. Rothwell conducted extensive research and presented an excellent overview of the evolution of these models with his *Generational Concept* in 1992 (Rothwell 1992)[11]. He described the transition from the 1950s technology-push model of innovation, where new materials, processes and inventions gave inspiration for designers to come up with new ideas - they were pushed along by the technology in a sequential, linear fashion.

From the 1960s to mid-1970s the market conditions changed due to gaining more and more competition and product diversity, which had the consequence that *listening to the customer* was pushed into focus *reg*arding the innovation process. Companies that ignored the customer found themselves losing market share.

However, it was felt that the technology push and market pull models were two ends of a spectrum and the reality was more central, being a synergy of science, technology and marketplace. Feedback steps were incorporated with increasing emphasis of integration between production and design.

IV CREATIVITY

The oxford dictionary definition of creativity is "the use of imagination or original ideas to create something'' (OED 2015)[12]. The standard definition of creativity is the act of turning new and imaginative ideas into reality. It is characterised by the ability to see the world in another and individual way and to connect unrelated data to obtain a solution. May stated that "Creativity is the process of bringing something new into being" (May

1994)[13]. As elaborated in more detail later in this report creativity is a practice. It is a cognitive skill that can be experienced and acquired.

As a conclusion, a differentiation of creativity from innovation is necessary. Creativity is the development of fresh ideas while innovation is the procedure of making these ideas tangible so that they can be used in a design process, for instance. Creativity is often an individual activity and innovation is a team process, the process of innovation creates a need which leads to creativity. On the other hand creativity is pioneering while innovation could be based on previous ideas. It can be inferred that creativity is basic step for problem solving process such as identifying the problem and generating the ideas to solve it and innovation is concentrating on how to implement the idea and evaluating its acceptance by the society.

4.1 Creativity in Design Innovation

First of all: What is an innovative design? The Oslo Manual (2005)[14] states that "an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." The Jurors for the 2015 Innovation by design awards (2015) were asked the same question and shared their expertise. For instance, Stuart Karten states that "innovative design is new and different. It introduces aesthetics that haven't been seen before". Mark Rolston concludes that "there's certainly no good checklist for innovation because by its very nature it should surprise us." So how are we to influence innovation then?

There are various factors that have an impact on innovation and the process behind it, but according to David Hands "it is commonly agreed that creativity is the seed from which innovative ideas and solutions emerge and indeed flourish. He continues to state that creativity is the most vital variable to the potential of the innovation process. Ultimately it is absolutely vital to be able to be in charge of this seed's thriving.

4.2 The role of creativity in innovation

The role of creativity in innovation appears to have gained more and more importance over the past decades. As Iványi and Hoffer (1999)[15] wrote about an increasing relevance and claimed in the late 90s that creativity "may be considered as a motor of innovational ability and processes", whereas Hands ten years later, even declares creativity as the exclusively important leverage in innovation. This is to underline with the fact that the influence on design processes is the biggest in the very early stages, when the cost of change is relatively low and the idea has just been come up with. The formative part of creativity mostly takes place in those early stages of inspiration and idea development which leads to the assumption that creative thinking itself is one of the first steps towards innovation. As per the definition of innovation as "the intentional introduction of ideas, processes and procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organization or wider society" it is the "successful implementation of creative ideas". All said and done, managing this implementation eventually defines the role of creativity in innovation, as being not just a trait but an asset to be managed with care.

4.3 How creativity can be utilized in design

Consequently, there is no way around the efficient management of creativity in innovation processes to tap the full potential of creativity as an utilisation in design. According to Agbor (2008)[16] it is vital to acknowledge the "leaders" encouraging creativity's thriving creativity in order to develop innovational environments. Supportive working conditions, recognition of social structure, individually meet employment circumstances and simply put creatively spirited working surroundings. When having taken care of that, the goals and results of design processes can be set. According to Gero (2006)[17] one can hence expect "something new" in the first place and provide the according design conditions for this approach or point in the direction of creative non-routine designing with the goal of producing something completely unexpected and putatively "incongruous" in order to build upon that in further design steps.

4.4 Creativity improving the success of innovation

Being creative is an evolutionary trait inherent to humans (Findlay 1988)[18]. As the success of innovation depends on the ability of people, it therefore depends on how they apply managed creativity in innovation processes in order to get the desired output. The national academy of engineering (2004) states that "creativity is an indispensable quality for engineering […]" hence declaring, that being in positive creative environments with the chance to actually be creative results in being an attribute of successful innovation processes. Scarlett Miller from the Pennsylvania State University describes a number of steps to accelerate creativity. She states that the focus needs to be on understanding the problem, looking at it from different perspectives, working in an inter- or multidisciplinary team and eventually in a creative environment. Those roughly formed approaches show how more value from the creative understanding of what is already known can be extracted (Buxton 2005)[19] in order to improve the success of innovation. So how can we actually be creative? Can anyone be creative?

4.5 The path to creative confidence

We all begin life being creative. However, this creativity can sometimes become suppressed through overly rigid, formal school education. So where does it go wrong? Why does this inherent attribute of human beings become secondary to routine thinking, and is it possible to regain this through design education?

If we wish society as whole to be more creative, we must start early – elementary schooling, through secondary school, university and beyond. It is understood that creative and entrepreneurial people show similar traits, they challenge conventional thinking, are playful, inquisitive, value teamwork, use trial and error approaches and learn from set-backs (Rauth & Koppen 2010; Levick-Parkin 2014)[20][21].

However, within the context of design business, it is clear that we cannot go back in time and re-educate our youthful selves, so we must find suitable approaches to re-awaken the creative spirit – this is the path towards creative confidence.

4.6 Creativity confidence

Creative confidence is the result of developing an extensive understanding of one's own knowledge of self and one's ability to tackle creative-type problems effectively. There are many types of problem solving; some examples are – analytical, logical and lateral. Lateral thinking is akin to creativity – it is facing a problem that cannot be solved logically or analytically and envisioning novel ways to approach it. Rittel originated the term "wicked problems" to define social problems that were often are not clearly defined, with no set start and end points and few rules (Rittel & Webber 1973)[22]. The problem's definition shifts and evolves during the solution process and often by the time the problem is fully categorised and demarcated, it is already solved (Coyne 2005)[23].

Often people faced with these types of problem freeze up, retract within themselves and do not know where to start – the antithesis of creative confidence. They feel like they do not have the knowledge and skills to attack the problem head-on, neither do they have the ability to see the wider picture and liberate their imagination and they struggle with the uncertainties (Rauth & Koppen 2010)[20].

However, even people with sufficient skill and knowledge struggle with these problems, but it is possible to develop everyone's confidence in their own abilities through creating scenarios where students are repeatedly presented with creative challenges. Each challenge builds on the last and the student's knowledge of their self and confidence in their creative abilities is fostered and strengthened. According to de Bono (2015)[24]" creative thinking is not a talent, it is a skill that can be learnt. […]". As already mentioned, it is an evolutionary trait and not at all fixed. IDEO's Kelley Brothers strongly believe in this idea and state that the separation between creative people and others as a "set of misconceptions" in correlation with "the creativity myth" (Kelley & Kelley 2015)[25].

4.7 Creativity as a practice

Research activities in 2012 (Bisadi et al. 2012)[26] resulted in describing this practice as a mental operation in a form of divergent thinking. Furthermore as a mental "process to given stimuli". The peculiarity of this intellectual approach is that "looking at things in different ways" and the production of existing aspects of a problem or a circumstance into novel elements that relate to the respective requirement. The researchers form the assumption that "the more mutually remote the elements of the new combination, the more creative the process or solution". This does not sound impossible or impractical but according to Kelley (2015)[25] "only 25 percent of individuals feel that they're living up to their creative potential." Kelley goes on and claims that the acquired fear of social rejection keeps us from unleashing creativity and it hence gets blocked. Purposeful unblocking it is what makes it teachable. If you don't feel creative it can be helpful to work on your mind set and make sure you surround yourself with people who are able to give you creative confidence.

4.8 How creativity happens in the brain

Is it therefore a valid assumption that creativity is a social occurrence? This might be correct when speaking of unleashing, developing or improving creative processes. But the quality can also be recognised and proven in the brain, which makes it appreciably individual. Research of the National Endowment for the Arts in

partnership with the Santa Fe Institute results in the statement that "new combinations of existing ideas, concepts, and perceptions that have been stored in the brain over time". This would basically mean a memory full of ideas and experiences. They explain that this memory consists of two major categories: "the declarative memory (memory of facts and events) and non-declarative memory (unconscious, procedural memory; knowing how to do things)."

In the end, they elaborate that a "part of creativity is the brain accessing that non-declarative memory, the learned experience." Dietrich (2015)[27] states that that "99 percent plus of all the brain's computations occur in the ill-lit basement of the unconscious." This is why people tend to differentiate creative and non-creative people. They have trouble understanding how they manage to unconsciously combined things. By establishing awareness of the proceedings in the brain and experimenting with idea generation this can actually be experienced

A new study from Stanford University revealed that by setting up creative tasks creative activities could be visible in the participants' "cerebellum, traditionally viewed as the brain's practice-makes-perfect, movement-control centre, hasn't been previously recognized as critical to creativity." Furthermore "the cerebellum may be able to model all new types of behaviour as the more frontally located cortical regions make initial attempts to acquire those behaviours. The cerebellum then takes over and, in an iterative and subconscious manner, perfects the behaviour, relieving the cortical areas of that burden and freeing them up for new challenges." (Goldmand 2015)[28]. It should be safe to say that creativity more of an applied process rather than a talent.

4.9 Team creativity versus individual creativity

Now that we know about creativity's practicability and the fact that it occurs differently regarding individual and group structures, the question is what characterises these distinctions. Research at the University of New South Wales and the University of Melbourne (Pirola-Merlo et al. 2004)[29] investigates that individual characteristics such as "sense *making*, *motivation*, and *knowledge and ability"* merge to a product of creative and habitual activities. Whereas creativity in groups is dependent on the following four factors: vision, social confidence (stated as "participative safety"), the goal of a high performance standard and the "support of innovation". Taggar (2002)[30] points out that individuality and group dynamic don't have to be one another's' result but can rather lead to the balanced emersion of synergy in which one part can't exist without the other in order to tap the process' full potential in an organisational innovation process. This concludes with the point that "group creativity can be more than the aggregated creativity of group members" but also as a separate factor, influenced independently. The research's main point regarding this issue is also our conclusion: In some cases the best or at least desired result can be achieved by the motivation of individuals whereas an overall project result needs vision as a group creativity factor to produce the best result. Therefore, it very much depends on the desired output, which characteristic to focus on.

V OVERCOMING BARRIERS IN THE CREATIVE PROCESS

5.1 Barriers

There are often a number of barriers to creativity in organisations, the majority of which relate to attitudes and behaviours. The attitudes of managers and influential team members play a huge role in the development of creativity and innovation. If there is negativity from these positions, new thoughts and ideas are difficult to nurture. Devil's advocacy is a harmful yet natural behaviour found in design teams. As described by Kelley, the standard preceding comment of "let me just play devil's advocate for a moment" removes any persona from what is about to be said (Kelley & Littman 2006)[10]. Assuming the absolute worst kills ideas before they stand a chance of developing. This isn't helpful and discourages people from sharing ideas for fear of being shot down if their idea is only in its very early stages. The structure of a design team and the personas involved plays a significant part in determining the overall success of a project. If businesses can develop their culture to better nurture innovation and creativity they may find greater success, according to a number of sources, and there are a few ways of doing this.

5.2 Solutions

Multidisciplinary to interdisciplinary teams

The most successful design teams are often comprised of people from vastly different social, cultural and academic backgrounds. This allows for different perspectives which is healthy, since, in many forms of design, the target audience will be varied. The team structure detailed by IDEO founder Tom Kelley in "The 10 faces of innovation" demonstrates the different personalities that IDEO draws upon for design success (Kelley & Littman 2006)[10]. These are split into learning, organising and building personas. The learning roles are necessary to keep an organisation in touch with the world outside of the company itself. The organising personas recognise the best ways for time and resource allocation within complex processes. The building personas are centred around actually making innovation happen, by drawing on the knowledge and insights gathered from the other personas. Von Stamm notes observing similar personas in successful innovative companies (Von Stamm 2008)[1]. IDEO has novel approach to characterising a creative team and given the direct manner in which this structure aims to prevent team attitude and behavioural problems, and the respective success of the company, it could be said to be successful. However, this team structure will not always be possible or necessary in different scenarios. IDEO are a creative consultancy so it may not be appropriate to attempt to implement this structure in other industries. Nevertheless, the concept of multi-disciplinary teams is important for all design teams.

Something which features frequently in literature is the concept of the T-shaped person, for successful operation in a multi-disciplinary environment (Brown 2009; Kelley & Littman 2006)[31][10]. The idea is that people need vertical and horizontal strengths. The vertical represents the depth of the individuals' skill in their field and the horizontal represents the interdisciplinary nature of the individual. The ability to cross the T "is what distinguishes the merely multidisciplinary team from a truly interdisciplinary one" as noted by Brown (Brown 2009)[31]. Brown offers the insight that a multi-disciplinary team involves many different personas each

championing their own ideas within the team setting, whereas an interdisciplinary team takes collective responsibility for all ideas. Perhaps in that case, organisations should strive for an interdisciplinary culture in order to eliminate team issues.

5.3 The Design Thinking methodology

Design Thinking is described by Meinel and Leifer as a "powerful methodology for innovation" (Plattner et al. 2011)[32]. It is defined as the integration of "human, business and technological factors in problem forming, -solving and –design." Tim Brown, CEO of IDEO, the highly successful creative consultancy, describes design thinking as an "approach to innovation…that can be integrated into all aspects of business and society" (Brown 2009)[31]. It is not something meant just for encouraging industrial creativity, but something far bigger.

The purpose of the design thinking methodology is to have an end user focus throughout the design process. It is based on multi-disciplinary collaboration from engineering, design, social and business contributors in an interactive and lively process. Behaviour is the key focus rather than knowledge. Design thinking can therefore be used as a method for overcoming barriers in the creative process.

Significant research efforts into the scientific reasons why the design thinking method of innovation works are at the core of the HPI-Stanford Design Thinking Research Programme (Goldman et al. 2012)[33]. One key focus of the research is the development of performance and assessment metrics for design thinking, in order to facilitate effective team management. This is highly important, recent research which may facilitate an increased uptake in the use of the design thinking methodology.

However, there are some problems with the implementation of the design thinking methodology in businesses. It is particularly difficult to instigate the methodology in companies with a vastly different organisational structure. To expect to be able to transform the methodology of a company's workforce without extensive re training wouldn't be foolish. One might say it would be a case of slowly introducing people trained in the ways of design thinking as new staff are required, but this would take a long time to transform the company methodology as a whole. For this reason and others, certain businesses simply won't adopt design thinking.

5.4 Harbouring innovation in businesses

Innovation has become a highly used buzzword across vast numbers of different industries from product design to finance, healthcare, education and even government policy. Politicians talk of the need to innovate and the European Union has policies and targets to promote innovation in its member states (Koskinen & Thomson 2012)[34]. However, it is rare outside of the world of academic research for people to step back and question what innovation is and what there is to be gained from it. It has almost become an unquestioned fact that innovation equals improved business growth – The Design Council's "Design for Innovation" plan stated that innovative companies' employment growth was more than twice that of non-innovative companies (Design Council 2011) and Li stated:

"*In today's rapidly evolving global and fiercely competitive economy, companies need to innovate continuously. Innovation is now recognised as one of the most successful strategies for profitable growth, capturing market share, and even the means of surviving*."(Li et al. 2007)[35]

Innovation inspires employees, drives growth and protects market share. If we take the premise that innovation is desirable, we must narrow the focus on how we define innovation and how we can harbour it in the design business environment.

5.5 The evolving definition of innovation

We have already defined innovation as the successful commercialisation of inventions. This has evolved from Schumpeter's original definition, being refined by Christensen in his seminal work *The Innovator's Dilemma* into two closely related but markedly different ideas: *sustaining* innovation and *radical* innovation. Markides further refined Christensen's definition of disruptive innovation into business model innovation and technological innovation (Christensen 1997; Markides 2006)[36][37]. A sustaining (or incremental) innovation is an improvement or evolution of a design, method, or system that can be linearly traced back to the previous incarnation; whereas, a *radical* (or disruptive) innovation is defined as having no lineage, no parallels and brings significant new meaning. Sustaining innovations usually serve to *maintain* the current industry-wide pace of improvement – systems are optimised, products refined, materials substituted, new technologies incorporated. The whole business structure grows and evolves to allow the process optimisations and significant value becomes embedded within the system. The larger a company grows, the harder it is to engage in *radical* innovation.

Christensen posited that, more often than not, radical innovations are at first clunky, awkward to use and lower specification than the current market leaders. (Danneels 2004)[38] countered this statement with examples of disruptive technologies that from the outset had higher specification and performance than the existing technologies. Recently Christensen, Raynor and McDonald further refined their definition of *disruptive innovation* and claim that these types of innovation are actually quite rare, despite many start-ups and venture capitalists claiming to be the holder of the newest disruptive innovation - these, they claim, are more commonly merely classic sustaining innovation (Christensen 2015)[39]. Either way, for the new product to be successful there needs to be some form of market, however niche that may be – early adopters, technology enthusiasts, or new markets that seize upon the opportunities the new technology affords. Christensen (1997)[36] showed that the rate of improvement of the new technologies can be more than twice that of current technologies. This allows the new product to rapidly catch up with existing products, quickly seizing market share, and often rendering the current technologies obsolete – this is represented in Figure 3.

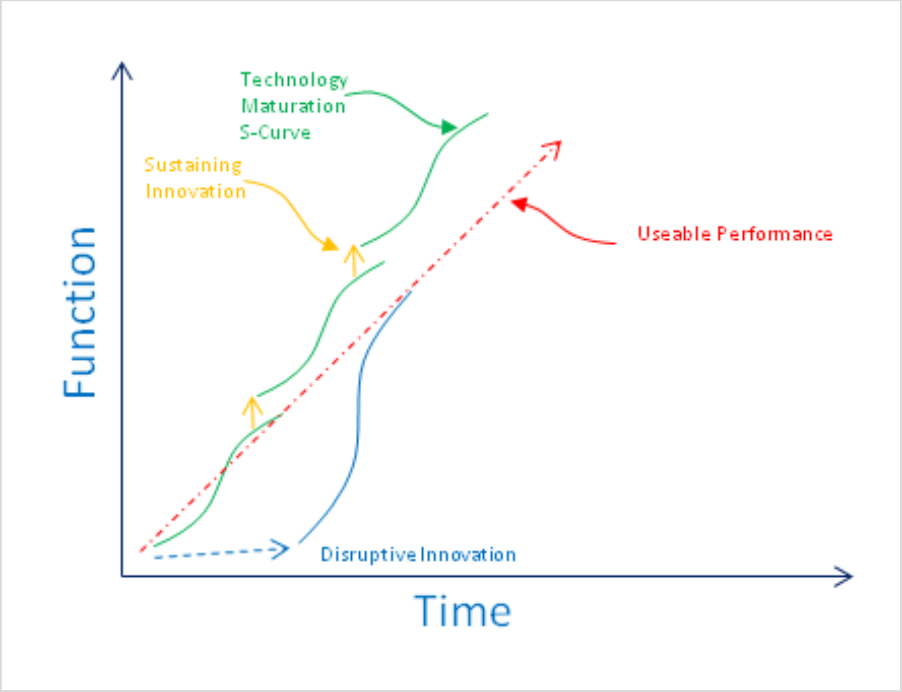

Figure 3: Sustaining Innovation vs. Radical Innovation

Through his detailed study into the rapidly advancing world of computer disk drives Christensen showed that it is difficult for newcomers to break into existing markets by competing on the current technology improvement path – the incumbent companies often have effective systems and excellent management, allowing them to keep on top of the pace of technological change. However, when an incomer presents a completely new idea, the large companies often fail to see it coming, or believe the new market will be of little value. Time and time again this has led to their ultimate demise.

With this in mind, how can companies prevent this? How can they strive to maintain their own product lines while searching out the new, radical ideas?

VI THE CHALLENGES OF DESIGN INNOVATION

When considering design there are many methods that have been developed to create an environment which allows innovation – design thinking, blank sheet design, multi-functional design teams and human-centred design (Rauth & Koppen 2010)[20]. However, (Norman & Verganti 2014)[40] argued that these methods are all excellent tools to foster *sustaining* innovation but not *radical* innovation. They presented evidence showing that not one single major radical innovation arose from asking the customer what they wanted. All major radical innovations occurred when inventors used a completely new technology in a way nobody had previously imagined. It was the exploration to find what was possible, rather than what people needed, that led to the invention.

At this point we need to remind ourselves that radical innovation is a risky business - one study estimated that 96% of radical innovations were not successful – in this case they become merely inventions (Norman & Verganti 2014)[40]. The challenge then appears to be picking the correct inventions and optimising them.

Many times large incumbent businesses assess these new developments as part of their horizon scanning processes and even carry out market analysis and seek customer feedback. These tried-and-tested business methodologies tell them that customers are not yet ready, the investment risk is high and the potential market size is too low. They choose not to invest (Christensen 1997)[36].

It is clear that if a company wishes to both innovate radically and bring the product to the mass market they need a new approach – they need to allow time, freedom and resources for designers to engage in the exploratory design process. They need to identify what the customers of the future might find desirable and develop new capabilities to bring these products to market. Then and only then can they use the vast array of design approaches that have been used so successfully by the likes of Apple, who have mastered the ability to distil, refine and optimise these rough, early ideas into polished, marketable and effective products.

Methods for successful management of design innovation and creativity

Finding new applications for old ideas is at the heart of the majority of successful innovative companies. This strategy is described as knowledge brokering. They make the point that the most successful innovative companies are those which have perfected their organisation and attitude, and not necessarily those with the best ideas. After all, ideas are just that until they are implemented.

Research has been undertaken which suggests that the creative behaviour of individuals is higher when the organisational culture of the business is innovative (Navaresse 2009)[41].

Von Stamm (2008)[1], a leading expert in the field of innovation, has published a great deal of material surrounding the management of design, innovation and creativity. She notes that collaboration is a key way to encourage innovation. If a company is willing to accept exposure to alternative methodologies, horizons can be broadened which may lead to implementation of new processes or organisational methods from witnessing success in other contexts Collaboration can also be successful between more evenly matched companies. Bordegoni & Rizzi present the idea of a Virtual Enterprise, which is created between two companies working together on a common project (Bordegoni & Rizzi 2011)[42]. Both Von Stamm and Bordegoni agree that there are several different business reasons for collaborating for innovation: sharing risk and costs, expanding the reach of the company into new markets, obtaining new knowledge and resources, and reducing the development time (Bordegoni & Rizzi 2011; Von Stamm 2008)[42][1]. In support of collaboration, Chesbrough discusses the advantages of utilising the open innovation method, as opposed to closed innovation in an organisation (Chesbrough 2006)[43]. Closed innovation is when everything happens within one company in theory to ensure the quality of the work, as everything has been done under the same management. The disadvantages of this way of working are that no new ideas are introduced, it is assumed that the way things are being done is the correct and only way, as the business is not open to any outside influence. Chesbrough notes that at the beginning of the 21st century, this style of innovation began to fall apart due to the increasing mobility of highly skilled and experienced people. It started to be less and less favourable for businesses to isolate and restrict themselves to home grown resources as they only stood to lose out when workers chose to move on, taking their knowledge and training with them.

Refusing to be open to the increasing resources (skilled people with new ideas, different perspectives etc.) on the outside became highly likely to result in the downfall of the company. The principle behind Open Innovation is that businesses be open to outside influence on design and marketing of their technology - that they accept there is no need to invest heavily to harbour innovation internally if the necessary talents and resources already exist externally. Figure 4 shows the Open Innovation Paradigm for the management of industrial research and development.

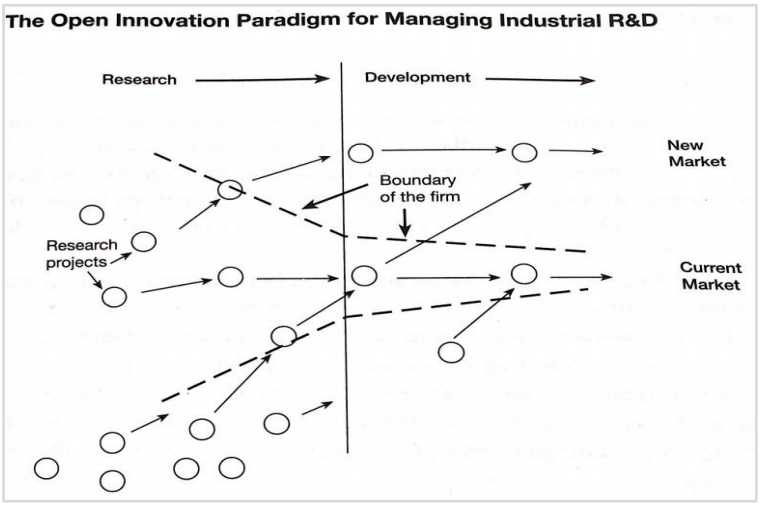

Figure 4: The Open Innovation Paradigm (Chesbrough 2006)

Innovation is usually considered at the product development level, but it can much more successful when applied to the business as a whole. Applied correctly, innovation can transform the culture of an organisation. According to IDEO it is not only enough to have a great product, but a company must be innovative at all levels, through all stages of the process, from design to marketing to human resources - a company with "360 degrees of innovation" (Kelley & Littman 2006)[10]. If the whole organisational structure of a business is geared towards innovation, it will be easier to manage at every stage.

However, there are some problems and disadvantages to design innovation and creativity from a business management perspective. Satisfying the customer requirements within resource parameters is the key goal of any design process. It is important that management can keep the design process under control such that schedules and budgets are adhered to, and the product meets what was asked, not necessarily the best solution possible.

VII CONCLUSION

From the investigation carried out into "Design Innovation and Creativity" a number of things are clear, and suggestions can be made for necessary future research in the field.

The knowledge and understanding of design innovation has come a long way and could almost be described as being on an accelerated evolution curve - the rapid uptake of new technologies has resulted in even faster innovation lifecycles, in essence a positive feedback loop. Marketplace changing technologies appear frequently and it is a huge challenge for businesses to stay on top. New theories and models are generated that describe the

innovation process, but it is rare that these models are tested thoroughly using empirical data, meaning that it is still very difficult to pick which new developments will be winners with confidence. An area of fruitful future research is likely to be thorough, methodical testing of these models and theories to find which ones best predict, or generate, the innovative designs of the future.

The research materials consulted were in agreement that it is behaviours and attitudes within a business that have the biggest influence on the success of design teams, rather than purely "how innovative" the business actually is.

Necessary further research is of the type currently being conducted by the Hasso-Plattner-Institute, into the scientific and psychological evidence behind the design thinking methodology. Further research to develop a better understanding of how it works may ease the difficulties experienced by businesses with a vastly different organisational structure, when trying to instigate the methodology.

It is to state that there will stay a problem regarding sustainability because design and innovation often lead to increased consumerism with which the majority of the world cannot cope. A development of indifference to environmental issues could possibly settle in. It is possible that the gap between "design that sells" and "design that helps" will get bigger. This is to be observed with care.

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