JYVÄSKYLÄ STUDIES IN COMPUTING
164

Sameer Datye

Life-Based Design for Technical Solutions in Social and Voluntary Work

JYVÄSKYLÄN YLIOPISTO

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Esitetään Jyväskylän yliopiston informaatioteknologian tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston päärakennuksen salissa C4
joulukuun 14. päivänä 2012 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Information Technology of the University of Jyväskylä,
in University Main Building, hall C4, on December 14, 2012 at 12 o'clock noon.

UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2012

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URN:ISBN:978-951-39-5019-4
ISBN 978-951-39-5019-4 (PDF)

ISBN 978-951-39-5018-7 (nid.)
ISSN 1456-5390

Jyväskylä University Printing House, Jyväskylä 2012

ABSTRACT

Datye, Sameer
Life-based design for technical solutions in social and voluntary work
Jyväskylä: University of Jyväskylä, 2010, 229 p.
(Jyväskylä Studies in Computing
ISSN 1456-5390; 164)
ISBN 978-951-39-5018-7 (nid.)
ISBN 978-951-39-5019-4 (PDF)

The Social and Voluntary work sector operates outside the organised boundaries and systems of normal business, financial and government organisational institutions. My target during this research has been to develop an optimum solution for decision support towards committing and accepting resources in the Social Work and Voluntary sector. In initial part of this monograph, I have traced the history of Design Thinking from the time it was 'art and craft' until modern times where multiple approaches are tried, tested and implemented for solution development.

For the actual application development, I have chosen the Life-based Design conceptual framework. Three design iterations were made in the application development process- Early Design Phase, iReach 1.0 and iReach 2.0. Usability tests measuring performance and focus groups giving insights about the perception of the solution were conducted with each iteration. The key-insight during the design development journey was that the users do not want a solution to make a decision for them. They expect to be presented with easily visible. searchable, sortable and filterable tool that provide emotional cues about the choices available. Multiple stakeholders influenced the decision making process and no single individual makes the decisions. This led me to choose SilverLight PivotControl tool for presenting data instead of using standard components.

Post the application development stage, I have recommended a new software development lifecycle model (SDLC) based on the actual development experience of Life-based design conceptual framework implementation. I believe that traditional SDLC models either lack ability of combining the long-term planning approach or flexibility, with each of them focusing on either end of the spectrum. On the other hand, the traditional models have a strong engineering approach while lacking a human-solution-oriented approach. The model that I propose leverages the benefits of traditional approach of waterfall, prototyping and agile models and uses them at different stages of the development process to optimise the output and do so in a cost effective way, deriving full benefits of the Life-Based design approach using practical usability engineering tools.

Keywords: Technical Solution for Social sector, Life-based Design practical implementation, Application Development Model, Human-Centred Design

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PREFACE

Nani gigantum humeris insidentes (Latin) – meaning, "Dwarfs standing on the shoulders of giants" (Merton, 1993, p. 76), is a metaphor commonly used when describing, in a humble way, how modern research is built. In other words, intellectual pursuit is built on the research and work of academics, scientists, philosophers, professionals and thinkers from various fields from the past. In this monograph, I have heavily relied on the works of luminaries who have contributed towards the development of Design Thinking from not only the scientific perspective but from the basic philosophical perspective of creating art.

I am indebted to many people for encouraging, believing, supporting and helping me in this work. First of all, I would like to thanks my Supervisor, Pertti Saariluoma for his time, continuous support, his invaluable insights, direction, advice and help with references to just name a few. Without his patience and flexibility to work with me remotely, this project would have been an impossible task. Ari Hirvonen, my colleague and second Supervisor, provided practical logistics help, gave insights on writing nuances of for this monograph- most importantly, he never gave up on me! I am also grateful to Dean, Pekka Neittaanmäki for encouraging me to start this project and facilitating the kick-starting of the process. I thank Jussi Jokinen (Doctoral Student,, Department of Computer Science and Information Systems; University of Jyväskylä) for providing the statistical analysis of the data from the tests and am especially thankful for the last minute fire fighting help!

This would not have been possible without the contributions of Sachin Kulkarni and Satyajit Rane. Sachin Kulkarni was forever balancing his personal and work life while helping in the application development process. His attitude of 'technology is just a tool to create solutions' combined with extraordinary technical skills, was a perfect combination for working on this project. Usability testing, documentation and data analysis became fun and easy with Satyajit's help. His experience and ability of working in a diverse usability environment coupled with remote testing and moderation skills were mission-critical in getting optimum output. Special thanks to Jussi Jokinen (Doctoral Student, Department of Computer Science and Information Systems) for creating the statistical insights from the data and last minute fire-fighting!

Thanks to Juha Lipponen, Sukant Panda and Vishwajeet Jathar for 24/7 support in the final proof reading round. Without their support, this would have been impossible to complete in the given time.

My employer Tieto Oyj., allowed me the opportunity to work and study at the same time with access to the tool required for developing software, for which I am grateful. Sampo Salonen led me to the 'eureka moment' with the introduction of the PivotViewer control. Fun and humour filled working days with constant encouragement and support, coupled with "Never say die" attitude from Ari Laakso helped me to keep going. The logistic management and managing internal stakeholders would not have been possible without

Carl-Herald Andersson believing and wholeheartedly supporting my passion for this journey.

The Baltic Sea Action Group (BSAG) team provided me the opportunity to work with real and live data converting this exercise from a theoretical one to a practical one. I would like to thank Samuli Tarvainen, Pieta Jarva, Anna Kotsalo-Mustonen, Mathias Bergman, and Henna Auno. I am awed by their passion and commitment towards the Baltic Sea.

This research would not have been possible without the participants across Europe and Asia, accommodating the logistics of time and technology- for which I am grateful to them. Neither would this have been possible without the support of colleagues, nor, friends, who helped them, overcome barriers locally. Sangita Shinde from Identity Foundation needs special mention.

I am profoundly grateful towards my family for always being there for me. Smita and Sudhir Datye, my parents for believing in me against all odds ☺. I am eternally grateful to, Namrata Kavde-Datye, my wife and co-founder of Identity Foundation for her patience with me for compromising 'family time' and not 'being there'. I hope little Leaa Datye, my daughter, forgives me for not spending enough time with her. It has been humbling and heart-breaking to see how accommodating and understanding she has been! I promise to make it up to you as best as I can.

Jyväskylä 28.11.2012
Sameer Datye

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INTRODUCTION

Charity Organization movement at the time of 'Victorian plenty', to address the poverty challenges, during the 1860s, can be viewed as the beginning of the Social Work profession (Woodroofe, 1962). In the last 150 years or so, Social Work has undergone a tremendous transformation. Its origin as work done by private citizens working with philanthropic organisations, acting in good faith for people in need has taken a political flavour in modern times. Social Work is no longer independent of the government, industry or social framework; rather an extension of the same. With the government, industry and other parts of organised society becoming major stakeholders in the activities of Social Workers by contributing resources (not only in monitory format), the 'voluntary-concerned-private-citizen' remains just one of the players in the ecosystem. Arguably, there are advantages and disadvantages of this situation; however, the need of a more integrated ecosystem enabled by technology advancements is inevitable. Take for example the modern way of getting signatures for a petition in public interest- the most common tool for driving the message and gathering support from public-at-large is the internet. Nevertheless, the main driving force behind the Social Work sector and the Social Workers participating actively is driven by 'good faith' and a desire for 'fairness'. I stop myself from calling it a desire for a 'fair and equal society' in order to accommodate the efforts of committed people working in 'not-so-democratic-societies'. The political situation in a society certainly creates different flavours in how social work is perceived and executed. Nevertheless, as Parton (1996), mentions in his book *Social Theory, Social Change and Social Work*, that Social Work creates a changing social order and encourages consensus through conflict in a legitimate format in the modern society. This is achieved without '*societal dislocation or breakdown*'.

> "Social Work fulfils an essential mediating role between those who are actually or potentially excluded and the mainstream society." (Parton, 1996, p. 6)

Every era calls itself special and modern. However, the time we live in is differentiated by the tremendous impact of technology in our lives. The social divide can now be extended to the idea of divide between the people having and not having access to technology- '*digital divide*'. The year 1989 is of great historical significance for two events- the fall of the Berlin Wall and the invention of the World Wide Web (Norris, 2001). The Berlin Wall event was comparatively more visible with the spreading of electoral democracy in the post-communist world Norris continues. However, the technology revolution happened with the launching of the web-browsing tool four years later.

> "Like dropping a stone in a pellucid pond, the ripples from this invention are surging throughout industrialized societies at the core, as well as flowing more slowly among developing societies at the periphery." (Norris, 2001, p. 3)

Norris (2001) holds that the digital divide has three distinct aspect- global divide, social divide and democratic divide. Global Divide signifies the access to the Internet or the difference in accessibility of the Internet between industrialised and developing countries. Social Divide signifies the gap between people within the same country separated as Information Rich and Information Poor. Democratic Divide is the difference between participants and members of digital communities to mobilise, engage resources and to participate in public life. All three aspects of this Digital Divide affect Social Work sector and the Social Worker. The sector and its participants have the unique dual role of being the 'Needy' and 'Supporting the Needy' at the same time. Since this sector operates in industrialized countries as well as developing countries, the level of access to the Internet is vastly different (Norris, 2001). Moreover, social workers are divided by the social divide within the same society depending on their own specialisation and focus of work, immaterial of them operating in industrialized or developing countries. Finally, the Democratic Divide is inevitable with the vastness and diversity of the sector. From industry perspective, creating solutions, tools and products for this sector is not a very lucrative phenomenon because of its financial structure. Despite institutionalisation of this sector, it largely remains voluntary and dependent on funding received from sponsors. The sector is not an industry, which can generate resources with trade and neither an organised institution, like the government, with access to public funding and support (Walsh, Stephens & Moore, 2000). Technology and solution providers, in my opinion, can help with innovations to bridge the Digital Divide without commitment of large resources, diverted from the beneficiaries of the Social Sector. My research and application development project is one such endeavour- largely driven by volunteering efforts of concerned citizens across Europe and Asia.

1.1 Research Target and Motivation

My target during this research has been to develop an optimum solution for decision support towards committing and accepting resources in the Social Work sector.

Based on the methodology of developing this solution, I intend to derive and propose a model for technical solution development- A human-life-centric inclusive model that promotes creative Design Thinking in the engineering process.

This work has its roots not in one, but multiple streams of study, from art, design, engineering, computer science, psychology, physiology to anthropology and more (Smith & Salvendy, 2007). The reason for indulging in this complicated and diverse (Sogge, 2002) research arose from the need to create a tool or a platform that could be used in the social welfare sector. A solution that can help the aid givers or receivers in the decision making process (Friedman, 1962) on where to commit or find resources. Though this is not really a new problem or void, research in this area is not very common due to the diversity of the stakeholders (Cheng & Mohamed, 2010). Emotional factors (Weyland, 2006) further enhance the complexity of the process (Pande & Vad Der Weide, 2012). The fact that this issue has a commercial implication also complicates the matter.

1.2 Approach

In the first part of the monolith, I have done literature review in order to identify the methodology for the application development I want to use. This phase consists of the history of Design Thinking when it was still more of 'arts and craft' (Lees-Maffei & Houze, 2010) issue. This is followed by the development of the Design Thinking with a scientific approach (Numbers, 1992) where it became a process and a method with an engineering focus (Rowe, 1991). Design Thinking with focus on Human-Computer Interaction (HCI) takes prominence after the advent of computers in mainstream human life (Jacko & Stephanidis, 2003). This happens in the latter half of the 20th century when computers came out of the realms of pure science and became an indispensable part of daily human life (Wikipedia, 2010). This phase in turn culminates into the modern days when computers or computing and ICT technology does not stay limited to the desktop computer, but also becomes mobile or wearable. Human beings are able to carry the ICT technology on their selves or in a mobile format (Barfield & Caudell, 2001).

The literature review explores the development of the thought process of Design Thinking all the way from the 'arts and crafts' times through the engineering era to the modern challenges of Human-Computer Interaction; this is journey is depicted in a pictorial format in Figure 1.

The second part of the monolith describes the application development process (Oosterlaken & Hoven, 2012) used in order to create an application that can be used in real life, by real users, to solve a practical life based challenge. In this section, I have tried to take into account the cultural aspects of the geographical distribution (Ess & Sudweek, 2001) of users across parts of Europe and Asia. I have derived a technical solution development model, in course of developing the application based on the Life-based Design concept (Leikas, 2009).

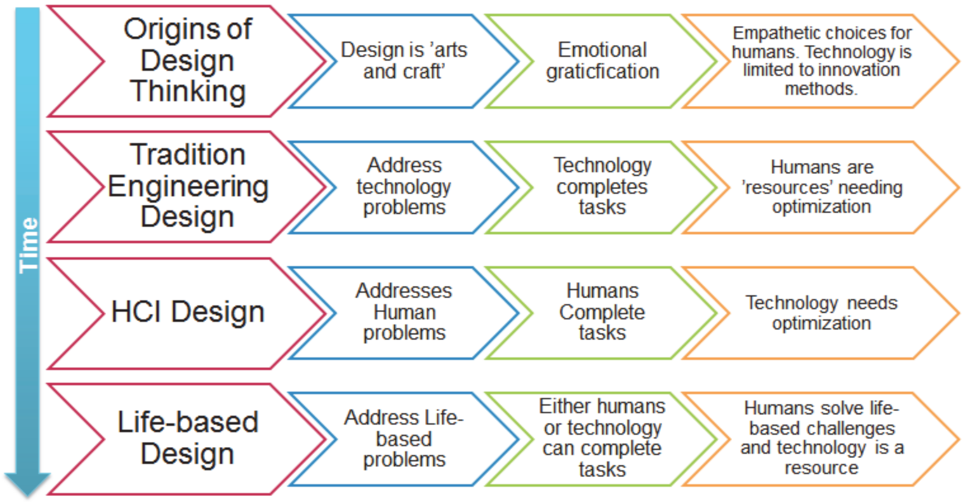


Figure 1: Theme and flow of literature review

With the tight integration of technology in everyday life, it is necessary for solution developers, to make form-of-life in which we participate, as the starting point of developing the solution. In my opinion a traditional engineering model is not sufficient. Hence, I finally propose the use of life-based technical design framework for solution developers to adapt in order to create solutions that solve a real life problem and not just address the fulfilment of technical functionalities.

2 STRUCTURE OF WORK

The following is a brief description of the structure of this monolith. The work is divided in 6 parts- 1. History of Design Thinking 2. Traditional engineering approach towards design 3. Human-computer interaction and Design Thinking 4. Life based Design Thinking and approach 5. Application Development using Life-based design framework, 6. Conclusions and proposal of solution development process based on Life-based design concept

History of Design Thinking: In this section, I have explored the origin of the design-thinking phenomenon (Menges & Ahlquist, 2011). Historical insights in to the design processes are explored, to put in perspective, the origin of the concept itself. This section deals with the philosophical aspects of the design process and its history while largely allowing the following sections to throw more light on the actual theories, practices and frameworks (Helander, Landauer & Prabhu, 1997)

Traditional Engineering approach towards design: In this section, review of Design Thinking literature, before the advent of computers in daily life has been explored (Ulrich & Eppinger, 2011). Largely, the focus of this section is limited to engineering related design with emphasis on Mechanical engineering (Pahl, Beitz, Feldhusen, & Grote, 2007). The associated product development process and the design engineering processes (Dieter & Schmidt, 2009) are explored.

Human-computer interaction and Design Thinking: With the advent of the computer age, interactive machines have been in use by people who may not have had the opportunity to use any hi-tech engineering products before. In addition, the mean time spent by ordinary people with intelligent engineering systems, which directly or indirectly give an engineering output, has increased many fold (Salvendy, 2012). Previously, the same people were using traditional low-end tools and suddenly circumstances and rapid growth in technology has forced them to become users of computers and computing products. This is not limited to physical computers alone. Computing extensions or intelligent systems have integrated in all aspects of life. Cars, smartphones, intelligent homes, automated office systems, digital learning systems, digital entertainment tools etc., which were not integrated with everyday life even a couple of decades ago are now a phenomenon that we humans take for granted and often do not even think of it as technology integration in everyday life (Haskell, 2004). This section explores the literature and research on symbiotic relationship between humans and computers, or for that matter, intelligent systems, where the scope is not limited to computers in the traditional sense, but also to digital intelligent systems that are part of people's lives (Rosson & Carroll, 2001).

Life-based design approach and framework: Design as an idea, an art, a philosophy, and a science has been evolving with time in relation to human life. The scientific approach towards Design Thinking has been explored in the previous section. The change in approach from traditional design approach to human-computer interaction design approach has also been explored previously. In this section, the life-based design approach (Leikas, 2009) and its framework has been explored. The fundamental question asked by this thinking is 'what is the problem or challenge that we are trying to solve'? The challenge posed is not an engineering challenge at its crux, but a philosophical question. The designers try to identify the root cause of the need to design a solution. At this stage it does not take into account how the problem will be solved and hence has no biases, technology or otherwise.

Application development using the life-based design approach: Practical application of life-based design approach and its framework are described in this section. A digital tool for decision support in the area of social welfare needs to be created. Ethical Design (Mumford, 1984) and Value-sensitive design (Borning & Muller, 2012) concepts have been considered in tandem with the life-based design approach (Leikas, 2009) while developing the actual solution. The research, its findings, iterations and the result with conclusions is documented in this section.

Conclusions and further research scope: Conclusions drawn from the practical experience of using the life-based design approach are enlisted in this section. Practical implementation of the life-based design approach (Leikas, 2009) is not common because of the relative newness of the theory. The conclusions from this research will provide practical guide for future developers, designers and researcher for further use of the framework. I have also highlighted the pitfalls that I witnessed during the application development process. This will serve as a reminder and alert for future researchers, developers and designers when they are leveraging this framework and approach for further development. Lastly, I have tried to encapsulate the design process and application development methodology that has been used in developing the solution in a simple-to-use-format. Modern technology development which needs a human centric approach, faces severe shortfalls using traditional SDLC models like waterfall (Royce, 1970), prototyping (Brooks, 1975) or agile (Beck, ym., 2001). I have proposed a new model for application development that leverages the simplicity and linear flow of a waterfall model (Royce, 1970), the flexibility of prototyping model (Brooks, 1975) and the agility and speed of the agile model (Beck, ym., 2001) with the Life-based design concept framework (Leikas, 2009). Though computation and technical solution development is an engineering paradigm, it is necessary to keep in mind that the solutions are developed for human usage and consumption. In addition, human beings need these solutions because fundamentally there is a challenge or problem that exists in the form-of-life (Leikas, 2009) they follow. The new model that has been evolved during this process will help the designers and developers to keep the context of form-of-life as proposed by Leikas (2009) as the central theme in their development process. At the same time, it will allow them to follow a SDLC model that leverages known paradigms from traditional engineering approaches in practical solution development.

3 HISTORY OF DESIGN THINKING

Design Thinking is the

> "…application of scientific and engineering knowledge to the solution of technical problems, and then to optimise those solutions within the requirements and constraints set by material, technological, economic, legal, environmental and human-related considerations" (Pah et al., 2007, p. 1).

In this definition, technology is seen more of a restriction. However, as will be seen as we progress with this study, computer technology from a human computer interaction perspective has contributed towards the facilitation of daily life of its users. Nonetheless, since computer science is a dynamic concept with a positive progressive aspect it can be said that restrictions under this definition is referring to those areas whereby computer expertise has still not provided solutions for. The method and process for the solution of technical problems is usually followed by the invention of new technical products or the optimization of already existent products. In addition, new methodologies are bound to arise when one is undergoing the process of Design Thinking.

> "When exploring a problem space, design thinking acquires an intuitive (not fully verbalized) understanding, mainly by observing exemplary use cases or scenarios, as opposed to formulating general hypotheses or theories regarding the problem; and synthesize this knowledge to point of views." (Lindberg, Meinel and Wagner, 2010, p. 5)

Design Thinking, therefore refers to the mental creation of solutions for the improvement of existing products or the creation of new ones. Design Thinking is consequently a way of thinking using creativity in order to solve problems even though there are often a number of restrictions surrounding the problem such as the imposition of certain legal requirements, the limited availability of material and the lack of available finances to support the coming into being of the projected solution (Pahl, et al., 2007).

Design Thinking, however, differs from analytical thinking in that it involves a creative thinking process from the very beginning as opposed to an opinionated process that is a characteristic of analytical thinking. There are various advantages of Design Thinking being a creative thinking process. For instance, the persons responsible for the Design Thinking are not discouraged, but are rather encouraged to work at their maximum effort and input, since the psychological fear of one's failing, are by the very concept of Design Thinking eliminated or considerably reduced. The latter persists, for certain, in the early processes of the prototype and ideation stages. Another positive aspect of Design Thinking is that due to its lack of stress on its creators, psychological well-being is promoted. The people responsible for Design Thinking may consequently think outside the box of traditional concepts and solutions (Pahl et al., 2007).

> "While creativity in design is important, design is an activity that serves economic as well as creative goals. The design process helps ensure that a design satisfies all such considerations. The process seeks to generate a number of possible solutions and utilizes various techniques or mechanisms that encourage participants to think outside the box in pursuit of creative or innovative solutions." (Ambrose & Harris, 2009, p. 10)

There is one main reason why the scope of Design Thinking is to create a new product or otherwise improve an existent product. It is to come up with solutions to cater to the needs of society in general, paying special attention to the market, environmental, social, financial, human knowledge and legal constraints among several other limitations, within which these needs must to be catered for. In line with this, (Brown, 2008) holds that:

> "…innovation is powered by a thorough understanding, through direct observation, of what people want and need in their lives and what they like or dislike about the way particular products are made, packaged, marketed, sold, and supported." (Brown, 2008, p. 86)

Thus, there is a purpose for the innovation, but there is no exact hard and fast rule on how this innovation is to take place. Resultantly, the mental creativity of human beings comes into place, even if it might be based on a framework of already existent data. The history of Design Thinking may be as old as the human civilization itself, however, a systematic approach to engineering design started with the beginning of the industrial era (Wiese & John, 2003) in the nineteenth century. From a modern perspective, Cross (2011) believes that design is very much a part of human life and identity.

> "The evidence from different cultures around the world, and from designs created by children as well as by adults, suggests that everyone is capable of designing. So design thinking is something inherent within human cognition; it is a key part of what makes us human." (Cross, 2011, p. 3)

Until then designing was focused on arts and crafts. Hansen (as cited in Palh et al., 2007) who in the beginning of the 1950s was first to formulate systematic design proposals, which was later revised and turned into a more comprehensive approach by Hansen's published work in 1965 (Hansen, 1965). However, Cross (2011) comments that traditionally design has not perceived as a special skill.

> "To design things is normal for human beings, and 'design' has not always been regarded as something needing special abilities. Design ability used to be somehow a collective or shared ability, and it is only fairly in recent times that the ability to design has become regarded as a kind of exceptional talent." (Cross, 2011, p. 4)

Although, a lot of the activity that had been made use of, for purposes of creativity in the 20th century and even before that, the term Design Thinking was first used in the 1980s. If one looks at the likes of Leonardo Da Vinci one will began to understand that he was a pioneer in problem solving through design, especially since he made use of systematic variations, that enabled him to come up with different solutions (as cited in Pahl et al., 2007). His work will most likely fall under the category of the early Design Thinking, as we know it today. This is so because, Design Thinking really emerged as a means to a solution that enables one, through the origin of a creative idea, to meet the needs of society at large, or of one individual client. In fact, until the industrial period, design was closely linked to arts and crafts. Eventually, design progressed into a science as mechanization, became increasingly more important to society (Pahl et al., 2007).

Nonetheless, the first authors known to actually make reference to the concept of Design Thinking were Herbert A. Simon (Simon, 1996) and Rolf Faste (Faste, 1972). The latter used McKim's work (McKim, 1972) to promote the concept of Design Thinking in his lectures at University. Rolf Faste made a huge effort to define the concept as a humanistic academic discipline. By means of Rolf Faste's (Faste, 1972) teachings, design started to be perceived more as a creative activity carried out by human beings. The term 'Design Thinking' received wide recognition through it use for the first time in academic literature in the writings and research prepared by Peter Rowe (as cited in Buchanan, 1992). Peter Rowe's writing span over two decades and he may be considered as the one who coined the term Design Thinking. During these two decades (1980s-1990s), he became a recognized authority on the subject of Design Thinking. By means of his literature, Peter Rowe used the term 'Design Thinking' in the architectural and urban planning fields, whereby Design Thinking became associated with the need to provide systematic problem solving procedures in these industries. This is how coinage of the term 'Design Thinking' took off with widespread acceptance by a number of professionals and initially by architects (Buchanan, 1992). This concept was then taken to a much larger scale by Buchanan (1992) by means of which Design Thinking became referred to as the tool that provided solutions to different human needs through the creation of design. Modern thinkers seem to move away from a systematic approach and defined steps but look at design. Brown and Wyatt (2010) comment that s spatial approach is necessary rather than a structured step-by-step approach.

> "The design thinking process is best thought of as a system of overlapping spaces rather than a sequence of orderly steps. There are three spaces to keep in mind: inspiration, ideation, and implementation." (Brown & Wyatt, 2010, p, 33)

According to Pahl et al., (2007), David M. Kelley, who, at the time, was also collaborating with Rolf Faste, sold the concept of 'Design Thinking' to the business industry. This is how Design Thinking has become a major business tool that deals with different industries and entrepreneurship needs in today's markets. It is interesting to note that the creativity notion, that is now days linked to Design Thinking was the result of the combined effort of the authorities and individuals that have been briefly discussed above. Brown (2009), of his encounter with Kelley says:

> "David Kelley... said that every time someone came to ask him about design, he found himself inserting the word thinking to explain what it is that designers do. The term Design Thinking stuck." (Brown, 2009, p. 6)

While Design Thinking may be traced back to the early 1980s, it is a quality that is innate in human beings. With time and recognition, Design Thinking has become an ability that is dependent on both skill and professionalism since a Design Thinker must at least be familiar with some basic characteristics and or functions of the intended product. Although creativity is an attribute found in every human being, Design Thinking has become akin to a professional academic discipline and as such carries many responsibilities with it. The lexicon Design Thinking has in itself become a widely used term both in career paths such as mechanical and electronic engineers, software engineers and architects as well as with different types of designers- interior and fashion design (Kossiakoff, Sweet, Seymou, & Biemer, 2010). Design Thinking is taking on the role of a humanistic, academic and scientific status. Authorities, who believe in its importance, aim to promote Design Thinking as a means to educate the thought, as well as its merits in higher levels of the educational spectrum. The main purpose of this educational propaganda of Design Thinking is to teach the human race to think outside of the traditional approach to solving problems, thereby allowing society to give chance to other possible options that serve as solution to a given problem. The end result of this movement, both as an educational and market vehicle, is to provide an added value in the economy, as those who make use of Design Thinking are deemed to have a better advantage over their competitors (Kreitner & Cassidy, 2012).

3.1 Design Thinking as a process for problem solving

In this sub-title, the process of Design Thinking as a process for Problem Solving will be analysed and assessed. It will discuss the main purpose of Design Thinking, which is that of providing a solution to an existent problem. This solution is one that takes place in the mind of the designer and therefore, Design Thinking, is said to provide a creative solution to the problem that is being faced (Plattner, Meinel, & Leifer, 2010). In addition, this sub-section aims to explain the different problems a Design Thinker has to cater to, as the whole process of Design Thinking will in itself pose certain difficulties. These issues must be taken into consideration by the Design Thinker for him to be able to properly fulfil his function, which is that of providing a solution to a given problem. The latter has already been discussed in the previous sub-headings.

This role of the Design Thinker, therefore, imposes on him the need to think for the long-term or better the need, to ensure that the final product has indeed solved the target problem, whilst safeguarding it from causing other major difficulties upon its physical realisation (Plattner et al., 2010). Resultantly, the process of Design Thinking needs to provide an answer both for current as well as for future needs. Two underlying parallel processes need to take place in Design Thinking. The objective of the first process is to see the parameters of the current issues and of any possible future problems. In the second process, Design Thinker is to put forward a solution for both time-frames (Lidwell & Manacsa, 2011). However, contrary to scientific methods, the focus is not on defining the parameters of the problematic area but the primary focus is on the current and future needs of the client or of society-at-large. Defining the extent of the problem and the analysis of optional solutions will then follow. Pahl et al. (2007) hold that as an

> "…essential part of our own problem solving method involves step-by-step analysis and synthesis. In it we proceed from the qualitative to the quantitative, each new step being more concrete than the last." (Pahl et al., 2007, p. 125)

Therefore, Design Thinking is not a simple spontaneous spur of the moment creative action; but in fact, it involves an in-depth profound thought process requiring designers to put forward analyses and synthesis. O'Donovan, Eckert, Clarkson and Browning (2005), have presented a modern take on design being a process.

> "The success or failure of any design process depends crucially on finishing on time and budget. To achieve this, a successful design process is just as important as a high-quality product. The effective and efficient execution of a design project depends on the understanding of the design managers and the quality and utility of their project plans." (O'Donovan et al., 2005, p, 61)

Designers then move forward from a qualitative (better known as the well-researched theoretical approach) to a quantitative approach, which will involve a numerical assessment and eventual implementation by other people down the line. Consequently, Design Thinkers are also responsible for the successful application of their Design Thought even if this is, as usually happens, applied by others (Plattner et al., 2010). The end result of this duty of Design Thinkers is to be forward thinkers, in that they need to take into account other skills and potential limitation to the application of their designs. Resultantly, a degree of mandatory plans and procedures has to be followed.

> "…for the general problem solving process of planning and designing technical products, and as guidance for the more concrete phases of the design process" (Pahl et al., 2007, p. 125).

However, regardless of the fact that the designers follow these mandatory plans and procedures, problematic areas are bound to arise. For instance, a designer decides to add new features to a product and while the feature is operational, it does not add value to the primary scope of the product. Piotrowski (2011) recommends that design process is necessary to help designers address the design solving challenge in an organised manner.

> "The Design process helps the designer move through the complex process of solving a design problem in an organized fashion." (Piotrowski, 2011, p. 30)

According to Haskell (2004), "this situation is known as feature creep and it tends to result in a more confusing user interaction", thereby creating another problem in itself. When problematic issues as these arise, it is clear that the consumer will be at a loss, and in my opinion, the Design Thinking process cannot be held to have been a successful one in these cases, since it creates another problem rather than solving problems attached to the product as best as it can.

> "The product designer must review the individual component specifications to ensure that no unexpected reliability problems are created". (Haskell, 2004, p. 28)

Despite my preceding opinion, if the problem is ancillary to a solution that has been provided to the main scope of the product, then in those cases an improvement has been made and consequently, Design Thinking has been successful as it met its scope, that is, of solving a targeted problem. After all, a well-known practice that designers keep improving upon previous design frameworks and methodologies implies that most designs do not come with a problem free guarantee.

Despite the possible problems that may arise, Design Thinking is seen as a problem solving technique because it is "a process that must be continued until a network of ideas - the design - emerges" according to Erkens (as cited in (Pahl et al., 2007, p. 11) and consequently, a solution is bound to be found. If the cost aspect is unsatisfactory, these factors have to be re-examined in an iterative manner (Matousek, 1957).

> "Thinking again includes several types of processes, e.g. reasoning, problem, solving or decision making. Since design activities are knowledge rich, several kinds of knowledge i.e. of memory representations, are inevitable."(Hacker, 2003, p. 8)

3.2 Conclusion and further reflections

Design Thinking from a historical perspective has been limited to 'arts and craft' as depicted in Figure 2. Emotional gratification was the main cornerstone of Design Thinking.

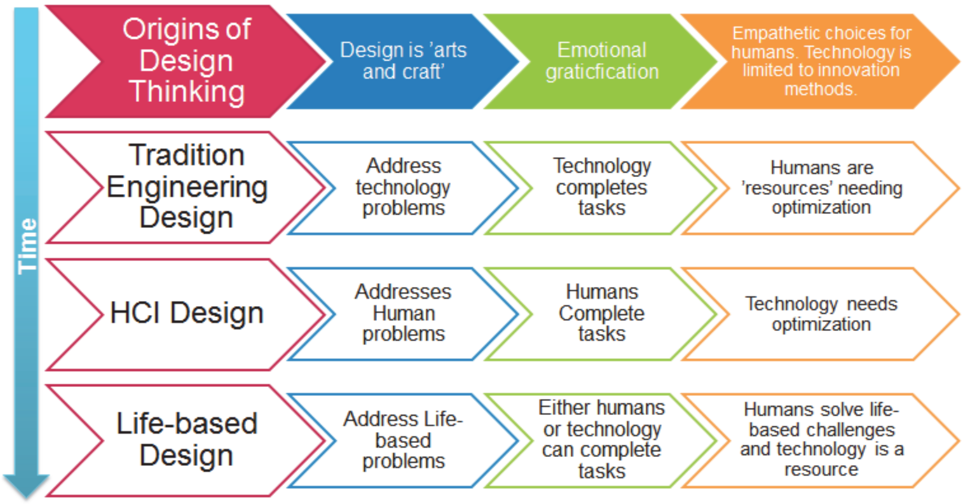


Figure 2: Origins of Design Thinking

Technology played the role of providing tools and methods to practitioners to create their art. In this stage, it is obvious that thinkers have largely ignored the importance of technology as a means by itself towards design. I believe that humans beings, historically have considered design, largely as an emotional gratification aid, rather than a productivity related issue.

Closer to the industrial age, there is a movement seen towards systematic design approach. In the following section, we explore the Traditional Engineering approach towards design. This was the phase during and post industrial revolution, that technology, started playing a more integrated role in human lives (Musson & Robinson, 1969).

4 TRADITIONAL ENGINEERING APPROACH TOWARDS DESIGN

In this part, I have analysed and collated design theories from a traditional perspective, which are engineering thinking driven, to a modern outlook towards addressing the Human-Computer interaction challenges. According to Pahl et al. (2007), systematic engineering design focuses on principles of optimization and efficiency, sufficient strength and stiffness, low wear and tear, minimum use of materials, easy handling and assembly, and maximum rationalisation. However, often these principles have conflicting requirements and a designer is expected to assess the relative importance of each factor in a specific product (Pahl et al., 2007).

Bach and Riedler (as cited in Pahl et al., 2007), made important contributions to the development of engineering design. They put forth that the selection of materials, choice of production methods and provision of adequate strength are of equal importance and that they influence one another. According to Rotscher (as cited in Pahl et al., 2007) a specified purpose, effective load paths, and efficient production and assembly are key elements of design. Thus bending moments should be avoided and shortest paths shall be used to conduct loads and that too with the help of axial forces. This is because longer load paths are not the best design to use, whether from an economic point of view or from a manufacturability perspective, as it often results in wastage of material, considerable changes in shape and resultant cost escalations. The starting point of any design is a set of requirements and some ready-made assemblies, from which, the calculations and layout must be derived. Scale drawings can be helpful in ensuring correct spatial layout and ideally, this should be done as early in the design process as possible. Calculations in the initial stages help to arrive at rough estimates and in the later stages help to verify against the detailed design (Pahl et al., 2007).

According to Laudien (as cited in Pahl et al., 2007), another famous contributor to design theory, advices the following with respect to load paths in machine parts: the parts must be joined in the direction of the load for a rigid connection. On the other hand, parts may be joined along indirect load paths if flexibility is desired. Similarly, he advises against making unnecessary provisions, over-specifications, and over-delivering above requirements, all of which can cause cost escalations. Instead, simplification and economical construction are the hallmarks of a good design (Pahl et al., 2007).

Progress in design was introduced by Erkens (as cited in Pahl et al., 2007) in the early 20s, when modern systematic ideas were introduced and a step-by-step approach to design was advocated. His design philosophy was based on constant testing and evaluation, balancing demands that are often conflicting in nature, to arrive at a network of ideas that lead to the final design. Wogerbauer (as cited in Heymann, 2009) is considered to be the originator of systematic design and he has devised a 'technique of design', where the overall design task is divided into subsidiary tasks which are further divided into implementation and operational tasks. He also gave consideration to the interrelationships between the various constraints that a designer has to address during the design process. However, a systematic detailing of the solutions was not provided by him and the design solution was arrived at in an intuitive manner from a set of solutions, which varied in terms of the basic form, materials and method of production. Once the solution set is arrived at intuitively, they are then filtered out with the help of tests and evaluations. Cost was also an element of consideration and he has provided a very comprehensive list of characteristics that can be used to evaluate solutions and arrive at an optimum solution based on testing and evaluating the results. Heymann (2009) claims that Wogerbauer thought that the existing design process is unsatisfactory. Even though he proposed a scientific approach, he concluded that a process with low levels of creative reasoning is not ideal.

Another major contribution was made by Franke (as cited in Pahl et al., 2007), who came up with a comprehensive structure for transmission systems. This was based on different physical effects of the elements used in the design thus leading to a logical-functional analogy. Thus, physically different solution elements are able to offer functional capabilities though they may differ in their electrical, mechanical and hydraulic effects. In design, it is better to use elements with matching physical characteristics for identical logical functions such as coupling, guiding and separating.

Until World War II, design was considered as an art form and not a technical field of study (Raizman, 2003). Thus, although isolated efforts were made to improve the design process and make it more rational, it was still more intuitive than approach oriented (Dembski, 1999). There was no reliable method to represent abstract ideas which marred the progress of engineering design. However, the post war staff-shortages in the sixties, forced the design community to adopt a systematic approach to design. Pioneers of a systematic approach of design, which evolved in this period, were Kesselring, Tschochner, Niemann, Matousek and Leyer (as cited in Pahl et al., 2007). Even today, engineering design is mostly based on their approach towards handling the various phases of systematic design.

Kesselring (as cited in Pahl et al., 2007) suggested the method of successive approximations by evaluating form variants based on economic and technical parameters. He also suggested five key principles for good design:

- "the principle of minimum production costs
- the principle of minimum space requirement
- the principle of minimum weight
- the principle of minimum losses
- the principle of optimum handling." (Pahl et al., 2007, p. 12)

Form design is concerned with the design and optimization of the technical artefacts and the individual parts; mainly governed by physical and economic considerations. The output of form design is the shape of the product, the dimensions of the various components and sub-systems, as well as the choice of materials and production methods. Mathematical methods may be deployed for identifying the best solution among a set of options. Pahl et al., (2007) maintain that, Tschochner was yet another designer who made significant contributions to design history. He refers to the working principle, the material, the form and the size as the four fundamental design principles. These four factors are interconnected to each other and designers would typically start from the working principle and then determine the material, size and form of the product. After the Second World War, the shortage of resources created propelled ground breaking work in Design Thinking by designers like Tschochner (Birkhofer, 2011).

The design process as described by Niemann (as cited in Pahl et al., 2007), one of the pioneers of systematic design, starts with a scale layout of the overall design which captured the spatial layout and the main dimensions of the design. This overall design is then broken down into subparts each of which is designed in parallel. The task definition leads to a systematic development of various possible solutions from which an optimal solution is selected based on a formal and critical selection method. During his period, there were no formal methods to arrive at a new solution and he had highlighted this in his works (Pahl et al., 2007).

Leyer, (as cited in Pahl et al., 2007) is mainly concerned with form design, for which he develops fundamental guidelines and principles. He distinguishes three main design phases. The first phase involves laying down the working principle with the help of already established facts or ideas; the second phase involves actual embodiment design and the third phase is the manufacturing of the design. In the second phase, layout and form design is arrived at, based on mathematical calculations and design principles such as the principle of shortest load paths, the principle of constant wall thickness, and the principle of homogeneity. Leyer (as cited in Heymann, 2009) was a proponent of the thought process that Design was as art process and not a science. He allowed that though the scientific approach can help the art process, it cannot act as an substitute for the art process.

> "In Leyer's opinion the main problem was the overestimation of science. He believed that the fascination of science had seduced 'whole generations of young engineers. The result of this fascination produced in his eyes a degeneration and decline of engineering design." (Heymann, 2009, p. 238)

These preliminary attempts made way for the intensive development of methods, mainly by university professors who had learnt the fundamentals of design by designing technical products of increasing complexity in industry, before becoming professors. This was also necessitated by the growing division of labour, which demanded that systematic methods be used for design, based on principles of information theory, power transmission, mathematics, electromechanical engineering and physics (Pahl et al., 2007).

Hansen's design methodology (as cited in Pahl et al., 2007) starts with an analysis and specification of the task, which leads to the basic principle of the design. The basic principle encompasses the overall function that has been derived from the task, the prevailing conditions, as well as the required measures. The overall goal and the context define the task-at-hand along with any constraints noted. The second working step is a systematic search for solution elements and their combination into working means and working principles. The third step where shortcomings are analysed with respect to their properties, quality characteristics and improvements made, is considered crucial. The fourth step is the selection of the solution with the fewest challenges and limitations. The fifth and the final step is the that these improved working means are evaluated to determine the optimum working means for the task and creating the documentation necessary. Ridgway, Todd and Wilday (1996) observe that the risk assessment of design during the Traditional Design phase of Design Thinking was carried out rather late in the design process.

> "The review of design methodologies indicated that risk assessment is generally applied in the later stages on the design process. Unfortunately risk assessment applied at this stage has little impact on the design concept. Problems can only be addresses through small design changes or the addition of alarms and guards." (Ridgway et al., 1996, p. 141)

Another proponent of systematic design was Rodenacker (as cited in Pahl et al., 2007) whose approach to design is based on developing the logical, physical and embodiment relationships in a sequential manner. His approach is focused on identifying and correcting any failures, as early as possible during the formulation of the design; the adoption of a general selection strategy from simple to complex; and the evaluation of all parameters of the technical system against the criteria quantity, quality and cost. He also emphasises binary logic based function structures and conceptual design based on the principle that product optimization can only happen after a solution principle has been accepted (Pahl et al., 2007). The systematic design methods of Leyer, Hansen, Rodenacker and Wachtler (as cited in Pahl et al., 2007) are still being applied today, as they are integrated into the more recent developments in design methodology.

4.1 Software Development Lifecycle Models (SDLC)

For developing software solutions, a framework is necessary for the various actors in the process to know their roles and follow a pattern in order to reach the ultimate target of creating a solution. In other words, it means a framework of methodologies, tasks, deliverables and roles is needed. The methodologies help the progression of the development all the way from idea stage, initial pilots, development, testing, deployment, post deployment, documentation and enhancements. Not only is SDLC required for new system development but also for enhancements or renewal of systems. Even minor corrections or modifications need a framework. With technology driving automation even in the tools and process of software development, it is even more necessary to have a definitive model to follow during the process.

The main reasons for using SDLC can be described as (Agarwal & Tayal, 2007):

- Create and understand the process overview
- Structured approach towards creating the solution
- Advance resource planning
- Controlling the resources in the process
- Track and manage the process

Over the years, various models have been developed to formulate the SDLC. In addition, with time they have been changing and adapting to the needs for the actors, the technology, the tools, the results, the challenges etc. In the following subsections, I have briefly described the most popular models.

4.1.1 Waterfall Model

The oldest and the most commonly used model until recent times has been the waterfall model as depicted in Figure 3. This appears in Royce's paper in 1970 (Royce, 1970). The cascading structure of the process, where the output of the previous phase becomes the input of the following phase, creates a waterfall like structure. Though this is a linear structured model, actors in each phase can be working in tandem and concurrently.

The waterfall model has certain shortcomings and has gathered criticism for being too simple and linear; which is also its strength. The following are some of the challenges of this model. Defining all possible requirements from a functional perspective from the beginning is difficult. Changes become difficult to accommodate. Large projects are difficult to be handled with this model. Users' needs are difficult to identify. Clear and obvious risk analysis phase does not exist. Heavy documentation is needed for the waterfall model.

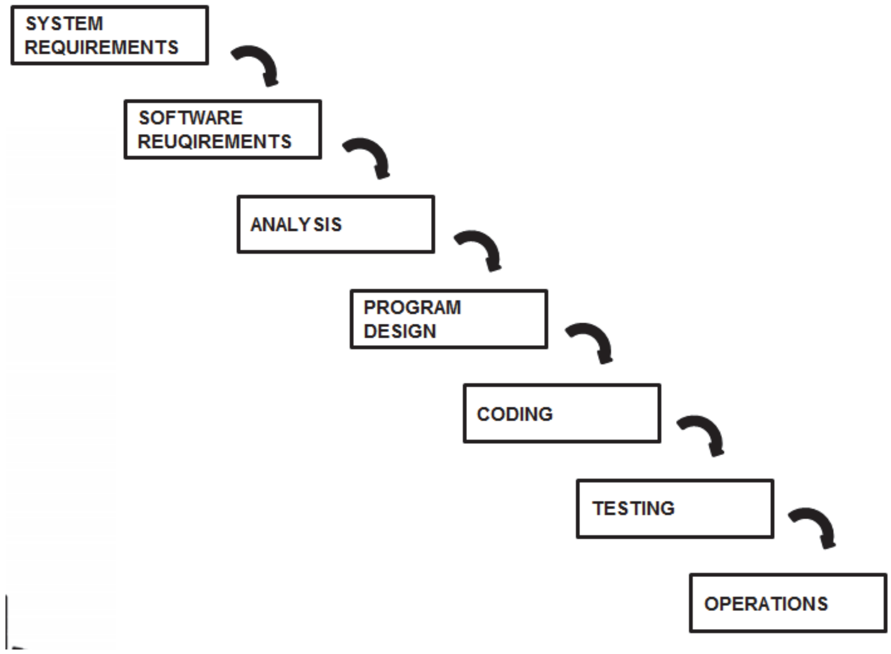


Figure 3: Unmodified waterfall model (Royce, 1970, p. 328)

4.1.2 Spiral Lifecycle Model

This model is derived from the waterfall model and learning from working on large and complex software projects in the government sector (Schwalbe, 2010). The radial dimension of the cycle, as depicted in Figure 4, represents the costs accumulated and the angular dimension represents the progress made in completing each cycle of the spiral (Agarwal & Tayal, 2007). This model takes into account that in a software development process there are a lot of iterations and a spiral approach is necessary (Schwalbe, 2010).

The model that Boehm (1995) presented also comes with its own limitations and challenges. It starts with the fact that there is no clear starting point or ending point in the cycle. It also lacks explicit process guidance in determining objectives, constraints, alternatives, relying on risk assessment expertise and excessive flexibility (Agarwal & Tayal, 2007).

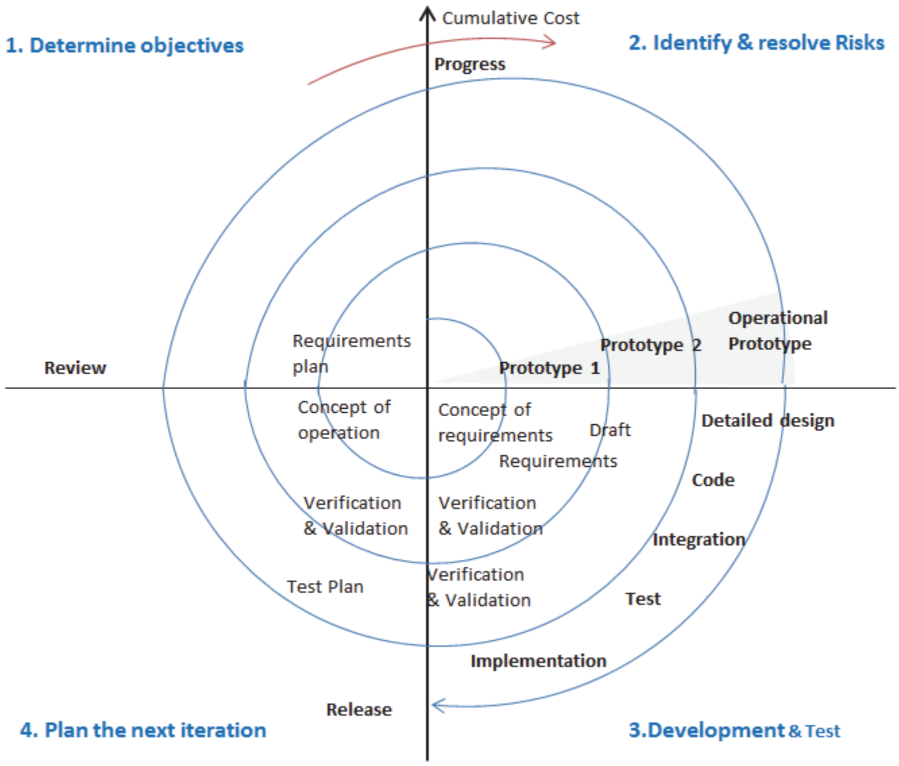


Figure 4: Spiral model (Boehm, 1995, p. 25)

4.1.3 Prototyping model

Prototypes are built in this model for clarifying the user requirements as depicted in Figure 5. In this process, the users are heavily involved in validating the fulfilment of requirements as a feedback mechanism to the developers. The developers are not dependent only on the written description of the requirements. The reference to this model first appear in the book Mythical Man-Month: essays on software engineering (Brooks, 1975).

A high development cost is one of the major disadvantages of the prototyping model. The process does not generate predictable results. It also tends to become a time consuming process. Developers also complain of loss of rhythm because of frequent knee-jerk changes (Schwalbe, 2010).

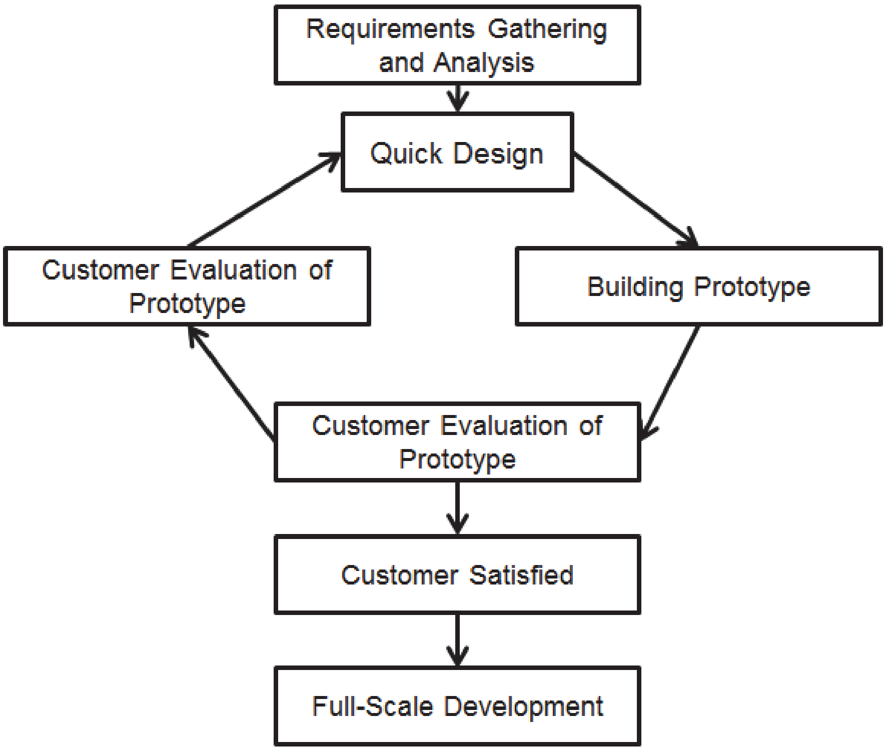


Figure 5: Prototyping Model (Kan, 2003, p. 20)

4.1.4 Agile Model

There are multiple variations of these process that are developed and used in the software industry. All these are predictive lifecycle models since the scope, budget, effort, schedule can be predicted (Schwalbe, 2010). Agile software development as a terminology was introduced in 2001 in The Agile Manifesto (Beck et al., 2001). It is a framework using adaptive planning, as depicted in Figure 6, evolutionary development and delivery, a time-boxed iterative approach, and encouraging rapid and flexible response to change (Larman, 2004).

The agile model is more developer and development centric rather than user centric. It is a model focused on getting the requirements and developing the code and not on the design of the solution. User experience is not a critical consideration in this methodology. Gualtieri (2011) writes his criticism stating that software developers are not coders, but experience creators. Agile methodologies are difficult to adapt to large mission critical systems and it is common to see organisations adopting a hybrid approach that is a combination of predictive and agile methods.

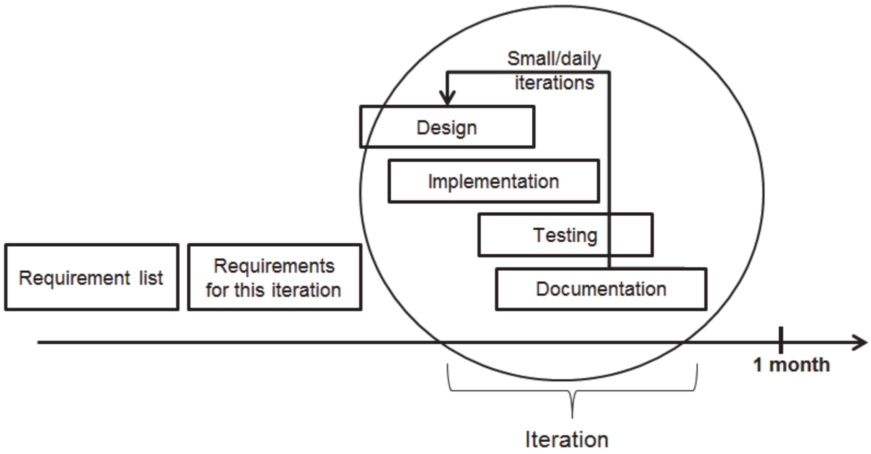


Figure 6: First Iteration in an Agile Development Process (Kontio, 2008, p. 3)

The software development methodologies and the Design Thinking processes need to be combined, in order to have a relevant model in today's age. The limitations both the development methodologies need to be addressed (Selby, 2007). A model that works *with the users, for the users and by the users'* needs to be created.

4.2 Development of Ergonomics and its definition

As new disciplines such as artificial intelligence, biotechnology, knowledge mining and neuro-linguistic-programming develop and progress, they make valuable contributions to the field of ergonomics, which is truly a multi-disciplinary field of study. In fact, one cannot derive true value from ergonomics if we limit the field of study to a narrow definition and specialization (Tullis & Albert, 2008), since it refer to various fields such as cognitive ergonomics, rehabilitation ergonomics, forensic ergonomics, physical ergonomics, and social ergonomics. While this kind of classification would help in explaining the field of study to clients and funding bodies, it is not useful to think of ergonomics in such a compartmental form while actually designing products. This is because if a parochial view is taken for this multi-disciplinary field then the true strengths and holistic nature of this field cannot be utilized effectively (Smith, Koubek, Salvendy, & Harris, 2001). To be truly useful, it is essential that ergonomics take a holistic view of all aspects of people's interaction with their environments and the interrelationships between these interactions. Although there are many definitions of Ergonomics, the definition proposed by Wilson (2002) in his paper *Repositioning Ergonomics* comes across as the most relevant one.

> "Ergonomics is the theoretical and fundamental understanding of human behaviour and performance in purposeful interactive sociotechnical systems, and the application of that understanding to design interactions in the context of real settings." (Wilson, 2000, p. 560).

Ergonomics as an emerging field helps to understand modern problems and find modern methods of solving them. Ergonomic models highlight the interactions between people and their environments and how the products that they use, can aid in the interaction and improve the quality of that interaction. Ergonomics is focused on human centred redesign of interfaces, equipment, workspaces, physical and virtual products (Salvendy, 2012). Thus, ergonomists typically have tools and frameworks to measure interactions and suggest improvements based on a wide variety of disciplines, which all contribute to the knowledge base of ergonomics.

In some cases, customers are wary of ergonomic designs. For example, gardening tool manufacturers focused on ergonomic design to bring out equipment, which prevented backaches and sore tendons. The older generation consumers, who would have clearly benefitted from these innovations, treated them with scepticism. This shows that ergonomic design alone cannot ensure a product's success in the marketplace. Good ergonomic designs have to be supported with the right amount of marketing for customers to start accepting the product. Today products that are marketed as 'ergonomically designed' do not succeed as much as the ones which are marketed based on their ability to make the customer's lives easier (Konz & Johnson, 2004).

In any product group, where cheap alternatives at lower costs pose stiff competition, ergonomic designs can prove to be a competitive advantage (Carayon, 2006). Ergonomic tools are developed by product engineers, when the focus shifts from minimizing the cost of production to maximizing the productivity of the tools. This is done by minimizing user fatigue and discomfort while using the tool. In the initial days of ergonomic design, manufacturers took products to market, by promoting their ability to reduce strain. However, this was not a success among consumers who were not willing to pay extra for ease-of-use of the tools.

Customers were more open to the idea of ergonomic designs when such products were marketed for the task that they were intended to do and on demonstrating how such tasks could be done better – either through time savings or through better execution of the task. Manufacturers of ergonomic designs therefore need to focus not just on form, but also on function (Salvendy, 2012). All ergonomically designed products also need to be backed with savvy marketing for achieving commercial success (Jacobs, 2008). For example, Apple Inc. is a case in point where the company focuses not only on the design of the products, but also on designing the signature retail stores through which the products are sold.

Apart from ergonomic design, the other key aspects of human oriented design include, compact design (with increase in storage problems, customers are looking for products that are easy to store), time-saving design (as people lead busy lives and are hard pressed for time) and products that aid in maintaining things/ideas in an organized manner (Benyon, Turner, & Turner, 2005). Thus whether it is a physical product or a virtual product, or one that uses both elements, it is essential that both the form and the features of the product are designed, keeping in mind usability and interoperability.

Today, humans are considered as users of technology who need to complete tasks and achieve certain goals. Thus, they are able to operate machines or technologies in a smooth and goal oriented way, with efficiency and accuracy. Today human factors and ergonomics have become central themes of design philosophy (Salvendy, 2012) and are no longer considered as an afterthought that needs to be incorporated after optimizing the cost factors and product assembly. According to Meister (1999), an ideal design is one which seeks to maximise safety, efficiency and comfort by shaping the design and operation of the technology to the physical and technological capabilities; and the social needs of the user.

4.3 Design Process and comparison of approaches

Dr. Nam P. Suh, (Suh Nam, 1990) considers the design process to be a spiral. He defines design as follows:

> "Design, as the epitome of the goal of engineering, facilitates the creation of new products, processes, software, systems, and organizations through which engineering contributes to society by satisfying its needs and aspirations." (Suh Nam, 1990, p. 5)

Design is an iterative process, which evolves from a need, to requirements to design. In each phase of the process there will be assumptions that are made, verified and either accepted or rejected. Traditional design can be thought of as sequential engineering where a product is designed to meet customer's need and evaluated for its manufacturability. Once the manufacturing process is designed, the design is evaluated to verify how easy it is to maintain the product. Problems with manufacturability or maintainability of the product are referred back to the designers for resolution. Human factors and ergonomics are not top most priority in this method and users are rarely a part of the design process.

4.3.1 Concurrent Design

In the concurrent engineering approach, design, manufacturing and support processes are designed simultaneously; manufacturing and support influence the design at a very early phase. This is a fairly new approach to design and was influenced by the Japanese manufacturing practices which take only half as much time as US companies to deliver products such as aircraft and automobiles (Charles Stark Draper Laboratory, 1989). It was noted that the Japanese practice of simultaneous design of the product as well as all its life cycle processes made it easier to shorten the product development cycle. Concurrent engineering can be defined as:

> "Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements." (Winner, Bertrand, & Slusarczuk, 1988, p. 28)

Different types of design will have varying amounts of innovation involved in the process. Based on this, designs can be classified into original design, adaptive design or variant design. The term original design is also used when existing or slightly changed tasks are solved using new solution principles. Original designs typically have a high amount of innovation involved and thus would require effort to be spent on each phase of the design process. The task-at-hand needs to be analysed both technically and for economic feasibility, before arriving at a design based on the physical and process fundamentals. Original design process can be followed for an entire product or in some cases only for specific components or parts or sub-systems of the product.

Finger, Konda, and Subrahmani (1995) argue that concurrent engineering needs to be looked outside its traditional perspective. Traditionally, from a technical perspective, it is a problem that can be solved by creating and integrating computer based solutions and tools. From an organisation perspective, it is a problem that can be solved by either creating a team of designers or reorganising them. In practical situations, concurrent engineering requires both technical and organizational solutions, which results in to concurrent design (Finger, Konda, & Subrahmani, 1995).

> "Concurrent design is the myriad of interactions that occur at the interfaces among all of the members of a design team and all their tools. Solving either the technical or organizational problems by assuming away the interactions will not solve the problems of concurrent design." (Finger, Konda, & Subrahmani, 1995, p.89)

4.3.2 Adaptive design

Adaptive design does not make use of new solution principles for solving problems. Instead, the tried and tested solution principles are adhered to and only the embodiment design is tweaked to meet the requirements. Sometimes, a combination of original design and adaptive design is used for designing a product with some components being designed using original designs, while others rely on adaptive design. The emphasis on adaptive design is not on the conceptual design, but on the manufacturability and usability of the product. Thus geometrical issues such as strength, stiffness, materials to be used etc. are of primary concern in adaptive design. Adaptive design is interpreted differently in modern times where technology helps in adaptation iterations based on previous learning automatically and not necessarily is a design function. This section should not be confused with the views in modern times especially in terms of clinical and pharmaceutical research or computer aided research. However, the modern definitions of adaptive design has its root in the original adaptive design thinking.

> "An adaptive design is an experimental design that chooses future point of experimentation based, wholly or in part, on responses observed in previous points of experimentation." (Rosenberg, 1995, p. 4)

Pahl et al. (2007), state that in adaptive design, there is no change in the principal of the solution. New requirements or constraints lead to adaptation of the embodiment. The innovation does not happen with the fundamental idea, but in the reapplication of the ideas during the adaptation of the existing solution. The general structure of the solution or the products does not undergo a paradigm change, but the analysis can lead to new features or modifications of existing ones. A requirement change or modification leads to the modification of the functional structures by variations, additions and or omissions of the individual sub functions. This can also happen with the change in the way or the sequence of their combination (Pahl et al., 2007).

4.3.3 Variant Design

In variant design, the amount of innovation is minimal. The fundamental design of the product structure is retained and only the size or placement of the sub-systems and components are changed to meet some specific requirement.

> "Variant design involves a change of scale or dimension or detailing without the change of function or the method of achieving it: the scaling up of boilers, or of pressure vessels, or of turbine for instance." (Ashby, 2005, p. 16)

Thus, this type of design is typically easier than original design and adaptive design. In variant design, the function or the method is not changed, but scope or dimension of detailing undergoes a change (Pahl et al., 2007). Fowler (1996) states that variant design supports the use and minor modification of an existing design specification, in order to adapt it in creating of a new variation of the original specification. Both automatic and manual retrieval mechanisms can be used for identification of similar designs. Basis of selection and identification can be dependent on various specifications, like the functionality needs. To adapt the design, various methodologies can be used once an existing design specification is found. The design goals and constraints define the level of sophistication needed to adapt the design and can be anything between manual to automatic modification (Fowler, 1996).

> "One can expect that a system capable of automatically adapting a (known) design specification successfully will utilize underlying representations which also enable sophisticated design retrieval strategies. Conversely, a system that provides rudimentary design retrieval based on manual review is unlikely to provide design adaptation capabilities beyond manual parametric modification. Near-term

> capabilities in design systems lie somewhere in between these two extremes". (Fowler, 1996, p. 1)

Computers or technology in the future may be able to automate the evolution of design much more automatically than it can do so today. Today, designer and solution creators are able to create variations and adapt design paradigms and create new variants using digital tools. There are also times when it is a pure manual process with little or no automation. The design process itself has undergone a change with the availability of new tools that are able to speed up the process, but the basics of the design process have not undergone a paradigm shift. The basic elements remain the same (Fowler, 1996).

> "The fact that designers will need to redesign existing designs, or use existing designs as the basis for a new design, or gain insights from the knowledge captured in an existing design, has not changed - nor is it likely that it ever will." (Fowler, 1996, p. 13)

There are similarities in the adaptive design process and the variant design process. In adaptive design, the solution principle remains unchanged; the embodiment is adapted to new requirements and constraints. While in variant design, the sizes and arrangements of parts and assemblies are varied within the limits set by previously designed product structures (Pahl et al., 2007).

4.3.4 Main Phases of Design Process

The Design Process involves a number of plans and procedures. Hence, more than one process could be applied to a design of a product. This section will also draw a comparison of the different approaches used.

It is the designers' role, to make the choice that leads to the best solution. While these plans and procedures may present to the designer with a backbone structure of what can be done, it is the designer who chooses which part of the plan and which procedures to adopt. Ultimately, the plan and procedures that are to be used to solve a particular problem need to be tailored to fit the needs of the situation. Therefore, plans and procedures are merely guidelines that help to explain to the common man, students of design and professionals at large, what a Design Process should involve as proposed by Eversheim and Muller (as cited Pahl et al., 2007). If designers do not adopt a plan for the design process, they will be faced with myriad of unthinkable approaches and solutions.

> "In searching for design solutions you should not look at the object but at the process. Designers should use a paradoxical way of seeing turned in to a way of knowing, of seeing the problem and its environment context." (van der Merwe, 2002, p. 15)

Since the plans and procedures applied by designers are unique to them and are dependent on the end product solution that needs to be created, no single book or author can really describe the mental process of each design thinker (Haskell, 2004). Because a number of disciplines are involved, Design, or namely, the thought-planning process is merely the first step of the design process even if project owners generally commission the project. Afterwards, other individual experts come into play to implement the plan and design, as invented by Designers. Because other disciplines are involved, it is the objective of a design process to also make plans for the input stage of these other professionals (Haskell, 2004).

However, in Design Thinking, one can say that there are some common stages of the workflow process, which are applicable to every product (Pahl et al., 2007). It is a fundamental requirement that designers take a step–by–step approach, which allows room for analysis and eventual creation of the design. Sydenham (2004) explains that iterations are necessary for design to proceed and it cannot happen in a mechanical manner in predetermined steps alone. Analysing the pros and cons at each step is required to go through the iterations (Sydenham, 2004). This gradual approach allows designers to go from qualitative to the quantitative investigation.

Hansen and Bischoff (as cited in Pahl, et al., 2007), defined the design development process as one that needs to follow a four step pattern. The analysis and specification of tasks critique, the matching of solutions to working principles using a systematic approach, the assessment of possible drawbacks in relation to characteristics of the solutions and working principles and lastly, the putting together of the decisions taken in the previous three stages which ultimately lead to an optimized solution using the best developmental design process. Pahl et al. (2007), summarizes the design development process on a similar line to Hansen and Bischoff- It has become common practice due to its usefulness to segregate the design and planning process in the following stages: Task Clarification; Conceptual Design; Embodiment Design and Detail Design. Hales and Gooch (2004) in Figure 7 have explored the same thought in visual format.

Hales and Gooch (2004) propose that the market analysis and the problem analysis activities come before the conceptual design phase and are part of the task clarification phase. Alternative solutions are developed in the conceptual design phase, while testing and development combined with designing for function, safety manufacturing etc., are part of the embodiment phase. In the detailed design phase, component and manufacturing assembly takes place followed by testing and quality assurance before the actual usage of the product by the users. Following actual use and learning from it, either the products can be revaluated for further development going back to the Task clarification phase or then they could be retired, recycled or scrapped.

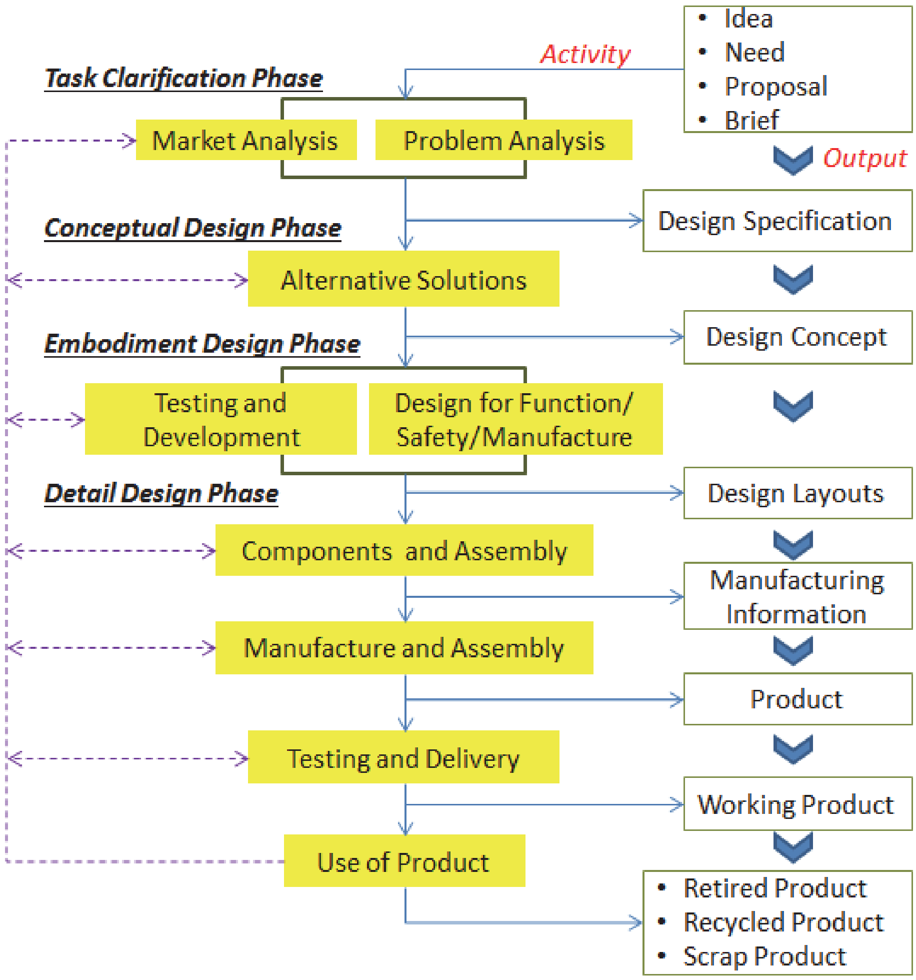


Figure 7: Schematic of basic design and manufacturing process (Hales & Gooch, 2004, p. 19)

4.3.4.1 Task Clarification

Task Clarification involves the determination of specific information and as such, this first part of the process calls for the identification and formulation of what constitute the general and specific assignments. Over and above, these tasks need to be assessed in the light of limitations that may be faced throughout the process and that are individual to that particular design project. Together with the task and constraints analysis, this stage also involves the drawing up of a list of requirements. Lately, Sakao et al., (2011) put forward that task clarification has strong influence on the cost and can be managed with rather small investments up-front.

> "Looking at fundamental insights from conventional engineering, revisiting the well-known relation between the cost and influence of each lifecycle phase (or stage) can be a research issue. E.g. a rule, 'the task clarification stage of product design accounts for only 10-15% but determines 50-70%' of the total cost is well known." (Sakao et al., 2011, p. 31)

It is not important what is the origin of the task allocation. It can come from the product planning process or as a part of a customer specific requirement. The next phase, conceptual design is based on the requirement list generated from the task clarification phase. In order to currently understand the requirements and create a requirement list, it is necessary for the designers to understand the customer needs and the market needs. Pahl et al. (2007), recommend the following questions to be answered during this phase for gathering the requirements:

> "What is the problem really about? Which implicit wishes and expectations are involved? Do the specified constraints actually exist? What paths are open for development?" (Pahl et al., 2007, p. 150)

By answering the above question, Pahl et al. (2007) recommend that implicit requirements that are not mentioned clearly by the customers but are expected by them be addressed. The main requirements in form of product features normally come from an agreement or contract made with the customer for product development and are relatively clear and explicit. The expectations that are not explicit but implicit are the ones that need to be addressed and listed carefully. This delta of explicit and implicit requirements also comes from the type of customer. There are two types of customers:

> "**Anonymous customers:** these include a particular market segment, those identified by the sales department without a customer order, and those identified by the product planning department.
>
> **Specific customers:** these not only include individual customers who place an order, but also market segments that are served by many companies with similar products in which requirements have become standardised, e.g. those for "compact cars" and "family cars". Although the actual customers in such cases are anonymous, they can, in effect, be treated as specific customers." (Pahl et al., 2007, p. 150)

The requirement lists that are the outcome of the task clarification phase need to be clear, complete and binding. It is acceptable to have them provisional initially, since they are bound to change and be modified during the design process (Pahl et al., 2007).

4.3.4.2 Conceptual Design

In the Conceptual Design stage of the design process, the principle or core-concept of the solution is established. In order to put forward an adequate solution, the designer needs to understand what the main and most challenging problems are. In the conceptual design stage, the designer cannot simply stop at categorizing the problems that might be encountered. Indeed, at this stage the designer will need to determine the function set-ups while brainstorming and eventually determining the working principles.

> "…designers can gain insights into understanding of the design problem and the solutions generated with an increasing emphasis on the product life cycle performance. Reasoning using context knowledge can further assist designers to concentrate on exploring design alternatives and generate more innovative design solutions thus reducing/eliminating the chances of redesign by considering manufacturing implications and increased costs earlier at the concept design stage due to the selection of a particular solution." (Yan & Rehman, 2008, p. 21)

The latter will then need to be combined with the function structures. Once satisfied according to their professional judgment that the working principles to be adopted fit well with the function structures as established previously, the principle solution concept would have emerged. Should, designers not be satisfied with the link between the function structure and the working principle, the designers will need to select, remove and replace different selections until he is satisfied that the solution concept will meet the requirements of the project (Pahl et al., 2007).

Haskell (2004) also speaks on the same line as Pahl et al. (2007), but makes reference to this stage as the development of the system architecture. However, like Pahl et al. (2007), Haskell (2004) maintains that system components need to be chosen and they constitute the system specifications.

> "…trade-off analysis is performed to determine the optimal combination of components and system partitioning for meeting the product specifications" (Haskell, 2004, p. 3).

The ability of designers to carry out the trade-off analysis as promptly and efficiently as they can is held by Haskell (2004, p. 3) as "*essential to effective portable electronic product design*" because it is this process that determines whether an optimal solution has been reached. The needs of the project can be assumed to have been met when: (a) the problem areas are adequately tackled and (b) the object of the design project can be achieved without having to face any further obstacles.

4.3.4.3 Embodiment Design

As the term itself suggests, the embodiment design phase involves that part of the design process whereby the body of the design is discussed. Specifics of the layout and the layout itself thus form a core function of the Embodiment Design stage. It is on the basis and measures predicted by the layout that the actual construction of the design would take place (Pahl et al., 2007). In the embodiment design stage, the Design Thinking starts taking shape in such a way that third parties not being part of the Design Thinking process can actually have a view and enables them to visualize the idea for the first time on basis of the layout provided.

> "A more detailed analysis of the selected concept(s) is undertaken in the embodiment stage of the design process. Subjects covered include form design, design for manufacture and assembly, materials and process selection and industrial design." (Hurst, 1999, p. 69)

The guiding tool of this step is that of the solution concept that was arrived at under the Conceptual Design stage and one can consequently appreciate the implications and the importance of the latter stage in the design process as being the turning point that leads to the finalized product. Resultantly, functionality requirements specified in the conceptual design stage are broken down one by one to enable the designer to come up with a technical layout of the intended product. Implementation of the cost budget plan also assumes importance in this step as well as in step two above.

It is ideal that the designer keeps the lay out solution as simple as possible as this will in turn lay-down and be a pointer to the working principles that need to be adopted (Pahl et al., 2007). The working principles have been catered for, in the previous stages. It is also possible for these to change at the embodiment stage; especially since it is at this stage that the designer can clearly visualize and determine the constructions structures and their stability or otherwise, for the overall structure. The ability of designers to change the working principles of the design at this stage as well as to ensure the division of activities, aids in the overall reduction of risks and mitigates the possibility of wasting of time that tend to arise from failure to plan properly.

During this stage Pahl et al. (2007), recommend that designers take the opportunity to minimize the number of forms that are possible to lead to the desired final product, opt for comparable forms and contours as well as adjust lines accordingly. Certain working principles such as those of safety, durability and reliability of the design should always be on the mind of the designers.

Once designers define the system architecture and the circuit design, the physical aspect of the design may start. This latter stage requires the involvement of engineers and designers and may be quite costly, but it is an indispensable investment, which eventually leads to the manufacturing of the intended physical product, which is then marketed and made ready to sell to a specified market sector. The physical design impinges on designers an in-depth knowledge of how the manufacturing process works and this includes the designers' familiarity with restrictions and limitations of this process. Having this knowledge is considered a discipline which ensures the successful manufacturing of the product at the lowest cost possible (Haskell, 2004).

4.3.4.4 Detail Design

The detail designs deals with specification of the production phase. Again, the application of a systematic approach is also important in this stage of the design process. This part of the design process requires a systematic approach, skilled project management and teamwork between different professionals. The latter ensures that decisions made by designers are the result of a combined skilled approach assessment, which is able to cover the prerequisites of the project

(Pahl et al., 2007). The design review carried out by different teams of experts is another example of the systematic approach and comes into play towards the end of the design development stages, although not necessarily all of them. The main objective of the design review is to check the results achieved and the assessment of the design development progress, according to Regius (as cited in Pahl et al., 2007). Although there are many reasons for a design failure, Gullo (2012) states that lack of review of robust review sub-process is an inherent design process weakness. It is with these reviews that risks of failure or malfunctions can be identified early on in the design developmental process.

Pahl et al. (2007) guide that, a detailed design reflects all the stages of the design process in more detail. However, the earlier phases of the design developmental process should have already taken care of the details of the design. Ultimately, these phases deal with quality of the product. Among the details of the design, one can find the need of fulfilling the technical functions, safety and usage considerations, ergonomics details and an assessment of the production and cost of operation. Failure to take into account these aspects of the production of the product, both the design and production's quality may suffer. Failure to achieve the intended result is generally due to improper design development planning and leaving out crucial stages of planning, development, production or marketing of the product (Pahl, et al., 2007). This stage is highly dependent on the Design Thinking process and the quality of teamwork interaction.

According to Pahl et al. (2007), the detail design phase of the product design development

> "…brings together expert knowledge, ensures continuous consideration of customer requirements and, in particular, provides short and direct information transfer paths. The latter ensure an iterative and continuous coordination of the design activity." (Pahl et al., 2007, p. 517)

Why is the detail design stage so important? It is important because, being an assembly stage it brings together all the design development stages and adds value to it, by paying a lot of attention to details, foresees gaps and problematic areas at different stages. At testing and distribution stage, it ensures that the whole process is aligned with the standards laid down for the concerned area of expertise including legal requirements. This in return helps reduce costs; makes the whole process more time-efficient; ensures a good product quality and helps prevent failure of the whole design process (Pahl et al., 2007). By making use of the systematic design method, the quality of the product is assured. The same may apply in fields other than traditional engineering, for example in educational technology.

> "Systematic approaches to the design of instruction promise to ensure quality." (Hackbarth, 1996, p. 30)

In addition, applying this simple to follow and established work design ethic, considerably reduces confusion, thereby facilitating the understanding of the tasks between different teams. This approach generally makes up for extensive analysis and testing, nevertheless organizations have come up with additional quality checks over and above this systematic approach. These additional quality checks take the shape of computer-based assistant kits, which have been developed by designers with the scope of assisting in the issuance of quality products while maintain project expenses at bay. These computer based design packages have assumed particular importance in predicting the life cycle of components and machinery as well as providing designers with a picture on risk faced, as well as a contribution to the overall technical system of the design development (Pahl et al., 2007).

4.4 Virtual Products and Spaces

As mechanical products gave way to electronic products, which had hardware and software elements, the design philosophy underwent a paradigm shift. Users started interacting with machines in multiple ways, and computer systems began pervading day-to-day life. The initial design philosophy in computers, considered it as being composed of hardware and software, where hardware design was focused on traditional design principles of mechanical engineering and expert users designed software only for complex mathematical calculations (Aksoy & DeNardis, 2007). However, as computer systems and software evolved, the design philosophy started incorporating the inputs of users in each phase of the design, so as to come up with products that were not just 'useful' but were also 'usable'.

Traditional software engineering did not have a user centred design approach. It was considered as an independent process with sequential transition from one phase to another. Later, this waterfall model (Royce, 1970) was modified to an iterative model where information is fed from one phase to the other and there are multiple iterations of each stage. User centred interface design evolved from the iterative model and is focused on the involvement of the users throughout every phase of the design life cycle. There can be various ways to achieve user centred design. Inputs can be obtained by observing users' work practices to having user representatives during the design, testing and development phases (Stone, Jarrett, Woodroffe, & Minocha, 2005).

There are several challenges in involving users in the design process. For example, design engineers would aim for cost effective solutions. Trade unions would want the manufacturing process to be safe and reliable and end users would want ease and efficiency of use. A software engineer, for example, may provide advice about optimal configurations of computer system architecture and the performance of the software. A graphic designer focuses on the visual appeal of the user interface and the graphics and icons used for various situations. Jones (1992) in his book "Design Methods" writes,

> “The objectives of design become less concerned with the product itself and more concerned with the changes that the manufacturers, distributors, users and society as a whole are expected to make, in order to adapt to, and to benefit from the new design.” (Jones, 1992, p. 6)

Marketing people want to sell products on time, as cost-effectively as possible and with the right image for the application. Users need to feel confident that the computer system will offer the right facilities to ensure that their work is carried out at least as effectively as with previous methods or computer systems. Sometimes, arriving at trade-offs related to design in order to reconcile all the varied views and requirements can be a tough choice (Sage & Rouse, 2011).

An iterative design process is amenable to the user involvement in each stage of the design process as the different knowledge points obtained from the user can be incorporated into the design. A star life cycle design process was suggested by Hix and Hartson (1993) with evaluation being the central point of the design process. Evaluation involves collecting usability data from a specific user group for a specific activity performed in a specific environment. Different design phases are supported by different types of evaluations, so as to evaluate the different needs of different products, user profiles and usage contexts. Some of these techniques include interviews with users, focus groups, surveys and in some cases just observing the user in a natural setting. Hix and Hartson (1993), state that the star life cycle can start with any phase of design, but evaluation is the central and over-reaching principle. It is useful for various types of design – top-down, bottom-up, inside-out or outside-in product development.

User-centred design requires that the design process takes into account not only the user behaviour and the tasks that they intend to perform with the device but also the organizational, physical and social environment in which the tasks will be performed using the system (Bevan & Curson, 1999). The main principles of human centred design are:

- The active involvement of users
- An appropriate allocation of function between user and system
- The iteration of design solutions
- Multidisciplinary design teams

In addition, the four essential human-centred design activities are (Bevan & Curson, 1999):

- Understand and document the context of use
- Specify the requirements of the organization and user
- Develop prototypes of design solutions
- Evaluate designs against requirements with users

4.4.1 Involving Users

As Stone et al., (2005), recommend users should be involved in every part of the user interface design and development life cycle.

Requirement Specification Stage: Users can be involved in requirement specification or in testing early mock-ups. Users may be observed in their natural work environment to derive the specifications. Feedback about current systems can also contribute to the design process.

Prototyping Stage: Different prototypes can be tested by users to provide feedback and improvement suggestions.

Before Product Delivery: At this stage, only minor changes can be incorporated in the system. However, inputs at this stage can be used to produce the next version of the product.

Post Product Delivery: Here again, users can give feedback about actual use of the final product (Hix & Hartson, 1993).

The user interface design process is augmented by information gathering activities and analyses as well as by incorporating design principles and design rules. The key difference between traditional design and human centred design is that while traditional design aimed to optimize the manufacturing process the human centred design aims to optimize the end user expertise. However, both approaches are based on the fundamental principles of simplicity, clarity and safety (Boy, 2011).

The evaluation of a design can be done through diagnostic evaluation, which attempts to identify all possible problems with the design, or a measurement evaluation, which measures the performance offered by the design. The role of the evaluation is always to measure the design and to improve it at all stages. Measurement evaluation frequently contributes to subsequent versions of a product. Different kinds of evaluation may be carried out at different design stages and for different reasons (Stone et al. 2005). During the early stages of design, evaluation can be done to validate the requirements, predict the usability and to verify how well the requirements meet the users' needs. Initial design evaluation can be done using paper based prototypes and mock-ups which help to gather information and feedback without having to spend huge amounts of money. Later stages of the design evaluation can be carried out to verify user reaction to the final design and are mostly focused on gaining inputs for future product versions (Stone et al. 2005).

Some of the ways in which user evaluation can be obtained for the design process are enumerated below:

Observation: Evaluation can be performed by observing the organization and how people work and interact with a product or prototype. The observation may take place informally in the field or in a laboratory as part of more formal usability testing according to Stone et al. (2005).

Questioning: Interviews, surveys, focus groups and even informal discussions are a great way to find out what they think about using the technology. Stone et al. (2005), state that, no matter how good users' performance scores are when using technology, if for some reason they do not like using it, then it will not be used. Surveys using questionnaires and interviews provide ways of collecting users' attitudes to the system.

Predictive Evaluation: In this method, the possible problems that users are likely to encounter are described without actually evaluating a design according to Stone et al. (2005).

The choice of which method to adopt depends on how much time is available for the evaluation, how easily accessible users are, how much it will cost and how will we benefit from doing it. Stone et al. (2005), caution that the key to notice here is that this is in sharp contrast with the evaluation phase of a traditional design method, where factors such as economy and manufacturing efficiency are the factors that are evaluated. User experience is evaluated, if at all, only after the product is manufactured and used by customers, by which time it is too late to incorporate any changes to the product.

A user focused design approach helps to reduce product failures in the marketplace as the output is likely to closely match user requirements. The study of human factors in design is focused on how humans interact with products, devices, procedures, workspaces and environments encountered in daily life. When human strengths and weaknesses are ignored in the design process, the resultant output can be confusing or difficult to use, unsafe, or inefficient and cause stressful work environments.

> "'Human factors research discovers and applies information about human behaviour, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, and jobs, and environments for productive, safe, comfortable, and effective human use." (Salvendy, 2012, p. 5)

4.5 Conclusion and further reflections

In this section, I have reflected on the thought process around the traditional approach towards Design Thinking. The approach and theories focus on creating frameworks and possibilities around mechanical and physical products as depicted in Figure 8.

During this phase, the technology challenges and problems are addressed in the design process. The basic understanding is that technology completes tasks in order to address the problems and challenges. Human beings are the resources needed in order to complete the tasks. There is already a visibility of looking at human beings as the 'consumers' of design and hence new thinking around ergonomics is already seen. During the era before computers become a part of daily human life, technology is restricted to specific users and products (Swedin & Ferro, 2007). The design landscape undergoes a complete change with the advent of computers, where a highly technical tool or a product starts participating in daily lives of majority of human beings. With it also comes the complexity of multiple devices and interfaces, tools, applications and programmes which focus on specific user groups etc. (Lazar, 2007).

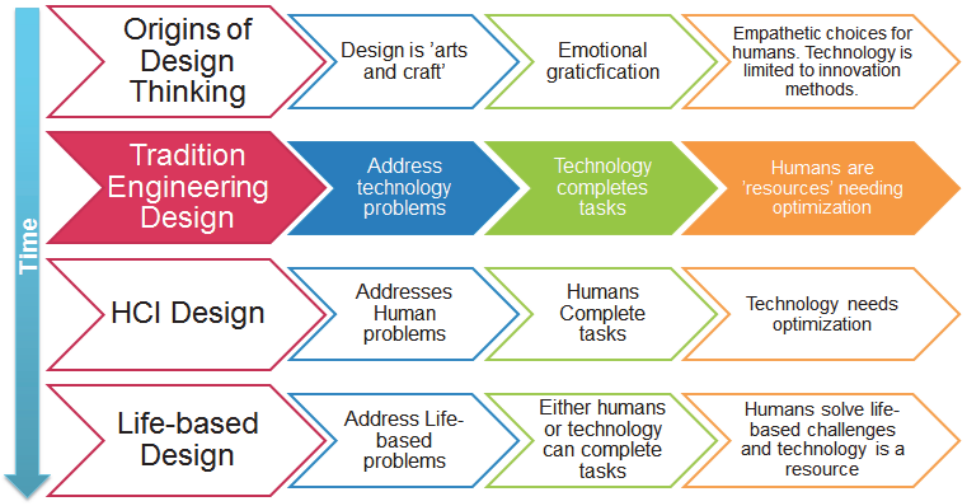


Figure 8: Traditional Engineering Approach towards Design

Design Thinking has been changing from the time it was considered as arts and crafts. It eventually developed to engineering design where it became a widely recognized scientific process, which has contributed towards a large number of innovative creations. Design Thinking saw the growth of the role of designers and the spread of the different specialities that have now become available in the field. The designers' role has however not only grown in importance but it has also attracted a wider array of responsibilities, the breach of which may result in the total destruction of the design process and in the reduced trust that is placed in designers. Holston (2011) claims,

> "The client-designer relationship is based on trust, respect and mutual-benefit. Designers who have strong interpersonal skills and methodologies for design problem solving can position themselves as trusted consultants offering both specialized and a broad range of knowledge." (Holston, 2011, p. 95)

In traditional Design Thinking, human beings are generally considered as part of the resources and as such, they need to be optimised in order to complete tasks; both within the scope and budget of the design project. In addition, while traditional thinking has given rise to a number of machines and useful operations, the human contribution in their operation, is also seen as vital if the use of machinery is set to be a successful one. One can interpret from Pahl et al. (2007), that, for the operation of this machinery, human beings are required to perform certain tasks. Tasks such as the pressing of the power buttons to turn the machine on, inputting of data in the machine or the alignment of the machinery's own settings, the supervision of quality and safety assurance requirements and the machine's own maintenance (for instance oiling, and the replacement of faulty parts). Consequently, individuals who operate this machinery are under the concept of traditional Design

Thinking, part of the value chain that completes the task that contributes toward the finished product.

> "Traditional usability work has concentrated on improving the work-of-the-tool." (Holtzblatt & Jones, 1993, p. 181)

Traditional Design Thinking, however, fails to focus on role of human participants. For instance, it has to be appreciated that when machine operators turn on the machinery, adjust settings and input data into the machines, their cognitive mental capacity is at work. Often, this requires the machine operators' understanding of the ultimate scope of the task and of the product itself (Pahl et al., 2007).

In addition, the traditional Design Thinking may be criticized in that it fails to gives weight to the human aspect of the design process. In fact, traditional Design Thinking is more focused on the delivery of a lasting, reliable and successful product design, whereby the focus is placed on engineering and technical design theories, albeit some make room for the ergonomic aspect of the product. However, traditional Design Thinking fails to take into consideration the perspective of the intended users.

The matching of the traditional Design Thinking to users' perspective necessitates further investigation. User's perceptions, abilities and limitations have now assumed a focal role in the design of computer systems. This has been made possible by the introduction of the Human Computer Interaction (HCI) approach, which has evolved into a number of different methodologies that can be used when designing for interpreting the product design from a users' perspective (Jacko & Sears, 2003). This is something, which clearly the traditional Design Thinking has been unsuccessful at implementing. On a positive note however, the latest human focus approach would not have been possible had the concept of traditional Design Thinking emerged in the first place. In fact, the traditional concept of Design Thinking may be said to have laid the foundations for technical considerations that enabled the amelioration of futuristic design methodologies (Smith et al., 2001).

In the following section, I have addressed the evolution of Design Thinking targeted at the Human-Computer interaction. This needs a dedicated deep-dive because of its relative newness in human lives and the quantum growth of technology percolation in our society.

5 HUMAN-COMPUTER INTERACTION AND DESIGN THINKING

Traditional Design Thinking evolved in its systematic form post the Second World War, when attempts were made to optimize the labour involved in manufacturing products. However, with the advent of information technology and the penetration of computer systems in most devices, Design Thinking has made a transition from the traditional approach to a human-centred approach where the focus is on improving and optimizing the usability of the product and not the manufacturability of the product. Most electro-mechanical products today are controlled by microcontrollers, which make the devices 'intelligent' and feature rich. However, users would judge a product not by the number of features, but by the number of features that can be used easily (Colborne, 2010). Thus, user-interface design is a vital element of designing a product, and thus human-computer interaction is gaining prominence in the design world. Today, computing systems are no longer used by the 'expert user', but by the common person for executing his day-to-day tasks (Morley & Parker, 2012). As a result, designs are evaluated based on how effective it is in various usage scenarios and how easy it is for various user groups across age, gender, geographies, disabilities and so on, to use the end product.

Human-computer Interaction is becoming more relevant today as computing systems are moving away from the domain of the specialist user to the common person. Today embedded microcontroller chips are a part of most day-to-day usage devices ranging from mobile phones to white goods to electronic appliances to even automobiles and aircrafts (Godse & Godse, 2009). Thus, most electro-mechanical products have today become electronic products, which are controlled by software and have a user interface for receiving inputs from the end user. Success of such appliances and devices is not measured by the features and design of the hardware, but rather by how simple and easy to operate the interface is. Thus, a device is only as good or bad as its interface (Stone et al., 2007).

The historical foundation of HCI lies in 'software psychology' and it was initially aimed at having a psychological approach towards software design and programming (Shneiderman, 1980). As software development moved from the waterfall model to an iterative model, HCI started looking at how to involve end users as early as possible in the design phase and usability evaluation shifted from summative to formative (Scriven, 1967). It was understood that while a formal evaluation is a good method to obtain which among a set of designs is more preferred, it is not flexible enough for requirements gathering from users. In the 80s, therefore 'Thinking Aloud' became the evaluation method of choice for HCI (Wright & Converse, 1992).

In the initial days of HCI, computer systems and software was mainly used by expert users and thus there was hardly any focus on the needs, preferences and capabilities of the end users while designing software solutions and computing systems. However, as soon as computing systems started penetrating daily life, the focus shifted to a user-centred system development process rather than a technology centred design process. By the nineties, both academicians as well as industry experts started recognising HCI as an integral part of computer science. HCI began to be recognized as a core area of computer science curriculums and research. Today the role of HCI designers is not limited to system development, as they are routinely a part of focus groups and other user-designer interactions, and in all stages of product development ranging from need identification, product planning, specification documentation, development and evaluation of prototypes and even in the design and documentation of training material (Kumar, 2005). Kumar (2005) continues that, this has been largely due to the commercial success of HCI. Some of the key questions that HCI attempts to answer include improving the iterative development process, managing resources in order to optimize cost, expanding the usefulness of cognitive user models, and most importantly, social and behavioural science knowledge merger with technical lessons in order to design a superior product.

According to Spence (1997), Iterative development emphasizes the discovery of new goals, the importance of prototyping and evaluation and the involvement of all stakeholders (including end-users) in the design and development process. Iterative development is not a 'trial and error' method and is aimed towards incremental improvements (Spence, 1997).

"Usability engineering" is an integral part of iterative development and there are three key aspects to it in the design methodology. First, iterative development must be managed with clearly defined and measurable "usability specifications" which have now become a standard part of HCI (Carroll & Rosson, 1985). For example, when word processing software is being designed, a goal of how fast a user can prepare a document with a defined number of errors and after a specific amount of training, can guide the iterative development process. Carroll and Rosson (1985) continue that the design team can then develop prototypes and evaluate it with the help of real life users to measure how much further the design needs to be modified to achieve the usability specification defined initially. Second, usability engineering was aimed to increase the scope of design and ensure user participation in the process. It is necessary to facilitate collaboration between users who are, experts in the domain and the work situation, and developers who are technical experts. In "participatory design," users are involved in setting design goals and planning prototypes, according to Carroll and Rosson (1985). The other approach towards garnering information about a user's real needs and context is through field-studies (Whiteside & Wixon, 1987) which replaced laboratory-based studies that were the norm during the initial days of HCI research. Field-study-method-based design is also known as 'contextual' design and this is different from 'participatory design' in which the former allows designers to observe and understand the context of use and circumstances, some of which the users themselves may be unaware off. In participatory design, on the other hand, users are actively involved in the design process and contribute their perspectives and insights (Simonsen & Robertson, 2012).

Yet another design paradigm known as "ethnographically-informed design" (Bentley, et al., 1992) emerged when contextual design principles converged with ethnographic research. This method did not encourage direct user involvement in design, but rather was focused on detailed observation of user behaviour in real life situations and was aimed at modelling the power dynamics, organizational characteristics and the practical knowledge available in the work place.

According to Carroll (1997), usability engineering also focused on cost effectiveness, as multiple iterations of prototype development, evaluation and redesign is an expensive proposition. In the early 80s, HCI was aimed at creating effective prototyping tools and models to aid designers decide when to stop further iterations by identifying the point of diminishing returns. Carroll (1997) continues that, one of the ways in which this was achieved was by separating the user interface from the application software. Thus, functionality of the software was separately designed and the user experience was delivered through the interface. This model of modularization allowed the designer to apply different design principles for the user interface and the functionality artefact of the software. Often, task transparent user interfaces were developed and today, with computing systems being a part of day-to-day appliances, this has become the norm for design and development. Thus, the functional software would undergo different iterations based on a different set of evaluation principles and the user interface would undergo a different set of iterations based on HCI principles (Carroll, 1997).

The issue of cost effectiveness also guided methodological work on usability evaluation. Indeed, the earliest refinement of the GOMS model was a keystroke-counting approximation (Card, Moran & Newell, 1983). Frequently, methodological shortcuts were grounded in the exigencies of system development. For example, thinking aloud protocols had become a standard empirical method, but they were generally not analysed at the level of detail typical in cognitive psychology. Often, they were merely gleaned for critical incidents: episodes of use in which something goes unexpectedly well or bad. Usability evaluation was also focused on cost effectiveness with systematic techniques for evaluation being considered more cost effective. An 'impact analysis' model of evaluation was suggested, where prototypes were evaluated based on user performance factors, in order to identify those factors which had the highest impact on usability specifications, defined during the requirement analysis phase. Other techniques aimed towards reducing the cost of user studies included "heuristic" evaluation, checklist based testing or script based testing rather than direct user testing (Neilsen & Molich, 1990).

Rosson and Carroll (2002) stated that, in the initial phase of HCI, most practitioners only followed the methods, which they originated, and there were no attempts to follow the best practices available. Therefore, the various techniques need to be synthesized and integrated in order to be able to obtain the maximum benefits. One of the areas where integration is absent is collation of different types of evaluation data. Though different evaluation methods are useful for different kinds of problems, often there is no method to collate the quantitative data and the qualitative data collected at various points during the design. There is also difficulty in arriving at trade-offs between the various evaluation goals derived from the user specifications (Rosson & Carrol, 2002).

The design rationale of a system (Moran & Carroll, 1996) addresses issues such as the user requirements the system is expected to fulfil, the trade-offs made during the design phase, the reason for inclusion and exclusion of features and the discussions that led to these decisions. This information would not only help the various stakeholders such as customers, service providers and marketers of the system, but will also aid designers who are working on improving the system for its next version. Moran and Carroll (1996) continue that the design rationale approach can be either solution oriented or process oriented. In the former approach, the reasons for selecting a specific design from various alternative designs is explained and shall include the various issues identified by the design team, the options considered for addressing each of the issues and the criteria used to select the option for the system. Another approach considers design as an 'embodiment' of the social and behavioural needs, abilities and activities of the user (Moran & Carroll, 1996). Thus, a programming environment is visualized as an embodiment of what the programmers know, do and experience as well as the context in which they perform various programming tasks.

In this section, I have collated and analysed the Human-Computer Interaction design theories, where the focus of the thought-leaders has been to create design keeping in mind the specific and changing needs of design, about the interaction between humans and computers or digital systems. Human-Computer Interaction is the design of effective computer interactive systems. This design needs to be easy and enjoyable to use so that human beings may be able to appreciate the benefits of HCI (Carroll, 2003). In fact, there is a lot to appreciate about Human-Computer Interaction, as it is used for many different activities, which have become vital for the efficient caring of the needs of society. For instance, Human-Computer Interaction can be used for online libraries, medical enhanced research and in the health sector including it being an assistant to medical staff in case of operations (Dix, Finlay, Beale, & Beale, 2004). Human-Computer Interaction is involved in a number of disciplines and can therefore be referred to as multidisciplinary; but regardless of the field a particular project is involved in one will always find an element base of computing science (Dix et al. 2005).

5.1 History of HCI

This section will discuss in brief the historical development of the major turning points in human-computer interaction technology. It will also highlight the vital role played by research carried out for the improvement that has occurred in the HCI Field. Governmental agencies have also invested many resources in the further discovery of knowledge in this field, which continues to show the utmost importance of HCI. Computer science has been to a large extent impacted by the successful advancement in research on HCI (Myers, 1998). Contributions from other academic fields such as that of ergonomics, psychology, human factors and design cannot go underestimated in the success of the developmental history of human-computer interaction according to Myers, Hollan, Cruz, and Bryson, (1996). Interestingly, the research area of Human-computer Interaction (HCI) has pooled together almost defunct research subjects with other relevant ones, giving them each a workable platform of importance under the umbrella term Human -Computer Interaction (HCI) (Carroll, 2009).

It is also important to note, at this stage, that the accomplishment of HCI technology strategies did not occur because of market-imposed discoveries. On the contrary, the market has only adopted Human-Computer Interaction strategies, to the design of computing products because they were backed-up by the reassurance of heavy and trustworthy research that was carried out by several institutes with highly dependable credentials. The victorious progress seen in human-computer interaction now days is therefore the result of the heavy investment of a period of twenty-five years that went in to research by different governmental sectors or licensed entities (Card et al., 1983). Consequently, it is safe and correct to assume that any corporate advancement done in the field of HCI such as software applications and different modes of interfaces is solidly backed-up by institutional research. Nonetheless, one cannot deny the important input in the HCI field done by the likes of AT&T, IBM and Xerox research teams among other industrial professionals in this arena (Card et al., 1983).

Carroll (2009), shedding light on the history states that, up to the 1970s, only Information Technology experts and those who enjoyed IT as a hobby interacted with the phenomenon of computers. In the 1980s, the subject of interaction with computers began to expand. In fact, the origin of Human-computer interaction (HCI) has stemmed from the computer science field. Around the beginning of the 1980s, HCI was not simply a researchable issue but it was also being implemented into practice. In the span of 30 years (1980-2010), Human-computer interaction (HCI) has not only seen a steady growth and adaptation, but it is often under the spotlight of several professionals from all disciplines with the aim of coming up with new methodologies and HCI solutions. The 1980s has indeed seen the birth of operating Systems, text editors, programming languages, spread-sheets, hardware and interactive computer games just to mention a few, thereby attracting a wider range of computer users both as a means of entertainment and work tool. According to Carroll (2009), with different users, diverse needs began to surface; pinpointing on several gaps in computer systems and attracting the interest of different disciplines. There was an effort to solve the loopholes of mysteries (such as software complex systems, ability to use it and skills to maintain it) that one could find at the time in the field. It was towards the end of the 1970s that cognitive science put forward solutions for meeting these needs. Parallel to this in the computing sphere the need for HCI began to arise. Carroll (2009) reflects that, in general, experts in the field began to accept that the future way was to include a study on how to understand users. Resultantly giving rise to products that were more user friendly, whereby 'use' became the main backbone of how HCI originated and consequently the starting point of what we understand by Human Computer Interaction (HCI) now-a-days. From just a branch of computer science, HCI has become researchable and worth investing in academic branch on its own merits. However, no HCI expert definition exists and consequently, because of its dynamic all-encompassing nature the education of HCI involves professionals from a wide range of industries (Carroll, 2009).

5.2 Evolution of HCI over the years

Although the IBM PC marked the beginning of the personal computing era, computers started being used by the common person when the WIMP (Windows, Icons, Mouse and Pointer) interface made things easy. Today, as computing systems become all pervasive and software becomes interactive, the role of HCI has increased to such an extent that it is no longer an after-thought or an optimization exercise, but rather a key issue that is addressed with the same amount of focus that the core features of the computing system get. In consumer markets, the ease of use is as important for a product's success as its features and HCI designers have the challenging task of simplifying the interface without reducing the number of features being offered in the product. Even if the product has an amazing set of features and great engineering design, it can be a commercial failure if the interface is poor (Jacko & Sears, 2003). Today, designers no longer think of the interface as separate from the product and often design moves from the interface to the underlying features and an HCI designer plays an active role in every phase of the product design from requirements gathering to conceptual design to embodiment and manufacturing. Describing the history of HCI, Jacko and Sears (2003), state that

HCI originated when computers moved away from being a tool for experts to the domain of ordinary users with the Xerox Alto desktop computer, which was developed in 1973, with a mouse and overlapping windows functionality. In 1976, the Star PC was developed in Xerox and this was a huge improvement over other systems at that time with a WIMP interface and a desktop design. The design approach of Star was also remarkable as it consisted of task analysis, scenario modelling, rapid prototyping and user involvement in design. According to Jacko and Sears (2003), Design principles that evolved with the Star, continue to be followed till date as fundamental human behaviour patterns do not change. Thus, it can be concluded that if human-centred design is well executed, it can result in a product that can endure for decades to come.

Thus, unlike in other sciences, HCI does not encourage radical innovation and good HCI design is often a result of evolutionary incremental innovation rather than revolutionary change. Good designs of technology systems require radical technological innovations without compromising the high-level principles of human behaviour as well as contextual user centred design evolutions according to Rosson and Carroll (2002). Today, the major contribution of HCI is in contextual design. Thus, a PC designed for office use shall have different features and design rationale than one designed for home. Cell phones are evolving from text based interfaces to speech based interfaces and as speech recognition technology improves its accuracy, this will become the interface of choice for mobile devices. In future, one would see the camera, Bluetooth, Wireless and GPS systems in phones being used for innovative purposes. The entry of 'apps,' signifies the future of mobile technology where software would be designed to innovatively use the hardware capabilities of a device. Thus, seamless integration of software and hardware would enable maximizing the potential of devices and appliances. Unlike text-based inputs, future interfaces shall work based on contextual information and the phone will intelligently respond to your perceived needs (Harper, Rodden, Rogers, & Sellen, 2008). Thus, inputs from the current location shall be used to make suggestions for the user, such as comparison pricing while in a super market, song previews while in a music store and so on. Contextual design takes into account the immediate context of the user, the activity context or the historical behaviour of the user and other participants in the activity and the situational context that deals with how other people would behave in a given situation (Carroll, 2003).

Contextual design combined with proactive response ability in a product can be a win-win for both consumers and marketers. However, in order for this kind of design to be fully effective HCI has to be combined with deep technical knowledge and BigData analysis in order to analyse user history and generate highly personalized service for each individual in the target population. Nayak and Ichalkaranje (2008) state that even though, many dynamic content generation and suggestion technologies are used, there is a potential for significant improvement in this area.

> "Considering practices in the current fiend of personalization using artificial intelligence and related techniques, it may be seen that however accurate a system is in delivering data to a user and accurately profiling that users interests and preferences, they are limited. Such systems will always be restricted to quality and availability of data for each particular user." (Nayak & Ichalkaranje, 2008, p. 28)

In future, contextual design would be combined with perceptual interfaces such as speech interfaces based on speech recognition engines or computer vision (camera) based interfaces. Examples of this is already commercially available in the form of Siri in Apple phones, bar code scanners that are available in most smart phones and even OCR which is used for business card recognition. Yet another application of perception based interfaces can be found in the use of face recognition software which can be used to generate metadata about the subjects of a photo or video. Apps can then be designed to share the photo or video with the subjects by obtaining their contact information already stored in the phone.

> "The eye and visual cortex of the brain form a massively parallel processor that provides the highest bandwidth channel into human cognitive centres. At higher levels of processing, perception and cognition are closely interrelated, which is why the words 'understanding' and 'seeing' are synonymous." (Ware, 2012, p. 16)

When metadata is to be exploited, contextual relevance is necessary to be maintained and human perception needs mirroring when developing design. From Ware's (2012) thesis, it is evident that, human brain is capable of making connection where logically the connections should not exist. Automatic speech recognition and voice user interfaces are being increasingly used as their accuracy and reliability have improved in recent years, making them commercially viable. These interfaces will become more and more prominent as people move away from computers to mobile phones for carrying out transactions, staying in touch and even for entertainment purposes such as gaming, listening to music and watching movies according to Harper, Rodden, Rogers and Sellen (2008). A mobile phone is more amenable to be used with a speech interface rather than with a text based interface. Today, most mobile phones with speech recognition have very large vocabularies making them quite easy to work with.

With all the dynamic progress of HCI, it is important for experts in the field to understand and always keep up-to-date with the fast pace HCI is evolving (Olson & Olson, 1990, pp. 221-265). Studies need to continue further as regards to human knowledge and cognitive psychology approach to HCI. A case in point showing the need to keep up-to-date with this research is the work carried out by Card, Moran, and Newell (1983) who have helped advance research in relation to a number of time relevant requirements. HCI has evolved to such an extent that it is now able to cater for the production of errors, grammatical models and time evaluation for learning curves in different systems as well as cost cuttings. Again engineering has played an important role in HCI and as of late professionals in the field have in fact taken on board the engineering "critical path analysis" so to be able to specify the interaction processes and their time periods (Olson & Olson, 1990, pp. 221-265). Regardless of the numerous advancements in the HCI field, professionals are aware of the loopholes in the awareness of the interacting process with computers. These gaps have, in fact, been highlighted by not only the extensive research that was carried out, but also the model framework on which current researchers operate., This has also been a pointer to lack of understanding of this process. The way people solve problems and errors, human performance and the interpretation of visuals together with the understanding of interlinked processes are some of the issues that have been put on the agenda by professionals in the field for this gap analysis.

5.3 Psychology and Design: GOMS Model*:* (Goals, Operators, Methods, and Selection rules)

5.3.1 What is GOMS model and its relevance to HCI thinking?

GOMS is a method for examining the individual aspects of user experience and are measured by time and efficiency of a user to reach a goal (Eberts, 1994). GOMS was created in 1983 as human information processor model and its relevance to HCI is that this model is used to observe this very same interaction process and that is the connection between the two terms (Card et al., 1983). It is important to note that the term GOMS originated from HCI experiments and not the other way round (John & Kieras, 1996). While GOMS is the basis, it gave rise to other analysis models, which yet again were born of the engineering sector, which specifically focused on the usage ability within the community. Predications of human learning skills, as well as execution time are of paramount importance in GOMS analysis, in order to further improve the overall understanding of HCI (John & Kieras, 1996). The main idea behind GOMS is that it seeks to lower a user's computer interaction to its rudimentary aspects, which are in turn used as a backbone on which user interfaces can be assessed and developed.

In this monograph, I have emphasised a lot on this topic because I believe that GOMS was the turning point in Design Thinking. It was with Card et al. (1983) focusing and working with GOMS, that the HCI fraternity started looking systematically at the human information processor model and the focus started shifting from Machine to the Man in the equation. This was a step away from engineering approach to a human approach in design. At the same time, Design Thinking graduated from machine centric approach to human centric approach. I believe that it also marks the beginning of the Design Thinking efforts by designers to address the human-computer system with focus on optimization of the machines to improve the performance and perception of the human participants in the system.

GOMS stands for Goals, Operators, Methods and Selection Rules. Each individual term in the GOMS abbreviation has a particular meaning relevant to HCI according to Card et al. (1983).

- Goals refers to the accomplishment intention of the user;
- Operators deal with the activities performed by users to reach their goal targets;
- Methods refer to the specific user operational sequence selection out of the different variations used to achieve the goal.
- Selection rules deal specifically with the user's choice of methods as opposed to other methods available

As it is easy to notice, the designer is dealing with flexible definitions of GOMS in their assessment of user's activities. Nonetheless, despite the fact that there are variations of GOMS models, the definitions of the main terms imply the same meaning.

5.3.2 Cognitive skills and applying psychology to design

When discussing the issue of cognitive skills and applying psychology to design, the issue always centres itself on whether successful problem solving, which is ultimately the role of designers, is dependent on specialization in particular fields or on the analytical ability and general thinking strategies (Perkins & Salomon, 1989). Perkins and Salomon (1989), suggest that both the general and specialized approach should work in close proximity, although the implication of this is dependent on the objective of each design. When discussing Human Computer Interaction vis-a-vis cognitive abilities and psychology, the main difference is that unlike psychology which mainly focuses on the behaviour, HCI looks at the behaviour in the disguise of skills and abilities and adds the unique medium of computer frameworks. Psychology has always focused on the motor skills. HCI goes a little further than that and looks at the result produced by the motor activity of users. Card et al. (1983), hold that the mental skill (cognitive skills) produces motor effects that can be perceived. In a computer scenario, the cognitive skill is visible in how users keystroke, click and select information among other possible examples. Human Computer Interaction also focuses on timing users while they are busy with different computer tasks; however, like psychology, it also looks at the underlying user emotions such as fatigue, stress and the novelty of the task, which also includes the adjustment period.

Consequently, the importance of psychology advancement and research, as well as that of cognitive skills together with Human Computer Interaction cannot be denied in computer design. Designers should therefore, keep up-to-date with latest developments and apply the latest research through an objective approach to their designs. Consultation with other experts in the human assessment areas becomes therefore, key to ensuring a successful adaptation to computer designs. Allen (1997) suggests using research, models and techniques from psychology and adapting them to address HCI needs.

> "The extensive literature in psychology on techniques for assessing individual differences and personality types can be applied to the evaluation of mental models. Standard assessment criteria like reliability and validity can be adopted." (Allen, 1997, p. 56)

Since, it is humans, who use computers and given that it is the role of designers to come up with solutions to problems, designers will only be able to find answers to problematic areas by understanding the underlying human element of the end –user for which the design is intended.

5.3.3 Advantages of GOMS

Apart from being able to assess user's knowledge and learning ability skills and the time taken to master each activity, GOMS has other advantages, which can assist to improve the overall understanding of Human Computer Interaction (Kieras, 1997). In addition, minimum efforts and time resources are required to accumulate the desired information. This is especially true if there are previous time estimates for the tasks under examination. According to Kieras (1997), because of the easy to use, non-time consuming and cost efficient nature of GOMS, research is more productive and therefore it leads to a faster and more practical implementation of methods that can be used in computers design with particular reference to the design of system interfaces. Furthermore, because GOMS tends to use real life users, the design is most likely to lead to an easy to use and easy to grasp design concept. This is because; the aim of GOMS is to provide solutions that result in time reduction and cost-effectiveness. GOMS methodology is lightly interested in the cognitive behaviour of users but highly focused on observing precise, yet simple body movements. While some mistakes may occur, GOMS is not tolerant of errors (Tonn-Eichstädt, 2006). Various experiments and research demonstrates that GOMS is successful even if different models and methodologies have emerged from it. For instance, if a technique of GOMS model is done by hand, it is most likely that the use of the GOMS model or its variant will lead to successful results which are both efficient and useful for the needs of designers and humanity at large (Kieras, 1997).

5.3.4 GOMS Variations

The CMN-GOMS: This is the original theory proposed by Card et al. (1983). The CMN-GOMS depends on the information as understood by the user and takes into consideration the senses of human–beings in their assumption as basis for the CMN-GOMS technique. For instance, the sense of hearing and eyesight are the main receptors of information which eventually enters the perceptual processor, kept by both the working memory and long-term memory. Information is eventually analysed by the cognitive processor and the required motor function is chosen and activated by the body of the user. When it comes to measuring these senses, a Methods-Time Management approach is used (Card et al., 1983). This provides the assessors with pre-established time measurement in milliseconds for each phase of the information processing by users as explained previously. In conjunction with these pre-determined time frequencies, a fast-man, middle-man and slow-man approach are applied representing the fastest, common and worse user performance respectively. These measurements enable designers to reach the time measurement that best describes the average user- mode paying particular attention to the time needed for the motor function to activate it once processing is reached.

The GOMS model was further developed and new variations were introduced. *The Keystroke Level Modelling (KLM)* variation was developed by David Kieras based on the original approach explain by Card et al. (1983). KLM is a stricter version of their original GOMS technique. While leading to a faster application and yet resulting in less accuracy than the CMN-GOMS technique, KLM is more efficient in measuring the time that is required to conduct activities such as typing, mouse selection and error correction. CMN-GOMS technique refers to the original model introduced by Card et al. (1983). Like the CMN-GOMS technique, the Keystroke Level Modelling (KLM) technique also makes use of pre-established time averages as may be found in Card, Moran and Newell (Card et al., 1983) works. It is important to note that in this technique several simple assumptions are made which are worth considering. For example, in order to determine the typing speed, the hands of the user are assumed to already be placed on the keyboard. These assumptions will therefore influence the average estimates inconsiderably and are thus worth keeping in mind when applying the KLM technique. Bonnie John a former student of Allen Newell, introduced the CPM-GOMS model (Gray, Bonnie, & Artwood, 1992). This model bases itself on the Human Model Processor and having the most competitive advantage of allowing the storage of parallel process information by the user (John & Gray, 1995). For this reason, the CPM-GOMS is said to be quite a problematic technique to put into action. Keiras (1988) came up with the *Natural GOMS Language' (NGOMSL),* yet another variation emerging from the GOMS technique. The 'Natural GOMS Language' (NGOMSL) technique consists of natural yet strict language that enables the creation of other GOMS models.

5.3.5 Limitations of GOMS

Despite its numerous advantages and its vast application and adaptation of different variations, the GOMS model is however, not the most accurate and reliant means of measuring human-computer interface interaction. In fact, whilst the different variations of the GOMS techniques lead to the attainment of valuable information, some limits pertaining to each of the GOMS models cannot go ignored. For instance, all GOMS techniques fail to cater for the element of human unpredictability, or for the behaviour of users which is the result of fatigue according to Sharples (1994). Moreover, no concrete attention is paid to the physical limitations, disabilities, the personalities and habitual attitudes of users and consequently; all users have the same equal importance under GOMS models (Sharples, 1994).

Nonetheless, in recent GOMS advancement, disabilities of users have been given a restricted acknowledgment (Schrepp, 2006). Another limitation that arises from GOMS models is that they do not use scientifically controlled environments and no actual humans are recruited to fill in the shoes of users for carrying out real human tasks. The failure to make use of these scientific methods is due to the fact that it is quite costly and not time-effective with the possibility of finance running out before an appropriate conclusion is drawn (John & Keiras, 1996). Furthermore, work environments and social ambience are also not envisaged in any of the GOMS widely applied techniques. The failure to take into account these drawbacks under different GOMS models renders GOMS techniques as a basic- if not generic tool of users' options and movements. While GOMS techniques pay special consideration to errors, it is hard to predict or prevent slips. Since the usability of a design system is the focus of all GOMS techniques, the latter omit any considerations in relation to the functionality of the system that is being developed, by failure to put forward any suggestions to this end.

Perhaps the most high scale limitation of all is the general assumption that the user has knowledge about the way to proceed, at any stage of the HCI observation. Consequently, new users may not necessarily lead to the desired results (Tonn-Eichstädt, 2006). The latter may negatively influence the end results making the information gathered from applying a GOMS model an unreliable source for the purpose of Human Computer Interaction. The role of the assessors of any GOMS model also play a fundamental part in the gathering of information from any user interface observation carried out. The important role is evidenced by the fact that all observers need to have a sound knowledge of the founding GOMS theories and of Cognitive Complexity Theory. While this is a good practice, it generally serves as a deterrent for successful and financially stable organizations to recruit the services of an HCI specialist. While GOMS techniques are useful even when carried out by hand, they will still require computer based tools in order to improve the software's usability and application process (John & Kieras, 1996).

5.3.6 GOMS analysis and assumptions

Assumptions are a key element of GOMS analysis and it is important that the researcher accounts for as many variable elements as possible using assumptions, before measuring average time taken to accomplish a goal. Card et al.(1983) recommend,

> "…record explicitly the assumptions in the analysis so that they can be later refined or corrected as more information about the system becomes available." (Card et al., 1983, p. 317)

It is also important to design the GOMS scenarios in such a way that it matches the real life scenario in which the product is likely to be used as closely as possible. For example, if a user interface of a fighter aircraft is being tested, it is safe to assume that the user will be in good physical condition and has excellent vision. It is also necessary to assume that the user will be a pilot who would have undergone years of training and hence is capable of handling complex controls. It is not necessary to evaluate a scenario of an old and disabled person handling the interface in this case. Since, one of the limitations of GOMS is that it does not allow accounting for errors; the experimenter has to be able to predict most common errors that are likely to occur and measure the time taken to cause the error and then correct it subsequently. For example, common typographical errors can be measured and accounted for in this manner (Lewis & Wharton, 1997). However, the challenge is to predict the probability of the error occurring, as an error will not occur every time a scenario unfolds. As an example, in her experiments with Older Adults using mobile phone tasks, Jastrzmbski (2006) came up with probability of a skill error as 0.006 for young users and 0.011 for older users. Rule error was 0.036 and 0.024 respectively for a simple one, and 0.156 and 0.324 for a complex one. A skill error is an unconscious and automatic action such as a key being hit more times than necessary, a missed hit etc., which results in an error. A rule error is caused by either applying a good rule incorrectly or a bad rule at the wrong time. One area where accounting for errors is relevant in GOMS model is for web page navigations where the experimenter would need to identify the probability of a focus-loss inside the page when navigated using the TAB key (Schrepp, 2006).

In conclusion, to this section, I restate that in my thinking, the GOMS phase was one of the most important times in the Design Thinking history. This saw the shift of focus from an engineering approach towards a human centric approach by designers. The human participants became central players in the human-machine system. Optimization of machines was sought to empower users, improve their performance and perception of the system. This distinctly was a step away from a systematic engineering design approach where the focus was to improve the performance of the human participants to allow the machines to perform their tasks better. As I stated earlier that, the origin of GOMS lies with HCI experiments as proposed by John and Kieras (1996). Usability has been the focus of GOMS and this generated multiple offshoots. All the iterations of the analysis models were implemented in the engineering sector. The systematic approach from the user's perspective was first visible with the GOMS model and its iterations. Its ease of use and implementation coupled with the possibility of getting insight into the users knowledge, learnability and performance proved to be the foundation on which further usability engineering paradigms have been built. GOMS focuses on observing body movements of the users in depth but defocus from observing cognitive behaviour of users with focus on precise results with low tolerance to errors. GOMS serves as the foundation of human-centric design development and is a major landmark in the history of Design Thinking in my opinion.

5.4 Approaches to HCI design

This section is influenced by the logic of flow followed by Leikas (2009) in her doctoral thesis. This section traces the modern human-centric ideas and research towards Design Thinking. In the beginning, I have dwelled on the more traditional approaches and following that, I have looked at the approaches that address the requirements from a focused perspective or a niche.

There are two main perspectives of how to look at, and interpret the approach to Human Computer Interaction design. There is first and foremost the user's perception which needs to be taken into account by designers, not only prior to commencing the design process, but also throughout the whole process each time the designer changes his options to the solution (Fukuda, 2009). Considering the impact on the end-users, as well as their performance, it is indispensable if designers really want to put forward a sensible solution. The intended use and performance of users is usually the scope of the design itself and one can therefore appreciate why users' perspective takes the front seat in computer design. The second, yet still fundamental perspective is that dealing with the technicalities of the design, which involves an assessment of what can be done within the restricted framework, the time required for the design to come to life measured against the funding that is available (Kazman, Gumaratne and Jerome, 2003). This sub-heading briefly describes both perceptions of the different Human Computer Interaction design approaches.

The technical perspective of the design requires HCI designers to look at the functionality. The functions required are dependent on the project scope and consequently, the starting point is usually that of looking at, all that is known about end users, together with what applications systems can provide this function. One can start by looking at the functionality aspect of the design by determining which functions are required in chronological order. Haskell (2004) holds that if

> "…this approach of a functional enabling matrix is used to initiate the product concept, and then this result should not be surprising." (Haskell, 2004, p. 40)

Generally, however, the design concept is not initiated in this way leaving the functionality needs of the design less certain (Haskell, 2004). In fact, if the systematic architecture approach is applied, the consideration at the forefront of the design is the limitations within which to come up with the design. Consequently, according to Haskell (2004), a number of alternative solutions become possible requiring a high level of creativity on the part of the designer. Once these restrictions are laid out, the designer can then move to other stages of the design and usually the next starting point is to look at the functional requirements (e.g. display graphic) and the corresponding technical needs (e.g. display interface). Once these have been established, the designer can move on to the processing requirements of the design (Haskell, 2004).

There are various approaches that can be used to put in place an electronic design. For instance, one can start by using two parallel stages. One stage would include the whole design performance and the second stage would be that of allocating available resources such as technology packages to the design process. However, this design approach is quite a daunting task and lacks efficiency since it requires the designer to look at all options making it both time-consuming and expensive according to Haskell (2004). While funding of the design may not be a problem, since this involves the early stage of the design, it is not feasible to invest a considerable amount of time looking at the different resources available.

Haskell (2004), states that, another more commendable design approach is working the cost and drawing up the form of the design. One can then adopt different technology packages available, to meet both the pre-established cost and form of the design. The most simple and preferred design approach is that of using comparative metrics and algorithms of the system components, which ensures prompt access to electronic packaging. However, it is up to the discretion of the designer to verify whether the intended results can be achieved using this approach according to Haskell (2004).

Design advisor software is also being promoted by a number of computer companies believing that this will help the designer through the estimation of results to be expected and thereby assist the designer in opting for optimized solutions. In addition, the cost factor also plays an important role and can be viewed as one of the restrictions of the design according to Haskell (2004). The aim of designers is to keep costs low while opting for system components that promise high performance levels. Experts in the HCI area acknowledge four HCI design methods that if used, help to develop an easier to use and user sensitive designs (Eberts, 1994). Designers may opt to go for an individual approach or a combination of these approaches in the creation of the interface design.

According to Hancock (1987), the goal of Anthropomorphic Approach is to achieve natural systems. By using this approach, the design is made to have human like qualities. For example, when using an ATM machine, it will thank individuals for their customership or the screen will display an apology for any inconvenience caused. However, the anthropomorphic approach does not centre itself on visual displays only. Sound or voice like automated recordings is also installed as part of the computer design system. According to Waern and Höök (2000), designers need to be careful because, anthropomorphic features can lead users to believe in existence of features that do not exist (Waern & Höök, 2000). Take a ride on one of the children’s toy rides on every corner of the street. The children may enjoy riding to the music, but the latest technology has ensured that once the children’s ride is over, the toy ride will say in a nice cheerful tone something on the lines of “Bye. Bye.” or “Thank you. Come Again.” Conversely, when a task is carried out well by the user, a pleasant sound is heard indicating to the user that the task was successfully achieved. The opposite is also true and in fact when the user misuses the application; a sound showing that the task the user is trying to complete has failed is heard (Rouat & Pichevar, 2005).

The cognitive approach targets the human brain and its perception senses in an attempt to come up with much more user friendly design products. The designers need to be familiar with the theory and advances in cognitive psychology. According to Hancock (1987), it is also necessary to be able to apply theoretical knowledge and perspective to real-life situations in human-computer interaction tasks. Cognitive approach considers the users to be interacting with the computers to solve problems. According to Hancock (1987), the user plays the role of a flexible, adaptive information processor. This approach gives insight into which design is better and does not stop at just testing it. Booth (1989) holds that the lack of clear goals is one of the weaknesses of cognitive approach. He elaborates it further,

> "Firstly, the central aim of cognitive approach within HCI should be to develop a theoretical framework for understanding what occurs at the interface, and that this framework should be used to contribute towards the development of techniques where the cognitive issues are addressed in the context of physical (ergonomic), social and organisational issues. Secondly, following from the first argument, the cognitive grammars should be viewed as research tool or theoretical test-beds, not as practical techniques for design." (Booth, 1989, p. 93)

This predictive modelling approach follows the GOMS steps. In simple terms, it is an approach that looks at the experience of different users. This user experience is broken down into different components or tasks. HCI professionals usually, compare and consider the average time users take to complete these tasks. That is why GOMS is focused on human information processing theory. According to Booth (1989), for following the predictive modelling approach, the designers need to follow existing models and apply them to various tasks.

> "Methods within the predictive modelling approach try to predict the performance of humans interacting with the computers, for instance in terms of errors." (Akoumianalis, Grammenos and Stephanidid, 2000, p. 340)

The empirical approach assesses the usability of multiple conceptual designs (Eberts, 1994) and this assessment usually takes place prior to final production stages. This observation often leads to designers putting together the most user-beneficial aspects of different design into an attempt to come up with a better design that incorporates all these benefits. Testing of the design will then follow.

The Anthropomorphic Approach, the Predictive Modelling Approach and the Empirical Approach, however, cannot exist on their own. The technical restrictions and know-how also need to be taken into consideration and thus designers usually aim to come up with a design that puts together the best of both worlds (ease of use for users and high performance components).

5.4.1 Visual Displays

Technology Designers had originally come up with the idea of display screen to solve a hierarchy of problems- such as cost, environmental reasons and the ability to edit without wasting time (Gould et al., 1987). However, it was originally designed to allow people to read or look at the visual displays. An area of interest among a number of researchers is a comparison between visibility on a hard form (e.g. paper) and visibility on a soft form (e.g. computer screens), and rightly so as this can help assist the facilitation of visually impaired users. Gould et al. (1987), from their numerous experiments found out, that there is a difference between the users' ability to read from a visual screen rather than on paper. In fact, users read more slowly from CRT displays than from paper according to Gould et al. (1987). Some, researchers, even though they are in the minority do not support this conclusion.

What is good to know is that researchers can now point their fingers at a number of elements that cause read delay on visual displays. For example, to be able to read faster, users need to have higher resolution, better display contrast, and dark fonts against a dark greyish background. However, there is no concrete statistics and the latter is not a concrete conclusion of what needs to be done to speed readability on visual displays. These elements surely make up for a good starting point on improving the visual display products to benefit all users out there. However, each element should be well analysed so that researchers can understand which elements influence the reading ability the most. This should be the primary subject of current analysis. Luczak, Roetting and Oehme (2002), comment that,

> "The computer and its applications continue to develop and some of these developments (e.g., virtual reality and augmented reality) require visual displays with characteristics very different from those found on stand PCs."(Luczak et al., 2002, p. 187)

As explained in other parts of this thesis, if the conditions under which, users operate better or if the lack of abilities of the users is made up for by the creation of new more user-centred visual displays, then HCI and computer technology will truly be solving a common user problem. According to Luczak et al. (2002), with intelligent and diverse interaction capabilities, visual interfaces with more spatial resolutions are possible. Devices all the way from lamps to graphic displays have been part of the evolution of visual displays.

Luczak et al. (2002), classify and distinguish visual displays on following parameters,

> "The variation of light or of a physical entity. The nature of data displayed, analogue or digital. The spatial dimensionality of the image produced: one-, two-, or three-dimensional. The set of displayable tokens: binary, fixed character set, or (practically) unlimited. The physical principal of image generation: emission, transmission, light reflection or a combination of these principals. The number of colours the display can present: monochrome or polychrome. The physical dimension of the display". (Luczak et al., 2002, p. 189)

They go on to comment that researchers need to remember that, from this list, only criteria relevant to the field of human-computer interaction need to be considered. Luczak et al., (2002) also alert that the visual hazards and impairments can be caused by displays ranging from effects of radiation and fields, impact on pregnancy, eye discomfort, and effects on skin, headaches, dizziness and musculo-skeletal discomfort. On the other hand, they can be avoided with ergonomic approach and proper work environment setup.

5.4.2 Motivating, Influencing and persuading Users

Not all computer applications have persuasion to do something particular as their scope. However, technological persuasion has been made use of in the design of a number of applications and is bound to continue to grow as research develops and as businesses continue to find ways to generate more profit. While there is no globally accepted definition of persuasion, it is generally accepted that persuasion tries to influence the behaviour of others but this is done without coercion, manipulation or deceit (Fogg, 2002). The relationship of motivating, influencing and persuading individuals to HCI is the very same change that occurs in individuals when using the former techniques. Designers are not too happy about using these methods as they see them as short-term changes and consequently not useful techniques in helping them find long-term solutions. After all, it is one of the objectives of designers to come up with a solution whilst avoiding creating other problem areas.

Persuasion techniques have indeed been used in a number of technological programmes. Although the intention of the technology designers behind this persuasion was a good one that aids others in living a better life, the persuasive design did not have the desired results. This, many argue was because, while individuals are willing to try the new approach, the decision to adapt it as their own is highly personal and consequently, no one can make the decision for them apart from themselves. Fogg (2002) puts forward a good example about how one such persuasive design worked. He refers to the *5 A Day Adventure* application that aimed through technology entertainment to make children eat more fruits and vegetables. The persuasion in this application was quite apparent. While persuasion may be subtle in technology design applications, for instance eBay's constant search for tailor made solutions for their customers; with commercialism, it is becoming more and more apparent. However, other scopes for technology designs are also part of the overall product. Productivity, entertainment and education consequently are a primary focus as opposed to persuasion, which is still an underlying element of the product. The success or otherwise of persuasive technology designs will always depend on the end receiver; but persuasion seems to, at least in short-term, reach its target results.

According to Fogg (2002), computers are influencing and changing the way humans think and act: While this change is happening, people working with HCI technologies help in creating technical solutions and products that influence the behaviour and attitude change. Fogg (2002) continues commenting about technology and devices,

> "They can motivate and persuade by merging the power of computing and with the psychology of persuasion. We humans are still supreme agents of influence- and this will not change anytime soon." (Fogg, 2002, p. 368)

Be it mobile, car computer, desktops, etc., the interactive interfaces are the agents that help influence the attitude and impacts behaviour in humans. Even though computers are not in the same league as humans in persuading and influencing behaviour, computing technology can be programmed to overcome basic human limitations like memory and energy.

5.4.3 Diversity

Interaction is understood as a communication process facilitated through computer applications and interfaces (Wang, Hawk, & Tenopir, 2000). Human beings, referred as users in HCI terms, are in fact able to communicate with other people using computers. However, the ability to communicate varies in different users. This diverse skill range is mainly due to old age, disability, impairment, being a computer novice, intercultural issues and gender implications to computers. Vanderheiden (2002) comments that diversity can be based on different populations as disabilities, gender, language, culture etc. All users can face diverse situations and environments leading to an impact on design requirements.

> "Within a single day a person drives, walks, shops, and recreates, at home, in the office, and in other venues, the differing demands and constraints of the different environments or activities will require different interfaces, often on the same device. In addition, people may switch preferences even within a single environment and activity." (Vanderheiden, 2002, p. 397)

Hence, according to Vanderheiden (2002), diversity of environments, situations and constraints needs to be considered with human diversity. This has led to the creating of products controlled by microprocessors and software that allow the flexibility to the users to adapt the interfaces to different situations- human or environmental. In the following sub-sections, I will discuss human computer interaction in the light of these limitations, that users often deal with when using the medium of computers to communicate.

5.4.4 Gender

The idea behind Design Thinking is to provide the best solution for a problem and is generally gender unbiased. It is interesting to note that since people are behind new inventions such as games; their products tend to reflect their subjective mental state. It is commonly accepted that a woman's place used to be in the house while the man could get education and work. Cultural background plays an important role in these prejudices according to Cassell (2002).

> "…in some cultures, fishing is woman's work, in others it is exclusively the province of men." (Cassell, 2002, p. 402).

These gender biases have been handed down over centuries and the mentality especially prevails when it comes to computer gaming. Consequently, it is correct to assume that technology design can be linked to a particular gender and to say that the design process itself and gender can be the subject of an HCI assessment. Gender discrimination is not always to blame, since a number of studies have put forward statistics portraying males as the highest percentage of users in the gaming industry. These statistics, in turn, will influence design philosophies behind each technology project (Cassell, 2002). Indeed, games and some computing systems have been gender oriented. Moreover, studies of both genders have come up with some interesting conclusions. Boys are more skilled than girls are, in computer design technology, programming and the like. Boys perceive computers as a recreational break whereas girls, showing better mastering of word processing seem to associate computers with work tasks and an overall career assistant. Teachers, it seems have also formed their own perceptions of gender and computers. According to Cassell (2002), teachers have reported that boys, even if they get lower grades, seem to be more enthusiastic about computing whereas girls' achievements are more often the result of hard work (Cassell, 2002) .

Although, the male gender was predominant as the *user* for which most computer designs were intended, now it seems there is a move forward to get the attention of the female gender. However, whether this is recognition of the female gender's ability to use IT technology with the same talent as the male gender or whether it is being done purely for commercial purposes, is debatable. What is certain is that, female users are now also forming part of the scope for which a product is being designed. What HCI therefore tries to uncover is how the genders use computers, what comes more natural to one gender as opposed to the other and how do both genders perceive computers and technology. After all, it is the objective of HCI to come up with solutions to meet the needs of the different technology users, who each have their unique needs. However, because of differences that exists between human-beings (regardless of their gender), HCI experts and other professionals tend to try to meet as many needs as possible with every technical solution they come up with while accepting that, it is not always possible to meet all these needs.

Cassell (2002), however, points that gender bias still exists with software designers, as they are aware of the different reasons for which both genders employ the use of computers; but when asked to draw up a gender free design, the end result is usually one that reflects the perception of the male gender. In addition, she makes reference to the fact that because of the gender's perception and approach to computer technology; it has been statistically shown that the male gender is the one that gets the best deal out of a career in the field. Moreover, as time goes by more employment opportunities require a certain standard of computer literacy. Consequently, HCI professionals have a challenge ahead of them in that not only do they need to make computer an easy to use and learn experience, but they also have to provide more appeal to the female gender.

5.4.5 Old People and Cognitive Support

The world's population is getting older (Randel, German & Ewing, 1999). Because of this, technological design-solutions need to be found, in order to cater for the needs of the elderly. However, looking at a solution for the elderly alone is not enough. Instead, there is a need to address the concept of old age together with the different impairments, this category of individuals in society might have (Newell, Carmichael, Gregor, & Alm, 2002). In fact, there is a combination of needs that surround this particular sector of society; some of which I have discussed in this section. However, examples of difficulties, people this age tend to face are reduced vision, hearing impairment and loss of memory to name but a few. Czaja and Lee (2002) state that functional abilities get affected with age.

> "…changes in sensory-perceptual processes, motor abilities, response speed and cognitive processes" (Czaja & Lee, 2002, p. 418)

Generally, technology design and HCI try to find solutions to motor control problems. Designers, therefore have a challenge in that they need together with the help of other professionals, to come up with design solutions in relation to software and internet applications that can assist in the different needs of these people. How do designers and HCI professionals improve the computer technology experience for these individuals? The starting point for these experts is usually the undertaking of a series of adjustments that are common to computers. By rendering this adjustment approach, for instance by creating bigger keys on the keyboard and larger fonts on the screen, the computer technology system would become more flexible for older users. HCI researchers, on the other hand, may focus on the experience of these users and how they perceive and compare in computer literacy skills. For instance, they can monitor the anxiety, the frustration and difficulty levels of older users.

> "The majority of studies that have examined the attitude of older people towards computer technology indicate that older people are receptive to using computers. They may encounter more computer anxiety and less computer efficacy; however, attitudes towards technology and comfort using technology is largely influenced by experience and nature of interactions with computer systems." (Czaja & Lee, 2002, p. 419)

Consequently, any adjustments carried out by designers should reflect a solution to these users' computer technology experience and make the interaction conducive to usage and adaption.

While there is not sufficient research out there to really enable designers to cater for the needs of older users, immediate attention to this subject is imminent, especially since the world's population is getting older. What is certain as emerging from literature reviews is the fact that when designing for this category of people, the functions need to be planned in the simplest way possible (Dickinson, Eisma, & Gregor, 2011). Technology skills support should be provided while allowing the elderly to learn at their own pace. Avoiding de-motivating, frustrating and too hectic situations may encourage the older generation to get their hands on technology gadgets, as they will eventually see the benefits that emerge out of being able to use them.

Czaja and Lee (2002) provide in the following table (Figure 9) as a guideline for developing interfaces for older users.

1. Maximize the contrast between characters and screen background
2. Minimize screen glare.
3. Avoid small targets and characters (fonts<12)
4. Minimize irrelevant screen information
5. Present screen information in consistent locations (e.g. error messages)
6. Adhere to principles of perceptual organization (e.g. grouping)
7. Highlight important screen information.
8. Avoid color discrimination among colors of the same hue or in the blue-green range.
9. Clearly label keys.
10. Maximize size of the icons.
11. Use icons that are easily discriminated and meaningful; label icons if possible.
12. Provide sufficient practice on the use of input devices such as a mouse or trackball
13. Provide sufficient practice on window operations.
14. Minimize demands on spatial memory.
15. Provide information on screen location.
16. Minimize demands on working memory.
17. Avoid complex command languages.
18. Use operating procedures that are consistent within and across applications.
19. Provide easy-to-use, online aiding and support documentation.

Figure 9: Interface Design Guidelines, (Czaja & Lee, 2002, p. 425)

Cognitive support is psychological support through ICT Design Thinking, for people such as the elderly, who might have a cognitive dysfunction. Cognitive dysfunctions may take the form of failure of memory retention and language (speech, illiteracy and hearing) dysfunction according to Newell et al. (2002). These people's needs may be provided for by well-designed ICT systems. In fact, there is a lot of room for IT designers to help improve the lifestyle of these people and encourage them to be in charge of their surroundings. Newell et al. (2002), provides some examples of how cognitive support through IT design can help improve these people's life styles. Provision of adequate and nonintrusive supervision, allows them to retain a high level of dignity and live independently. Adequate communication and support keeps them both physically and mentally involved facilitating their continued social integration.

There are various ways in which designers may help facilitate and thus provide support to people with cognitive dysfunction. For instance, keeping the system as basic as possible, by building large fonts and functions, are ways of providing support (Newell et al., 2002). Although a lot is being done in order to improve support in this field, much is left to be desired. The improvement needed in IT systems for people with cognitive dysfunction however requires the skills of various disciplines according to Newell et al. (2002). Consequently, there is not only the need to run a deep research into the matter but this also calls for different professionals to come together. In addition, any undertaken research should also include the feedback of these specific users in order for their needs to be met, and for an enhanced solution to be found. This can perhaps be facilitated by methodologies as proposed by designers. On a positive scale, computers may fill in the motor skills gap of people with cognitive dysfunction and just like an iPhone, may be helpful in assisting in the tracking of an individual’s activities to aid memory or to assist in carrying out other tasks.

5.4.6 Disabilities, Accessibility and Inclusive Design

As also expressed in other parts of this thesis, disabilities play an important part in the psychology of design of technological products. This is because designers seek to find a solution while mitigating the rise of other problematic areas in their product design. Disability percentage of users is one of the problems designers have to overcome. While it has been accepted that there is no one-fits-all product, designers try to find solutions that cater for as many needs as possible. Sear and Young (2002) recommend that, it is necessary while there is a need for understanding technology as it is presently available; there is also a need to explore new technology possibilities that overcome the limitations of the current technologies, enhance their potential and develop alternative interaction possibilities. The work of designers is facilitated by human computer interaction (HCI) experts; who take the time to get to know users habits, abilities and time-frames within which they can carry out pre-determined tasks.

An important distinction between disability and impairments has been drawn by WHO (World Health Organization). Sears and Young (2002) state that the WHO published ICIHD-2 (International Classification of Impairments, Disabilities and Handicaps, final draft second version) in 1980, define the terms. While both are the result of a health condition, they are slightly different when it comes to consequences. Impairment means an abnormality or a loss of part of a body structure whereas disability refers to the restrictions on carrying out certain activities by the person who suffers from a particular health condition. Consequently, once an individual has impairment, lack of muscle movement for instance, then he may have a disability (inability to key in a fire alarm code due to lack of muscle strength for example). It is important therefore for designers to take into consideration all technology related restrictions that people with impairments and disabilities will most likely face (Sears & Young, 2002). For instance, there is a lot of social pressure to make lifts, stairs and streets accessible for this category of people; but not the same can be said for generating access to these people in terms of other technological products, with particular reference to the use of computers.

Technology designers' tasks are however rendered quite difficult in the light of the latest technology trend, whereby technology driven products are becoming integral part of every aspect of human life. Not only that, but the designs seem to push for smaller, faster and albeit cheaper products (Sears & Young, 2002) which while benefiting humanity at large, will undoubtedly make the life of people living with a disability more frustrating and burdensome. Among the various disabilities that impinge on the ability of a computer user, one can find- Spinal cord injuries, strokes, muscular problems, epilepsy and other neurological and motor function restrictions. Sears and Young (2002), refer the Maryland Journal article by Young, Tumanon and Sokal (2000),

> "Although computing devices can be convenient tools for traditional computer users, they can also serve as barriers for individuals with impairments. A design process that considers the impairments of potential users can turn these barriers into powerful tools that increase employment opportunities, provide enhanced communication possibilities, and enable increased independence." (Sears & Young 2002, p. 483)

The concept of 'inclusive design' originated in UK according to Clarkson (2003), and was led by the design and the disability communities. The purpose was to extend support and encourage businesses to cope with and cater to the needs of a demographically changing society. Inclusive design was proposed more on the lines of a process and not as a design methodology or performance measurement. Aging population, disabilities, motor-ability challenges etc., create an impact on healthcare, welfare, transportation, cities, houses and other products and services (Clarkson, 2003). The needs of older people and disabled people, for example, are looked upon as special needs. While design and products cater to a stereo-type definition of average or normal based on young, fit, white, affluent male according to Clarkson (2003). Ignorance of the lifestyle aspiration of older and disabled people has led to products and services that do not fit their requirements, reflecting poor quality in adaptation, with a bias that this market has low demand, low margins and commercially unviable. However, for the last few decades, there has been a movement, where designers are consciously trying to address this niche and create products and designs that match-up to the desires of this segment. With the aging population in the western world, this change is becoming more visible because of the obvious increase in commercial viability. Changes in legislative frameworks have also contributed towards the change according to Clarkson (2003).

> "A major driver for change has been the militancy and determination of organisations and individuals pressing the case for equal rights for disable people, and more recently older people. The legitimacy of these developments was first established by the United Nations Declaration of Human Rights (1984), but until recently has been slow, and there is a long way to go before we will see a world were accessibility and inclusion are fully recognised and supported by international standards and levels of provision." (Coleman, Lebbon, Clarkson & Keates, 2003, p. 4)

Computers and HCI has been rapidly adapting to the needs of changing social needs driven by an ever-increasing market. Assistive and inclusive features that were 'hidden' are becoming not only visible but also being promoted actively. In mobile devices and even in the latest operating systems, voice recognition and commands, zoom capabilities, clean and large interfaces, inbuilt device location features etc., are now selling features, promoted actively, and not limited to fulfilling legislative requirements that have led to adaptations.

5.4.7 Cultural sensitivity in design

The latest technology products serve wide arrays of different users. Meeting different needs is also the business goal of most corporations who deal in IT products or services. This part of the thesis puts forward a brief analysis of the importance of drawing up a comparative analysis of different cultures. The importance of this cross-culture analysis in terms of HCI is that by drawing up conclusions about the way users in diverse cultures experience computers, it will intensify the research into a better understanding of the way users interact with computers. The result is that computer programmes and hardware will eventually be designed on the findings of this research. In fact, research has evolved to such an extent that it can account for several culture related issues and their impact as per individual culture on a particular computer function or hardware design. The impact is where HCI comes in. Built on HCI observations, the next stage is that of finding solutions to any gaps discovered. This responsibility rests on designers. Being part of a culture themselves, designers are also influenced by their own culture in the way they perceive their own designs. Marcus (2008) argues that consequently, all designed artefacts are cultural objects. Cultures therefore are the backbone for any user related research for advancing the users' computer experience. Cultures are like a measuring tape, against which the extent to which designers may adopt a globalized approach to computer design and ultimately align users' common needs and interests can be benchmarked. To meet the multicultural needs of interaction, two design strategies are implemented- internationalisation and localisation.

> "…internationalisation, by which every country or culture obtains an identical user interface…localisation, by which every culture obtains a culture specific user interface." (Pedell, Degen, Lubin & Zheng, 2003, p. 233)

An appropriate balance of both, internationalisation and localisation, are necessary for ensuring commercial success according to Pedell et al. (2003). Some examples of how inter-cultural studies in relation to computer technology has progressed would include: a better understanding of how different cultures react to colours, their preference with regards to background colour, the likely underlying cognitive and emotional approach (for instance, the Muslim culture would be saddened if interest profiting websites are promoted in their culture). In addition, there are various hierarchical subjects that are common to all cultures such as politics, religion, approach to gender, health, prominent regional disabilities, information technology know-how, overall educational level and economics (Marcus, 2008). These cultural aspects are usually good starting points for cultural assessments. It has been acknowledged, that while areas such as disabilities, have common problematic needs, each user is different and culture does nothing more but add to the different needs of people that fall within this group. The assessment of different cultures of users' behaviours is consequently a challenging aspect of HCI. The scope is always that of rendering the use of computers more efficient, and one, which as time goes by, meets more users' demands.

5.4.8 Information Visualization

There are many things that come to mind when one mentions the term 'visualization'. According to Card et al. (1983), even researchers and professionals understand different things when discussing this concept. This is mainly the result of the endless possibilities by which one can generate images and the varied objectives for which these images are generated. The objective of visualization is to help entities and stakeholders share different points of view through the use of visual diagrams and images in order to expand on what humanity feels to be common interests as well as proposing ways to ameliorate the current state of affairs.

Visualization is the ability to form a mental picture (Spence, 2007). Card et al. (1983) maintain that latest research carried out by Skeels, Lee, Smith, and Robertson, (2008) has coined, for the first time the term 'information visualization' although they acknowledge the pre-existent use of other phrases with the same intended meaning such as 'visual display', 'visualization' and 'scientific visualization'. A definition of information visualization as proposed by Card, Mackinlay and Shneiderman, (1999) was,

> "Information Visualization is the use of computer-supported, interactive, visual representation of abstract data in order to amplify cognition". (Card et al., 1999, p. 7)

Consequently, Card, et al. (1999), recognise the fact that computers are used as a tool through which the image is portrayed and through which cognition of information is facilitated. On the same line of thought Chen (2006) described visual information as a computer-aided process that serves to optimize users perception and visual-thinking capability in understanding concepts that are not easily represented visually and briefly explained as a method for seeing the unseen (McCormick, 1988). In addition, Keim, Panse and Sips (2004) put forward proof that a certain level of convergence between geo-visualization and information visualization exists.

Computer graphics, images and IT are some examples of the means used to project visual data. Individuals are making use of and noting information all the time; especially hypermedia technologies together with other latest means of visual displays are quite well known to computer users. Means of visualization can be categorized in two ways; the heavy visualization tools and the lighter visualization tools. Heavy visualization is that approach whereby a lot of info is placed on the image in an attempt to communicate it to the user whereas lighter visualization requires less data and the focus is on the image.

Lindquist (2011) propose that visualization can be classified as follows:
Information visualization and data analytics requires the co-existence of multiple computing and graphics disciplines with the motive to have a visual representation of a spread of science based information. This approach also includes the amelioration of how humanity is able to assess and learn information. *Graphics and information display* promotes the attraction of different designs in putting forward information having as underlying intentions namely interaction, marketing/advertising, and new ideas. *Visual facilitation* approach is highly dependent on visualization techniques and the idea behind it is to use diagrams as a means of encouraging thinking, strategies and comprehension of other people and their needs as well as difficulties. Which type of visualization technique is used often depends on the end recipient and the reason why the visualization is needed (Lindquist, 2011).

The importance of studying the interaction of users and means of visualization has been highly recognized. For instance, it can help cross-border governmental exchange on observed users' experience statistics, thereby contributing to the overall well-being of computer technology according to Lindquist (2011). Once visualization dynamics are reported to technology experts, they can in return apply this knowledge to ensuring a better user experience and the continuous growth of visualization technology.

5.4.9 Designing for wearable computers

There is no one definition that explains wearable computers, as a definition is highly dependent on, the scope and area of use of the wearable computer design. However, a successful wearable computer system is one that caters for the various needs about the work development and the user's body condition. It is consequently important that the users take on a focal role in designing wearable computers (Rügge, Ruthenbeck, & Scholz-Reit, 2009). Recent years have seen an impressive advancement in the area of wearable computing solutions but at the same time, its launch into the market has encountered several barriers leading to technical shortcomings of the technical applications that have been made available to date. Because of this, many suggestions have been put forward to allow for more configurations and the need to invest in new methodologies. Since wearable computers, as the name suggests, are aimed at being worn by users on their body, the development of particular wearable computer apparatus need to take the semblance of serial clothing manufacturing (Rügge et al., 2009). This recommendation was merely derived from the fact that for wearable computers to be useful they will need to be equally acceptable by users. Hence, Human-Computer-Interaction (HCI) methods are central to the development of wearable computing systems. The main issue surrounding the constant improvement and acceptance of wearable computers is linked to the fact that these are dependent on central application software systems; which gives rise to numerous difficulties in ensuring that the wearable computer is flexible enough to be adapted to the users. This is especially true with the various components that are being added to wearable computers, which renders the issue of co-relation to body movements and consequently user flexibility quite a challenging task for designers (Scholz-Reiter, Windt, & Freitag, 2008). In fact, although there is a market for wearable products, the latter has not been tailor made to meet the needs by providing solutions to the relevant market sector yet. Some examples of wearable computers are gloves, mobiles and vests, although the later and the former example are still work in progress. Characteristics pertaining to Wearable Computing Solutions that have been found to be most likely common to all would include-

- sensitive (sensors)
- are wireless
- allows the user to be hands free while constantly operating even though the wearable computer is a mobile product
- provide user support
- acts as an information channel to its owner even if not being used and
- is user environment sensitive etc.

All these can be said to be characteristics of Wearable Computing Systems. However, according to Rugge et al. (2009), while these elements are the scope of wearable computing system, their presence does not imply that they can burden the mental state of the user as this detracts from the users' ability to focus on the main task and as such wearable computers designers should also aim to prevent cognitive overload.

According to Siewiorek and Smailagic (2003), Carnegie Mellon University has developed a User-Centred Interdisciplinary Concurrent System Design Methodology (UICSM), that uses experts from the field of electrical engineering, mechanical engineering, computers, industrial design and HCI, to build rapid prototypes with the end-user. As the methodology is web-based, it is not only possible define interim design results and products and follow the evolution of the design, but also the designers and end-users can participate in the design activities remotely.

> "The design methodology proceeds through three phases: conceptual design, detailed design, and implementation. End-users critique the design at each phase. In addition, simulated and real application tasks provide further focus for design evaluation. The methodology has been used in designing over a dozen wearable computers with diverse applications ranging from inspection and maintenance of heavy transportation vehicles to augmented reality in manufacturing and plant operations. The methodology includes monitoring and evaluation of the design process." (Siewiorek & Smailagic, 2003, p. 636)

Siewiorek and Smailagic (2003) hold that there is a lack of consensus around the mechanical and software interfaces and in the capability of the electronics since there are multiple dependencies ranging from inspection, maintenance, manufacturing, navigation to on-the-move collaboration, position sensing, global communication, real-time speech recognition and language translation.

5.4.10 Design for Pleasure

'Aesthetics' is a Greek word referring to sensory perception and understanding or sensuous knowledge (Costello & Edmonds, 2007). Eventually, the term started to be used to mean gratification of the senses or sensuous delight (Goldman, 2001) which is what visual artistic products aim to achieve. According to Jordan (2000), pleasure is the emotional, hedonic and practical benefits associated with products.

It has been acknowledged that designer should strive for aesthetic pleasing designs; although as will be explained below, the aesthetic appeal of a product should not mask the failure to meet other technical needs of the product's intended use. For instance, a social network might be appealing in sight boasting a colourful or tailor made background with a lot of opportunity for social interaction. However, a social network might lead its users to experience frustration; if for instance, the users need to go through a lengthy process in order to delete unnecessary email histories. A designer consequently has the role to ensure that the sensory pleasures received by the design of a product are in similar proportion to a positive users experience by ensuring that the product has undertaken sufficient assessment to meet the use it was intended for in the first place. Resultantly, according to Desmet and Hekkert (2007), sensory pleasures should not be the sole focus of designers, as neglecting the functionality aspect of the product design might ultimately lead to a displeasing user experience.

Nonetheless, both the aesthetical factor and the functionality element of a product are important considerations in the design development as they both contribute to the successful marketing of the product in the end. If designers take both of these factors in to account when envisaging the design, it may be said, that they are ensuring that users actually have a full experience of the intended product. Hand-in-hand with this, other human elements such as emotions, understanding, the abilities to use what is learnt, cognition, disabilities and motor skills should also form part of the overall product development analysis (Hekkert, 2006). Intertwining all these separate yet co-related aspects of a design process proves a challenge even to the most capable of designers. This is so since the traditional view of artists is one that sees them as free and unencumbered from the constraints designers are typically faced with. Hence, a multi-disciplinary approach is always a better option than a one man job when designing for pleasure, especially as design needs to look into different perspectives in such a way that is it meaningful to people (Bardzell, Rosner, & Bardzell, 2012). This requires an advanced level of expertise involving creativity and reasoning with strong communication skills, supported by ethical and aesthetic sensibilities and thus creating more complexity for supporting pleasurable design (Bardzell et al., 2012). In addition, lack of design knowledge in the field had been widely recognized. For instance, Kaplan, Chisik, and Levy (2006) hold that designers of children's digital libraries and pedagogic tools are not knowledgeable enough to create an attractive children's reading experiences. Children as consumers of online books, therefore, need to be the centre of observation of designers to be meet their tastes and needs (Kaplan et al, 2006).

The design for pleasure process is generally linked with playful interfaces in an interactive art context such as online gaming, PlayStation and Xbox. The process also involves the first step of developing a concept (as is mostly favoured in traditional Design Thinking) which is later tested against an evaluation of users' experience (Costello & Edmonds, 2007). It is therefore part of Design for Pleasure to compare artists' perspectives what constitutes pleasure as experienced by them against users' experienced pleasure during evaluative workshops. Contrary to the traditional view taken on artists, artists involved in the interactive art area have their focus placed on delivering a pleasurable audience experience and consequently, account of users' limitations, needs and abilities is made room for which leads them to recognise the fact that restrictions are applicable to their creative designs.

According to Dickinson (2003), the thing that speaks directly to the people works well as a design concept. Since human beings mix emotions and cognition when purchasing products, interface and product designers had to begin considering the emotional and pleasurable aspects of products in terms of users' satisfaction (Buccini & Padovani, 2007). Consequently, interactive artists take a more user-cantered approach in the design development process of their artworks (Costello & Edmonds, 2007). By adopting the user focused approach, interactive designers have taken guidance from the studies in the areas of HCI, design, and social science. One can therefore conclude that while the scope and end result of a design for pleasure is different from regular design projects, the methodologies used in the two different fields are aligning themselves with design methodology as we know it today (Costello & Edmonds, 2007).

As has been explained in previous sub-headings, the design process of a product requires designers to take into account a number of factors such as the methodology employed, the functionality aspect of the product and ease of use, the materials used, cost and time planning as well as ergonomics. However, Buccini and Padovani (2007), argue that the experience factor (the sensation, emotion and pleasure derived) is still a much neglected part of the design process, especially when designing for pleasure. It is easier for people to appreciate the use of products that are more entertaining as aesthetics stimulates their creative ability. Conversely, attractive products are easier to use and are consequently more in demand (Kuniavsky, 2003**).** In line with this view Norman (2005) holds that, more than the practical elements, the emotional side of the design may be more important, as consumers' choice of a product is not only a rational one, but also an emotional decision. Consequently, consumers' pleasure should take the forefront attention, in addition to the functionality or use-aspect of the product, thereby adding to the challenges designers face in their projects. According to Jordan (2000), usability, functionality and pleasure should be all related, as the product should be functional, usable and pleasurable. The debate of quality in interaction design assumes quite an important aspect in designing for pleasure and consequently, it has been suggested that designers should not limit themselves to usability but rather to understanding usefulness and together with this, designers are to understand human emotions, users' experiences and how they experience pleasure (Buccini & Padovani, 2007). The inadequate presence or absolute absence of any of these three elements as described by Jordan (2000) may lead to users' dissatisfaction, which can harm the overall business success of the product.

Understanding people and their interaction with products is the main objective behind the Pleasure-based Design theory (Jordan, 2000**).** The Pleasure-based Design theory aims to understand where the stimulation of human beings is derived from. A number of methodologies have emerged from the Pleasure-based Design theory and are based on four distinct levels (Buccini & Padovani, 2007). The Physio-pleasure stage which is associated with the senses (including sensuality); Socio-pleasure as emerges from social relationships using a medium of communication, as opposed to being face to face or people who share similar thoughts. The cross-reference to people's cognitive and emotional feedback in relation to product usage (Psycho-pleasure). Finally, the intellectual artistic value (from books, art and music) of a product (Ideo-pleasure). In line with this, there are four Design for Pleasure principles (also applicable to all senses) that should be adopted when designing a product aimed for the entertainment of its users; the product should provide to users "*maximum effect for minimum means, unity in variety, most advanced, yet acceptable, and optimal match*" (Hekkert, 2006, p. 157). In addition, Ueki, Kamata and Inakage (2007) hold that in order for a design to embrace the daily life of human beings, it is no longer appropriate to opt for products that require intense concentration on part of the user, but products should rather seek to be more entertaining while remaining useful at the same time.

According to Hekkert (2006), another relevant theory in Designing for Pleasure is the appraisal theory, which proposes that the emotional feedback to products is in itself, an appraisal and it can be seen as either in a positive or negative light. An example is the purchase of a suit whereby an individual might experience distaste for it being too fancy. A professional tailor-made suit may on the other hand, provide peace of mind to the purchaser, that they will receive a lot of attention when wearing it. An important consequence of the appraisal theory is that each unique emotion has its own pattern of appraisal, but there is almost no link between a given circumstance and the resultant feedback, thereby dependent on interpretation of rather than the event itself. Interpretation is an issue of emotions and how people deal with will influence individual's appraisal process. Resultantly, more research is required in order to understand any similarities and dissimilarities in the appraisal process of the human race at large (Hekkert, 2006).

A fact however, that has been ascertained is that human beings will always have more desires to be fulfilled, thereby calling upon the need of constantly improving and upgrading products. This on-going need of humanity to have something new is "*associated with contemporary, unsustainable patterns of consumption*" (Woolley, 2003, p.77). This in return calls upon designers to enhance their expertise in the field of users' desires (Buccini & Padovani, 2007). In addition, products are deemed as being limited with time. This is because the pleasure, users derive from products, will drastically reducing, with the passage of time. The extension of products desirability is consequently yet another challenge for designers (Woolley, 2003). Moreover, designers also need to keep in mind that products that are Designed for Pleasure need to cater for long-term communication while at the same time provide means by which the privacy of the users' interaction is kept intact (Dickinson, 2003). Christou, Zaphiris, Ang, and Law (2007) hold that in today's time, an online game is considered to be of good quality if it also provides the pleasure of socializing with other players, although more research into the integration of both game design and interaction need further investigation.

5.4.11 Designing Decision Support Systems (DSS)

Decision Support Systems (DSS) is a term used whereby computer are designed in such a way as to allow them to be an "*active participant in the problem-solving and decision-making process*" (Smith & Geddes, 2002, p. 657) of computer users. The analysis of how humans perform in terms of computer skills and how they perceive, acquire skills and face problems, is consequently central to designers of decision support systems. In fact, the designers will need to rely on a human centred approach in order to add to the design, users enhancing skills. This is how decision support systems provide support to users. What type of decisions do users have to make when using computers and what kind of problems can they face? This question centres itself on the computers' operating systems, which may become inefficient or faulty due to slips, lack of knowledge of an application or errors made by both the design and implementation team, as well as by users in general. Some examples of errors would include the Designer Error, the System Approaches to Error and the Errors and Cognitive Biases-Implications for Design (Smith & Geddes, 2002). A Designer Error is usually indicative of failure of designers to foretell the way users will apply and approach the DSS. This can also be taken on a group level, whereby the error is usually due to lack of coordination and appropriate planning or the process itself that is applied by the group in making design decisions (Janis, 1982). System Approaches to Error focuses on how errors are approached and the process in which they are prevented. It is not a good practice to become obsessed with all that can go wrong. According to Smith and Geddes (2002), ultimately, for a system error to take place a number of co-existent elements have to be present and they are likely to be fixed prior to the system error taking place. Errors and Cognitive Biases-Implications for Design are errors that due to their consistent occurrence indicate that there is a problem with the approach taken for the design. It is, as already indicated, the designer's role is to ensure that the design does not give birth to new problematic areas, which will also require design solutions. Consequently, for designers to be successful in what they do they have to make sure that their knowledge is up-to-date with recent progress. Any of these errors, if existent, may result in a deficient DSS design. Indeed, new problem areas are usually tackled using the general problem solving approach (Newell, 1990), which should be handled using a decision-process based on expertise and know-how. However, instead the latter is used in errors, people are more familiar with.

The success of a Decision Support System depends on two factors. Firstly, a good cooperative approach from users, and the design and implementation team, as errors are possible with any of these people. Secondly, the constant research and upgrading of the DSS by designers and related professionals, as Smith and Geddes (2002, p. 659) hold that "*it is not safe to assume that no further changes will be needed*".

5.4.12 Empathic Design

Emphatic Design is not a standalone area. The empathic design methodologies were first introduced by the electronic and automotive industries. Thereafter, the empathic design techniques have been widely applied by several other business industries. In fact, it has its roots in marketing research and strategy, better known as marketing investigation as well as in anthropology. The original approach of this investigation is to use both qualitative and quantitative research tools to investigate human life and behaviour as it generally takes place. The first use of Empathic Design was found at the inception stage of product development or better in the Design Thinking process, which gave rise to new ideas (Wang, Hwang, & Ho, 2009). One can appreciate the important role played by Empathetic design since product innovation is what provides a competitive edge to businesses in today's ultra-dynamic economy (Deszca, Munro, & Noori, 1999). The main reason behind this shortend development period is according to, von Hippel, Thomke and Sonnack (1999), is the fact that the users themselves would have already adapted themselves to improving a product. Hence, the empathic design observation of consumers' usage experience is valuable and will put forward pre-tailor-made solution. However, if the increase of productivity in the development life of the product is to be experienced, different groups should participate in the observation process made up of various experts such as anthropologists, ethnographers, engineers and designers (von Hippel, 1999).

Leonard and Rayport (1997) believe that there are five stages in the empathic design process, namely, the observation stage, the recording of information stage, the reflection and analysis stage, the brainstorming for solutions stage and the stage involving the development of prototypes of possible solutions step. The observation phase is highly important for the discovery of new ways of how users perceive products and services (Leonard & Rayport, 1997). A technique added to the observation step is the Kano model (Sauerwien, Bailom, Matzler, & Hinterhuber, 1996) which involves various groups of designers from different disciplines and groups of different customers, as well as the use of surveys. This enhances the brainstorming session for data collection which is then recorded by means of a diagram (Lofthouse, Bhamra, & Burrow, 2005). Another technique added to the observation step is that of *probing* as used by Mattelmäki and Batterbee (2002). This observation technique enables designers to collect data by recording habits, activities and different styles of use (Mattelmäki & Battarbee, 2002). Diaries, flash cards and camera recorders were used as tools to gather this information.

Brandt and Grunnet (2000) suggest adding tools to create a closer connection to the process and its use in real life. These tools help advance the empathic design process as this ensures the collaboration for the generation of new design concepts, as users would be deeply engaged in the design process itself (Brandt & Grunnet, 2000). An excellent example of the observation stage using other tools and a real life product in the empathic design process is that of designing for baby bottles. A number of designers in Milan decided to observe new mothers as they picked up their children from their nurseries. Observation also took place in these new mum's homes. By observing how these parents and children interacted with their bottles, these designers were able to understand the needs of this target market. Notes leading to data collection were recorded while the observation was taking place (ICSID- International Council of Societies of Industrial Design, 2006). As a result of this process a series of differently designed bottles were then produced. This example shows how the proposed empathic design process can be applied to develop successful new products.

A close by approach to the end user of the product seems to be inevitable in emphatic design. In fact, Suri, Batterbee and Koskinen (2005) make mention of designers going to the extent of putting themselves in a specific category of users (the visually impaired). By wearing glasses and working in a dimmed light environment, these designers could mimic similar users' perspectives and better understand, what they go through, as well as come up with ideas of what type of design would help improve the product for this select category of users (Suri, Battarbee, & Koskinen, 2005).

The recording of information phase may take place through the use of prototypes and role-playing together, with other means of learning as these allow designers to gather customers' feedback. An *avante garde* empathic design process application is that carried out by the company, bearing the name IDEO which truly believes that experiencing things first hand is the best way to cater for the human factor which is the underlying inspiration of emphatic design (Leonard & Rayport, 1997). On the other hand IDEO while still basing their design model process on that of Leonard and Rayport (1997), they place the understanding of the market, customers, technology and possible limitations as step one of the empathic design process (Kelley & Littman, 2001). This is followed by the observation phase which requires observers to note what customers like, love or simply can do without. Also of importance in this stage is the observation of what is not working well and thus necessitates improvement that will enable designers to meet the needs of potential customers. In-depth observation is therefore a fundamental step for the successful process of this design method. The next step involves the creative aspect of visualizing new ideas, followed by the evaluation and refinement of the prototype stage. The empathic design process is then finalized by coming up with marketing schemes to sell the new design idea. The five steps of the empathic design process are promulgated by Leonard and Rayport (1997) is merely the background framework serving as guidelines to other empathic designers. In fact, other designers have indeed built upon the emphatic design process as proposed by Leonard and Rayport (1997). The introduction of new techniques over and above those of the five-step design process framework is consequently, a common occurrence.

5.4.13 Worth-Centred, Value-Sensitive and Ethical Design Thinking

According to Cockton (2005), HCI has evolved from a system centric approach in the seventies, to a user centric approach in the eighties and context centric approach in the nineties. Today HCI focuses on a value-centred design methodology. Each of these approaches has made valuable contributions to the design approach and one can look at a computer system design as being a cumulative output of the technology, the user, the context of usage and the intended value. Design can be defined as the "*intent to create value*" (Cockton, 2005, p. 1292). One should not confuse value centred design with value sensitive design, as the latter is based on human values with an ethical import. The term *worth centred design* which was proposed by Cockton (2005) helps to allay this confusion.

Value Centred Design (VCD) or Worth centred design (WCD) attempts to design systems that are not evaluated just on the basis of usability or contextual fit, but rather on the value that it provides the end user. Product features do not automatically translate to values; rather it is the perception of the system by the user, based on his interaction with it in a particular context. The user's own psychological values, needs, wants, motivations and goals also influence the perceived value of the system. (Kujala & Väänänen-Vainio-Mattila, 2009). Cockton (2005) proposes that value centred development framework consists of three main activities – value identification, value delivery envisionment and value impact assessment. Value identification is the phase in which the intended value or benefits of the system is defined (Cockton, 2005). WCD requires users to be involved in the design process from the very beginning and not just during the evaluation phase. Thus, user needs are the starting point of the design of a system, and the system's success is based on how well it addresses the needs and wants of the users. Usage contexts shall be studied in this phase to identify what are the needs and wants of the user in the specific context. Usage of personas, story boarding, culture diagrams and focus groups are some of the techniques that can be used to uncover the values of individuals as well as the contextual group - either the work organization, or the family members or the stakeholders as the case may be. Worth mapping can be performed using techniques such as sentence completion (Cockton et. al., 2009). For example, while designing a patient care system, the primary value for doctors would be easy access to the medical records of the patient. The primary value for a caregiver could be the ease of recording the patient's progress and the ease of retrieving his medications. For a patient, who is an indirect stakeholder, the system's worth may be measured by the access-security of the system which protects his information from unauthorized access. The outcome of the value identification phase is a set of intended value statements, the format of which can be arrived, depending on the level of detail required. It is ideal to keep these statements brief and to the point, so that it can be easily documented, accessed and analysed throughout the design and evaluation phases. The value statements shall be converted into measurable evaluation criteria that can be used to measure the design or to perform a comparative analysis of competing designs. It is ideal to have a weight assigned to each criteria, so that in case, design trade-offs are necessary, it is easy for the designers to prioritize which needs are more important than others. The evaluation criteria of the system shall also include questions on whether the system manages to deliver the intended values.

The design activities shall be focused on achieving the intended values as a result of the human interaction with the system. The value delivery envisionment is achieved with the help of scenarios that describe how the intended value is delivered by the system. Cockton et al. (2005), hold that this will be closely aligned to the evaluation criteria for the system. The interactions of the users with the system are designed first and then translated into implementation. In the value impact assessment or the evaluation phase, the criteria defined earlier are used to evaluate whether the system delivers the value for which it was designed. Evaluation methods to monitor and measure the value achievement include user testing as well as continuous monitoring of the system in real usage situations. If the evaluation results, show that there has been a value loss (or a gap between the achieved value and the intended value of the system), then a process of iterative development shall be followed, until the system is able to deliver the intended value. In an ideal scenario, this should be done without compromising on usability or contextual fit; however, if a trade-off is needed, WCD recommends a trade-off of usability to achieve the intended value, than the other way round. In fact, only those usability issues that directly lead to a loss of value are taken forward to the next iteration for remediation. Causal analysis can be performed during the analysis to identify reasons for the poor evaluation results. Poor results may not always be due to poor design, but could also be due to poor understanding of what is worthwhile by the stakeholders. In such a case, educating the users about the benefits of the product is a much better approach than a change of design of the product. Thus, WCD offers total iteration potential where anything from the users' perceptions to the interactions design and even the implementation can be fixed. As a result, all stakeholders are involved in the iterations in order to design a 'worthwhile' product (Cockton et al., 2009).

Value centred design aims to achieve a balance between a commercial sense of value (value to the supplier) and an economic sense of value (value to the buyer). Most often, design is focused only on the commercial sense of value and aims to create products that are 'profitable' in a 'market' and are 'competitive' in terms of price and features. Worth Centred design is focused on the context of impact and not on the context of use of a product. Thus, a product's quality is defined as its ability to meet the wants and needs of the people and a poor quality product is one which has a reduced worth (Cockton, 2005). As computer based systems and products move from the work place to other arenas of life such as home, entertainment and even expressing one's identity (social networking sites), the scope of WCD has shifted from cognition and efficiency for a work system to emotion and fun for a leisure system. The parameters of worth would vary widely based on the profile of the user and the purpose of the product as well as the context of use. Thus, a smart phone's worth for a businessman may be measured in terms of the speed with which a calendar entry can be retrieved, whereas for a teenager it could be the speed of upload of a picture on to a social networking site. The achieved worth can be assessed in terms of the 4Ds – donation, delivery, degrading and destruction where the design delivers more than expected in the first case, as per expectations in the second, or less than expected in the third and none at all in the fourth (Cockton & Campus, 2004).

Yetim (2011) holds that Worth Centred Design aims to keep iteration and evaluation as distinct from each other. The evaluation of a system is based on the value achieved through interactions with the system rather than on the features of the system or the usability of the feature. Thus, if a system has an easy to use interface, but does not aid the user in achieving what he wants, then it is a failure as per the WCD methodology (Yetim, 2011). Worth Centred Design allows integration at an activity, role and domain levels (Cockton, 2006). The total iteration model of WCD allows activity integration across all the design and development processes. It encourages role integrity by forcing frequent interactions between the design team, the sponsors, the end users and other stakeholders in the project. Domain integration is arrived at, through cultural forms in worth arenas. WCD aims to focus the development activity on the user goals while designing digital products and services. It is thus commercially oriented as it evaluates a design based on what motivates usage and purchase of a product and not just on interaction quality between human and machine.

Worth-centred design is still not widely used, and thus there is an absence of proven approaches for this design. In order for Worth Centred Design to be more widely used, there has to be more work done in the following areas:

- Formats for capturing intended value and evaluation criteria
- Methods for documenting scenarios to explain the value delivered by the system
- Methods for measuring the impact of usability and contextual trade-offs in an attempt to achieve value

Value Sensitive Design ('VSD') is a design approach that emerged in the nineties, and advocates a focus on human values throughout the design process of information and computer systems. VSD aims to be proactive about human values during the design process and to account for human values in a systematic, comprehensive and principled manner. Value Sensitive Design draws heavily from other fields such as Computer Ethics, Participatory Design and Social Informatics. VSD encompasses the different values that may arise in different contexts – workplace, home, online communities and even e-commerce. Some of the key human values that VSD focuses on, include cooperation, participation, democracy, privacy, trust, human dignity and well-being, informed consent, intellectual property, ease of use and universal access, standardization of technical protocols and freedom from bias. (Borning & Muller, 2012).

Yetim (2011) holds that, VSD has an integrated tripartite design methodology involving conceptual, empirical and technical elements. Conceptual investigations are mostly philosophical in nature and involve analysing issues such as how to conceptualize values, how to assess them and implement trade-offs between competing values such as security vs. trust or universal access vs. privacy. Empirical investigations use quantitative and qualitative methods such as surveys, observations, and focus groups, to study and measure the user response to the technology. Technical investigations focus on the design and the performance aspects of the product and encompass both the study of existing products and technologies as well as the design of new systems. These three investigations are performed iteratively during the design of a product. Value Sensitive Design can start with any of the three investigations and it can be successful regardless of which investigation is started first. For example, a browser cookies and privacy design started with conceptual investigation (Millett, Friedman, & Felten, 2001); the Watcher and Watched studies started with empirical investigations (Friedman, Freier, & Kahn, 2004); and technical investigations was the starting point for the CodeCOOP project (Miller, Friedman, & Jancke, 2007).

VSD does not consider values as endogenous or exogenous, but rather as an evolution of the interaction between people and technology according to

Friedman et al. (2002). Thus, while VSD attempts to adhere to certain universal values, it also appreciates the fact that the manifestation of the value would vary in different cultures and different contexts. Values vary not only across cultures, but also between genders. Diversity, for example, provides yet another filter to evaluate the list of values that the designers have shortlisted. VSD should be inclusive and include diverse views and be acceptable to all sections of the population, including minority groups. VSD involves both direct and indirect stakeholders, i.e those who directly interact with the computer systems as well as those who are affected by the system indirectly. For example, while designing a medical records system, VSD would focus not only on the usability factors of doctors, medical workers or insurance personnel handling the system directly, but also on the privacy concerns of patients who are indirectly affected by the system. VSD projects are often not only focused on incorporating values into computer systems, but also on how design can contribute to social activism (Friedman, Kahn, & Borning, 2008).

As VSD is involved with the concept of values, there will be different perspectives that would come up during the design process, and the design team should focus on arriving at a common ground between the explicit values identified during the initial phase of the project and the values of the stakeholders without being biased by the designers' own values. Friedman et al. (2008) hold that methods of participatory design, collaborative ethnography and action based research can be valuable tools in the VSD process. For example, the co-design model of participatory design, the scenario-based requirements gathering from end users, observation of users in their work contexts etc., allow the designers to garner valuable insights about the key values of the stakeholders. Most VSD projects focus on one or two aspects of values such as security, information bias or privacy, but do not take a holistic view of values. VSD also focuses on the value conflicts within an individual as well as value conflicts within a system and is committed to analysing and uncovering such heterogeneity. According to Borning and Muller (2012), VSD can be used to investigate how a technology affects human values at both the individual and the collective levels and how values can drive the design modifications of the technology, data usage and the system interface. It is necessary that human values are given as much importance as some of the more traditional design criteria such as usability, accuracy and reliability, while designing technology systems and evaluating whether a design is good or not. Just like other design criteria, Value Based Design may also require trade-offs. However, if a design team has commitment towards Value Based Design, it will automatically become part of all phases of design such as requirements analysis, conceptual design, the embodiment design, the design evaluation criteria and the final product. Good value sensitive design aims to arrive at the right balance between the social values and the technical requirements of a product (Borning & Muller, 2012).

In order to enable more widespread adoption of VSD, the following aspects need to be addressed according to Borming and Muller (2012)-

Adapt the 'universal values' paradigm of VSD: VSD is based on the premise that certain values are universal in nature and only their manifestations differ based on culture and context. This is often too simple a view to be of practical use. Over the years, VSD proponents themselves have changed their view on how universal should values be, and whose values should design aim to emulate. If there is a focus on universal values, invariably, there will be a cultural or religious group that would emerge as the proponents of those values and may attempt to impose these values on others forcefully. The other extreme of being parochial in approach will not be beneficial, either. Therefore, VSD needs to be open to the modelling of a defined set of values, which are adopted at the requirements gathering phase of the design, rather than try to emulate a universal set of pre-defined values.

Develop a list of values for initial consideration during the design phase based on the context, use of the product and user profiles: VSD literature is replete with lists of values, which can be used as starting points during the design of a technology system. However, most of these lists do not refer to the context and culture for which they are applicable. One such list included the thirteen values of Human Welfare, Ownership and Property, Privacy, Freedom from Bias, Universal Usability, Trust, Autonomy, Informed Consent, Accountability, Identity, Calmness, Environmental Sustainability and Courtesy (Friedman & Kahn, 2002). However, these values are not universal, but rather representative of a liberal Western society. Thus, it may not be applicable to a conservative Eastern society product. A much better approach is to define the list of values, which are important for a specific design project, after taking into consideration the context of use, the culture and profile of the target user and the nature of the product (Le Dantec, Poole, & Wyche, 2009). For example, a military application may be designed with the values of courage, discipline, honour, loyalty etc., whereas a medical application may focus on privacy, accuracy etc., as the core values. It is also necessary that the list of values are documented in the local language as often, the translation from English to a local language can result in a different meaning being attributed to the value.

Enable the voice of the stakeholders to be heard in the right forums: Although, Value Sensitive Design and Participatory Design focus on a democratic approach towards design, often it is only the voice of the researchers that are heard in forums and journals. It is important for the advancement of VSD that the voice of all stakeholders finds equal representation, so that the technical knowledge and contextual knowledge are equally incorporated into this field. This is especially relevant for VSD, where the researcher's own value systems and culture may influence his authority and knowledge and bias his views and impact the impartiality of the solutions being proposed. Multimedia such as audio and video recording, storyboarding methods, and photographs can be used to make the voice of the end user heard during the VSD process. Newer modes of engagement such as social media platforms can be used to encourage a wider participation in the design process, and crowd sourcing can help in the design process, especially during the short listing of values stage.

One of the key benefits of having a value sensitive methodology of design is that it allows for the constant critical re-evaluation of the value systems of the stakeholders and designers. It also explores the evolution of values due to the use of new technology and computer systems and how societal values influence their development. Therefore, it is necessary that VSD does not stop evolving at any point in time. Using an original list of twelve or thirteen values as the starting point of every VSD design would mean that the field gets stunted. Instead, a participatory and contextual approach is necessary to fully obtain the benefits of VSD (Friedman, Kahn, & Borning, 2002).

Ethical design is aimed at widening the criteria used to judge the quality of computer systems and interfaces beyond functionality, contextual fit and usability to include the aspect of how well the system aids in the advancement of ethical values, either through the technology itself, or through the interactions with the stakeholders. This field of study is also concerned with how ethics can proactively influence the design of technology systems during the conception, design and implementation stages. Ethics can be defined as a rational study of the moral dilemmas in human action. While the concept of a moral action vs. an immoral one, varies from one person to another, depending on several factors, including their personal beliefs and values, there has been an increasing focus on making design ethically correct and to include ethics as a specific design imperative in the design goals stage itself (Feldman, 1978). Ethical principles for any field are defined by a set of guidelines. Some of the key questions that designers should consider while following ethical design principles, include, the ethical goals of the specific project; based on the user profiles and the context of use, whether the design is environmentally ethical, inclusive and multi-cultural; the means to achieve an ethically sound product design; the methods and tools used; and finally, how to ensure that the form and function of the product are not compromised in an attempt to be ethically right.

Website design is one area, where ethical considerations have been discussed and debated upon. Often, the established ethical code for software engineering – the ACM-IEEE Joint Software Engineering Code of Ethics (JSECOE) is adopted as the ethical baseline for website design as well (ACM, 1999). The first JSECOE code advocated that "Software engineers shall act consistently with the public interest" (ACM, 1999, p. 1) while the second code was modified as "Software engineers shall act in a manner that is in the best interests of their client and employer, consistent with the public interest" (ACM, 1999, p. 1). Ethical website design thus needs to hold public interest as the key focus area. Since JSECOE is not prescriptive in nature, there have been various views on the guidelines for ethical web design. Harris (2009) proposes four broad design guidelines for websites, which is equally applicable for other information systems based products, as well. These are:

- "Information should not be hidden.
- Information should not be used or transferred without proper consent.
- Consent should be properly obtained.
- Privacy should be maintained". (Harris, 2009, p. 215)

Other attempts at ethical design of information systems based products include, making sure that there is informed consent in an acceptance of a Web browser's tracking cookies; ensuring the right encryption for communication protocols; designing gender inclusive computer games (Flanagan, Howe, & Nissenbaum, 2005); and of light weight vehicles, where there is a focus on not compromising on the ethical values of safety and environment protection (van Gorp, 2005). Ethical design is faced with numerous challenges as it is not easy to achieve an ethical design of an autonomous, neutral and inclusive technology that supports ethical values while remaining rich enough in features so as to be commercially viable. There will often be competing ethical values from which the designer will have to choose the right set of values to be modelled in the specific design project. There is also the challenging question of how to identify the right points during the design process where ethics should be considered and evaluated. These questions must be kept in mind while designing an information system, in order to make the ethical design attempt successful (Palm & Hansson, 2006).

According to Robertson (2006), ethical design is important because, as information technology permeates day-to-day life of humans across various environments such as work and leisure, there is a risk of specific metaphors of human behaviour being embodied into the technology. This can result in an enforcement of, albeit inadvertently, a specific set of ethics and values into the work place, the organizational culture and even the social identity of the end users of the system. Ethical design allows the stakeholders to choose between alternative interaction design decisions that are similar in terms of functionality and usability (Robertson, 2006). Another way to look at ethical design in cyberspace is through the structure of network architecture and the seven layers of the network (Gleason & Friedman, 2005). There are different ethical considerations to be addressed while designing each layer of the network. The physical layer or the hardware design has considerations such as the environmental impact during the manufacturing and use of IT systems and equipment such as mobile phones. They emit radiation during use, there is a need to ensure that the carbon footprint is kept low for computer systems while they are transported from the country of manufacture to the country of sale, and finally the disposal of toxic waste during manufacturing and the disposal of e-waste after the system itself is discarded. There is a human element to be considered as well, as the continuous use of IT systems cause ergonomic health concerns such as wrist pain and carpal tunnel syndrome, eyestrain etc., which are caused by the incorrect design and use of keyboards and computer screens.

At the network layer, issues such as availability of domain name servers and domain name management are ethical in nature. (Gleason & Friedman, 2005).

The user interface through which the user interacts with the underlying computing system in a device, poses its own set of ethical challenges. According to Newell (2011), ethical design should aim to be inclusive in nature – the interface should be accessible and usable by people across gender, disability, age, language and other differentiating factors. Good design should also remain sensitive to cultural differences. As the internet increasingly becomes a medium of social identity, it is necessary that users are made aware of the rules of cyberspace at the technology and social levels, in order for them to take advantage of the medium, without being taken advantage of. When protocols or standards of technology are created by a small group of individuals or private players, it poses ethical issues as well, since the standards may be created in such a way as to encourage the commercial success of a particular product (Ostrow, 1998). Copyright and patent violations in design are also of importance, not just from an ethical design perspective (Stair & Reynolds, 2011), but also from a commercial perspective as is evident from the recent patent lawsuit win of Apple over Samsung, which may force Samsung to withdraw many of their successful smart phones from the American market. The issue of regulatory compliance is also a key focus area of ethical design and attributes such as privacy, data collection and sharing, archiving and backups are designed based on the applicable regulatory requirements.

Davis (2009) holds that, a participatory design approach helps to create a communication process between the stakeholders and designers, thus allowing a discussion and debate on ethical issues such as privacy, corporate responsibility, awareness, informed consent and sustainability, during the design process. An ethics centred consultation process with the stakeholders will contribute significantly to the design of the product. According to Sicart (2009), in ethical design, a 'one size fits all' approach will not be useful, as the ethical considerations while designing a computer game would be vastly different from the ethical considerations while designing a robot that is used for assisted living by the elderly. While the game design may focus on aspects of privacy, promoting violence or being gender neutral, the ethical considerations in the latter case are likely to revolve around the artificial bonding between man and machine and its social implications on human relationships. This is because, even though there are certain universal ethics, their applicability varies based on the context, user, culture and even the regulatory environment (Sicart, 2009). A good design team has to approach the design with an open mind and engage in a dialogue with the stakeholders to arrive at the ethical considerations that are important for the specific project, in such a way that the greater good of humankind is not compromised for the commercial success of a product.

5.5 Conclusions and further Reflections

Gordon E. Moor, the cofounder of Intel Corporation stated that the number of components in the integrated circuit (IC) had doubled every year since invention of the IC's in 1958 (Kanellos, 2003). He further commented that the same trend will continue for the next 10 years (Moore, 1965). Not only have his predictions been accurate when it comes to the semiconductors industry, they resonate positively in almost all technologies associated with the consumers of the semiconductor industry. Lot of digital devices are linked with the capacity enhancements of the semiconductor industry like processing speed of machines (computers), memory capacities, pixels in a digital camera etc. These too are growing exponentially and hence affecting human life in the same manner. To look back a few more decades, before the invention of the telephone, it would have been unimaginable that most homes in the world would have an instrument that anybody in the world could ring and could talk. It must have been further impossible to imagine that this could be done also wirelessly and with live video as we now use mobile phones capable of this today. Nobody might have even dreamt of the good old postal system becoming obsolete with the advent of fax machines, and the fax machines in turn almost exiting, because of email services. Computers in the early days were the big crumb-some giant machines that were in the basements, which only experts new how to use.

Today, the computer in one form or other, is omnipresent in every aspect of our lives. If we empty our pockets at any given point of time, we could find at least a few of the following computer aided devices in our pockets- phones, digital keys for car, cards for carrying money, shopping loyalty cards, digital keys for homes and offices, digital storage devices like pen-drives or microchips, Bluetooth or wired audio equipment to just name a few. It is extremely difficult to predict what the future may look like. It depends on multiple factors and is only limited by the capability of humans to dream of possibilities. We know some basics of us as human beings and our ability, efficiency, effectiveness and learnability to work with digital devices with the insights from various branches of science not directly connected to computer engineering. Design of the interface between technology and humans has evolved, all the way from the time, design was associated to arts and crafts, to the time when it became more structured with engineering processes and now we have it evolving further where design tries to address human problems and challenges with optimization of technology, in order to allow humans to effective and efficiently complete their tasks as depicted in Figure 10.

The Usability Engineering approach takes into, account humans as an integral part of the ecosystems in which the machines operate. It also takes into account the special needs of certain groups of humans, which have special and specific needs. It focus on trying to make the human users of technology complete their tasks as efficiently and effectively as possible with minimum learning time and with minimum errors. Even though focus of HCI is solving the usability challenges of technology, there is the limitation to address fundamental question of what is the basic problem or challenge or opportunity of the human life form that technology is trying to address.

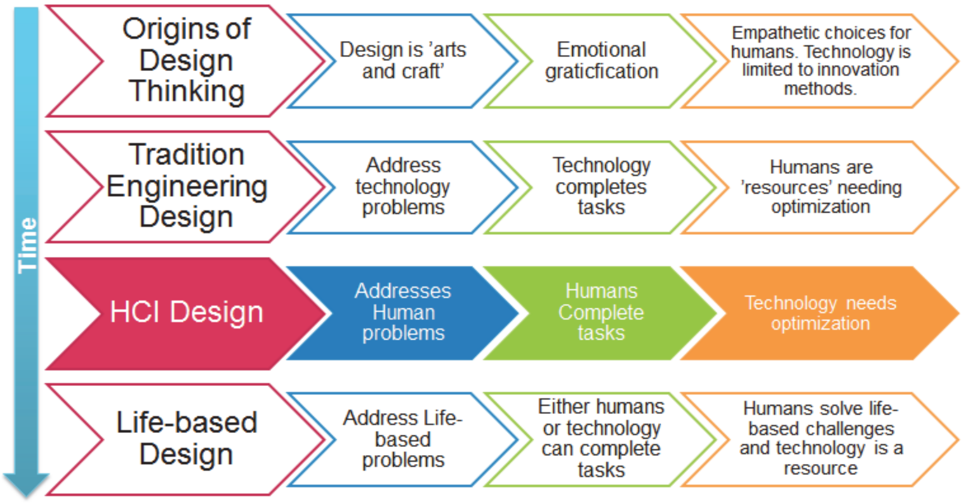


Figure 10: HCI approach towards Design

With the focus of my study being the creation of application in the Social Work domain, I find the evolution of the Design Thinking theory fascinating in terms of worth, value and ethical arguments. Social Work by itself is 'worthy cause', based on the values of the people or organisations involved and promising to deliver ethical solutions to real-life problems. Hence from my perspective, the first step towards creating solutions aimed towards this domain should also first try and understand what is the real-life challenge that exists, that needs a solution. In the following chapter, I look in to the concept and framework presented by Leikas (2009) around life-based design. The theory uses 'form-of-life' as the fundamental fulcrum to evolve solutions that address the challenges that real life situations, human life throws up that designers needs to design solutions for.

6 LIFE-BASED DESIGN APPROACH AND FRAMEWORK

In this section, I have tried to reflect on the life-based design theory and thinking; a radical new thought process that tries to analyse the root cause for the need for design. Life-based design proposes the need to analyse the fact that products and technology are not a mean by itself, but a mere tool to solve a real life problem or challenge that humans face. This thinking steps away from addressing the design challenge as a way to optimise the performance of machines or technology as well as addressing the human performance issues. It dwells on a more fundamental issue of identifying the real-life challenge, which needs to be solved, where both technology and humans can be resources. The expected result is not optimizing the technology performance or the human performance, but solving the fundamental life-based problem itself. During which, it may happen so that there may be a need for optimization or learning of either the technology or the human participants.

With the advent of the computer age and a vast majority of people having to work with computers, it has become necessary to look at design from a holistic perspective. Technology cannot exist in isolation limited to machines, but humans are an integral part of the ecosystem now. The approach towards designing the interface between computers or digital systems and people cannot be limited to technology, but needs to be addressed from the human perspective than a technology perspective. In other words, instead of technology focus to address challenges of daily life it is imperative that the approach needs to come from the human angle. Real life situations throw-up problems or challenges and we humans try to find solutions. Thus in order to find solution, it is imperative to understand people's lives in the first place. This is especially relevant since the problems or challenges in real life situations are more-and-more driven by the integration of the technology in life itself; which in turn, is not limited to physical products only, but to services and the designing of services.

Leikas (2009) proposes the concept of 'form-of-life' as the main concept behind Life-Based Design approach in order to propose a well-grounded set of tools and methods to investigate and examine the elements of life itself. In order to understand the form-of-life, one starts with defining what people do by following their rule-following actions and attributes in a context. Once the form-of-life is defined, it helps the designers to figure out what can be done in order to improve the lives of people affected or sharing that particular form-of-life. Once the form-of-life is defined and followed up by defining the rule-following actions (RFAs) and Design Relevant Attributes (DRA), Technology Supported Actions (TSAs) can be extrapolated; which in turns creates the grounded work for the designers to define problems accurately and work on solution to solve or address them (Leikas, 2009).

6.1 Designing for life

As technology evolves, it simultaneously integrates seamlessly with our lives. It throws up new situations and paradigms, we as human being need to learn, understand and adopt in order to be users of the technology. This is done consciously and even unconsciously. Today we tend to take technology evolution for granted and as a way of life. This phenomenon is no longer limited to certain geographies, but is evolving as a global phenomenon. Digital products and services that were exclusive to the western world are no longer so. To cite an example, TV is relatively a new phenomenon in India. National telecast was introduced in 1982, prior to which only seven cities had television service. This service was limited to the state run channel- Doordarshan. Colour TV was also introduced to the Indian market for the first time in 1982 (Wikipedia, 2012d). In a very short period, the country of 1.3 billion had national television coverage with hundreds of television channels. Content became accessible through multiple modes- free-to-air, cable, Direct Broadcast Satellite and IPTV. The information revolution did start with the TV, but the internet and the growth of the IT outsourcing business and with a huge young, educated and content hungry population's need and desire for access drove technology to homes in all urban areas as well as a fair coverage of the rural areas too. Technology, which was a rare phenomenon until the 80's and mid 90's in a couple of decades, has become completely integrated in the lives of urban Indians. The consumption and use of technology is no different any more in India (and for that matter most Asia), to the west. Be it email, internet, mobile telephones, navigation systems, home security systems, interactive TV, intelligent kitchen utilities, intelligent air conditioning systems, on board computers in cars, all now form an inseparable part of daily life.

In the previous section of HCI Design Thinking, the concentration of the Design Thinking was all about how to integrate technology in human life as seamlessly as possible. HCI broadly deals with usability and ergonomic issues regarding making technology usable from a learnability, adaptability, and intuitional usage for human beings. It focuses on the ability of humans to interact with the technology, their competence and ability to work with the technology and the limitations that the technology needs to overcome in order to become more usable. Jordan (2000) observes that the fact that this approach can almost be dehumanising since usability tends to view products as tools and people as cognitive and physical components, within a human-technology system. This will lead to creation of products that are easy to use and display human efficiency in their usage. This approach alone is not enough. However, on one hand, it qualifies the products or service as efficient and easy to use, it does not take into account the fact that products and services that are not supporting everyday lives of people and the values that follow; will not be enticing for users to use (Leikas & Saariluoma, 2008).

Leikas (2009), in her thesis states that enhancing the quality of life should be the focus of technology, efficiency and effectiveness, which are the traditional benchmarks of usability, have no real way to connect technology to life. The focus of designers needs to be on 'what' do people actually want to do and 'why' instead of 'how' the users do it. In other words, there is a need to make sure that the process needs to figure out 'what' is the challenge or opportunity that people face in real lives, what do they want to do with that situation and why do they want to address it in that particular way. The usability aspect of how best can technology address the situation or how satisfied are the users with the technology solution is not enough. Better usability will no doubt affect the perceived value of the product or the service, but this may not be enough to address the value and the motivation of people to use a product or a service. It is necessary to consider other influencers towards the decision making process.

The original idea of different forms of utility of things was introduced by Paulsson and Paulsson (1957). Redström (2001) comments on the practical use, social use and aesthetical use of products. Mobile phones have the practical use of being able to talk to other people. On the other hand the model, can be influenced by the social symbolic value attributed to the phones like smart phone, flip phones, etc. Different cultures may have different value systems that drive decision-making. In China for e.g., successful business people want to be seen with smart phones- the bigger- the better. On the other hand, in the Nordics, the same smartphones are desired for a very different social purpose. Smart phones allow discrete and varied communication alternatives for different situations. It is very common practice to use the phone as a navigator, a wallet to make payments and use as a mobile bank, entertainment in form of mobile games etc. People tend to like their instruments to be discrete but at the same time to offer and cater to all their needs of modern urban dwelling (Redström, 2001). Aesthetical values on the other hand can be a reflective choice based on preferences of beauty. Certain people prefer Nokia Lumia 900 in the blue, black and pink colours that are available with the launch, or others prefer to wait for the white colour model is promised to be launched. Some people prefer the rugged and metallic finish of iPhones while others prefer the plastic and lightweight feel of Samsung phones. Thus, the aesthetical preference goes beyond the practical as well as social use of the product or the service and is driven by individual likes, dislikes, and preferences.

According to Leikas (2009), technology solutions not only need to address the physical usage of the products and services but need to take in to account various factors like social environments, psychological impact, motivation influencers, context of need, the real life individual situation etc. Technology needs to improve the quality of life in general by adding value to everyday lives of people. Without the tie-in of the technology to the value it generates in the lives of people, its reason for existence is nullified. Usability *engineering* thinking and approach alone is not able to identify the value it brings to the people's lives. Designers need to refocus their attention towards designing for life instead of optimizing the efficiency and effectiveness of the technology or solution. Leikas (2009) holds that, deep understanding of human life itself and its elements need to be analysed in order to create the right goals and make the right decisions towards the design process. This also means that the focus of testing design needs to happen much earlier in the process at a more fundamental level. It cannot start with the testing of usability of tools or solutions, but needs to begin at understanding the challenges or opportunities that the real life situation throws up for the people. It may even mean that the original pre-conceived notions of the designers and tool creators need to be discarded completely and a very new approach for finding solutions needs to be examined. Life itself needs to be looked at closely in order to identify the challenges and opportunities within. This acts as a starting point to understand the people's needs and their goals, which in turn helps to understand and identify the design goals. Leikas (2009), proposes the use of 'form-of-life' (Figure 11) as the basic concept and building block to analyse the relation between everyday life and technology paradigms; thus opening up the possibility of investigating various biological, psychological and socio-cultural aspects of life in order to create requirements for the technology solutions.

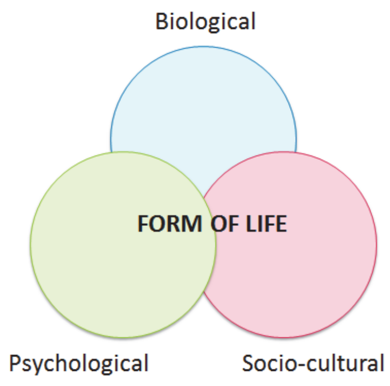


Figure 11: Form-of-life comprising of Psychological, Socio-cultural and Biological aspects (Leikas, 2009, p. 88)

This could create the starting point for creating the right cues for designers to arrive at their design goals for a holistic understanding of people's real life needs and preferences in context of their environment (Leikas & Saariluoma, 2008).

6.2 Form-of-life and Technology

Technology is an inseparable factor of human life. Its evolution is dependent on the evolution of our way of life and our way of life influences the evolution of technology. What comes first is a matter of contention. We do not necessarily develop technology to address a particular need. Technology can even create new needs. For example, with the development of internet, an array of products and services associated with the internet have been developed and have become a part of our everyday lives. Basic tools like internet banking or mobile banking are not developed because there was a need for them. They were developed because it simply was possible to develop them. With banking going online, the number of services that a bank offers in physical reality have been diminishing. It is common for banks to have interaction possibilities at a local branch to be chargeable to the customer, while the internet service is a free service. These changes in the way business is conducted is not prompted by the technology developers, but is a side effect of the actual technology development (Leikas, 2009).

Form-of-life itself has been changing with internet, mobile telephony, smart transportation systems, smart household devices and more. These changes in the technology landscape change the human life forms too. The experience is multifaceted in form of social-cultural, psychological as well as biological level according to Leikas (2009). To continue with the discussion of Internet and mobile telephony, the root of major changes in society arise from the fundamental changes that these technologies bring in communication. We as a race, have come a long way from having communication in form of gestures in prehistoric times to modern times where communication has endless possibilities and ability to communication is not restricted by the technology, but enhanced dramatically by it. Nevertheless, at the same time, the new technologies changed the form-of-life, we were used to for generations. For example an everyday form-of-life of washing clothes or washing dishes has undergone a dramatic change. Instead of simple tools like brush, water and soap, we are now faced with the choices of instruments we need to buy, the space we need to make in our houses for having these instruments, the electrical needs for the instrument etc. In Asia, where even today, domestic help is easily possible for a factional cost of an electronic instrument like a dishwasher or a washing machine. People consider cleaning as their trade and are able to offer manual cleaning services every day for the same. In this form-of-life the person who comes to the house daily for cleaning the dishes and clothes plays a minor part as a member of the household. This presence of these people interacting with the people living in the house, offers a chance for some level of socialization to both the parties. There is a relationship formed and thus results in the service provider becoming a minor part of the household. The task that the person may end up performing are not necessarily limited to the agreed tasks of cleaning the dishes and washing the clothes alone. It is common that the service provider does minor things in the house that does not necessarily form a part of the terms of employment.

In my opinion, this is the change in form-of-life that happened during the transit from the time when the woman of the house did the laundry and dishes and the men worked outside to earn money, to the time when the woman stepped out of the house and became breadwinners too. What is different in the evolution of the forms-of-life in the west compared to Asia is that the woman in Asia is still the 'home maker' even though she may be working and earning like her male counterpart. These are undergoing a change, but rather slowly. With technology, there has been a possibility of this change getting more rapid. It has been easily possible for years now for people to buy washing machine, dishwashers and vacuum cleaners and substitute the service providing people with them. What in reality has happened is that people do buy these instruments but do not stop the services of the human service providers. In real life, the household wants to adapt to the new changing technology without letting go of the old way of having domestic help providers who are a social contact point for the members of the family. It is normal that people have all the modern gadgets that technology has to offer in their homes, but have rarely used them by themselves. On the other hand, the service providers, who may not have the expensive instruments at their own homes, use these instruments in their employers homes. It may sound strange for people from the west to understand why do families have all this electronic equipment and at the same time still use the help of domestic service providers. There may be multiple reasons for the same. One of the main reasons is the non-willingness of the households to give-up on the social contact with the domestic workers they have and visa-a-versa. Secondly, the cost of the wages if the domestic works to the family is not unaffordable in most cases, since they work in multiple places and are not dependent on a single income. Thirdly, with commuting time rising rapidly in most metropolitan areas in Asia, the time available at home is very small. It is not uncommon to be commuting back and forth from office for 2-3 hours every day, thus leaving very little time at home for domestic chores, even though they may be automated.

One more example is that of the technology that goes in car design. In India, for example American brands like Ford and GM had a challenge in increasing their market share for a long time. The cars were designed for use on western roads and driven in a form-of-life by drivers who were also the owners of the cars. The driver's seats were the most comfortable and the digital tools were aimed towards addressing the needs of the driver, who in the west is also the owner of the car. In India, it is very common for people to hire drivers for driving their cars. These owners found the passenger seats in the back very uncomfortable and did not see the use of the electronic tools in the car. The question was why pay for things you did not use. Later on this was changed, more comfortable passenger seats were introduced, and at the same time, electronic equipment that was useful for the passengers was introduced. This changed the buying pattern of the customers who saw the new designs catering to their form-of-life. Again, over the years, there has been a rapid change and cars In India are more and more self-driven, leading to subtle changes to make the driver's experience more pleasant. The more technology becomes seamless in daily life matters, the designers need to dwell deeper on the fundamental questions of what form-of-life are they trying to address in order to be able to designing the right technology solutions for their users.

Form-of-life is not a predetermined or voluntary choice of human beings. They simply can be by-products of the situation in which they dwell. Technology around us, by itself can throw up new forms-of-life, or rather, we human beings can land up in different, varied and ever changing forms-of-life. With the institutionalization of mobile technology in human life, not only as mobile phones but smart devices like web pads, navigation systems, and other communication devices, that till very recently did not exist, we are faced with a challenge of adapting to the new technology possibilities and moulding our lives around them. Before the mobile phones, parents and guardians did not have any way of keeping in touch or track the movement of their children when they were not in controlled environments of their homes or schools. It was not even deemed necessary to do so. However, with mobile phones or even simple tracking devices, children and parents can stay in touch. Parents can keep track of their children without seeming to be intrusive (McNamee, 2005). Children on the other hand may experience a feeling of empowerment with their mobile phones with the ability of calling, texting or simply writing emails on the go. The mobile device (phone, pad etc.) creates a completely new set of possibilities. A very accessible phone number for example is the beginning of the personalisation of the device. Then come things like colour, and 'clothes' for the device that can be add-on's. The screens of the device are customised. The ringtones can be customised for individual listed on the phone or for groups. For example the user can store a different ringtone for her family, than the tone she has chosen for general numbers. She can further customise the phone by choosing a different tone for every member of a family. Thus rendering a personality that is an extension of the person using it (Hulme & Peters, 2002).

On one hand, these mobile devices have a tangible value in the lives of human being and at the same time, it is easy to observe that some of them even have a social status value associated with them. Business application on a mobile device can be a strong driver. On the other hand, business with the availability of mobile devices, is not limited to the designated office space (May, 2001). It is a new form-of-life to be doing 'business' while talking on the phone in the car or writing business mails while waiting for the dentist's appointment. At the same time the car can also be a place where people listen to music, talk to friends, listen to shows, look for information about shopping, eating, places of interest on their navigation devices etc. Moreover, while sitting in the dentist's waiting room it is possible not only to write business mails, but use social networking sites, play games, learn new tools etc. The mobile devices and the internet have blurred the physical boundaries of our lives earlier segregated in compartments by physical spaces of home, office, school, car etc.

Leikas (2009) divided the rules and regularities of form-of-life in three types viz- legal rules and social norms that govern the society, the conscious way of acting and lastly the unconscious tacit regularities in behaviour. The multidimensional structures of the form-of-life concept need to be examined through the core concepts of different disciplines such as psychology, sociology, biology and ethics. The complexity of the topic and the interdependencies coming for different core concepts make the concept of form-of-life elusive (Leikas, 2009). Nevertheless, human life is complex, and designing for human life betterment is bound to be a complex issue too and the idea and concept of form-of-life enables us to integrate these various core concepts and ideas to be able to design technology.

6.3 Life-based design process

In order to leverage and use the Life based design approach, Leikas (2009) has proposed a framework and a practical approach towards embedding this concept in the design development flow. This subsection details out the framework of the concept and the steps proposed in order to use this concept in the development process. Leikas (2009) proposes that the analysis of life itself is the starting point of the design. In the Life- Based Design approach, the early design phases are important and targeted at producing design ideas for concept design and human user requirements for the development of the concept itself. Being an iterative process, it means the inclusion of the definition of the design problems, creating the design solution alternatives, analysing these design alternatives, and subsequently constructing the design requirements from shortlisted and acceptable design alternatives. She further goes on to prescribe the methodology and the framework for the concept with the definition phase of the problem that the designers want to address and solve as the first step in the Life-Based Design process. The next step is the linking of the form-of-life using the form-of-life analysis to the design plan. Form-of-life is based on the multidisciplinary sciences both social and human, which is analysed using established and verified methodologies from these sciences. This FoL analysis approach is strategically different from traditional concept design approach. This approach focuses on the strategic management of the design through design relevant attributes, which are the outcome of the FoL analysis. Leikas (20009) holds that Life-Based Design is an iterative process. It is made up of four stages. The first being, defining of the design problems by analysing the form-of-life; followed by the second step of generating the possible design solutions; followed by analysing the design alternatives; and finally creating the design requirements from the shortlisted accepted design alternatives. The following subsections provide a brief description of Leikas's proposal of the Life-based design process.

6.3.1 Process Description and theoretical background

Life-based design is not an independent process in conflict with the more traditional Human Computer Interaction or Usability Processes. The framework does not aim to substitute the existing process, but compliments and supplements the existing processes and ideas. The aim is to leverage the understanding of the users as people with real emotional, psychological, cultural, practical and social needs as much as looking at their performance and perceptions using the tools and aids that they are currently using to complete their tasks. The biggest change in the way life-based design influences the conceptual design process is the early involvement of the users in the process, as early as beginning to describe the problem statement itself. This frees the problem statement creation process, being held hostage by the limited understanding or abilities of the designers, usability experts, product designers, engineers and the tool creators.

Conceptual design and life-based design are different on one major count. The conceptual design process aims to define the technical solution in a hands-on manner. On the other hand, Life-based design process aims to develop a conceptual description of a technology that can be later leveraged to develop solutions- technical or otherwise. Following this process, I have tried to develop a rational base and model, tried and tested with real people in their real lives to derive their requirements on which the design can be based or tools can be identified, chosen, modified and applied. The concept of life-based design is derived from the original ideas presented in Wittgenstein's works-Philosophical investigations (as cited in Leikas, 2009). He introduced his idea of form-of-life as human forms-of-life are defined by the fact that they are forms created by language, and that language is the mark of human sociality (Wittgenstein, 1953). The Life-based design paradigm is introduced based on the concept of form-of-life (FoL). Forms-of-life are combinations of Rule-following actions (RFAs) based on peoples biological, psychological and socio-cultural facts and values. The transformation of the rule-following actions into technology-supported actions (TSAs) is the main innovative step towards life-based design (Saariluoma & Leikas, 2010). The life-based design process is not a linear process but an iterative one according to Leikas (2009) and the following four steps are proposed as part of the process.

6.3.2 Definition of design problems (Rule-Following Actions)

To fully comprehend the goals of the users, it is necessary for the designer to define the rule-following actions (RFA's). It means understanding the perceived needs of the people. This approach is not substituting or separating the understanding of user needs but is an inclusive process. It is important to study and understand people's needs in a comprehensive manner as a starting point.

It means exploration of the connection between the emotions and the value people set for elements and artefact in their lives. Based on these we investigate the possibility of using or leveraging technology to support the actions of people and the fulfilment of their goals in their desired formats. These RFAs, facts and values concerning the form-of-life, lead to the design-relevant attributes for the design problem at hand.

6.3.3 Design Ideas (Technology-Supported Actions)

Since not all design problems have a technology solution or even may not need a technology solution, in this stage it is necessary to investigate and define the technology supported actions (TSAs) needed for addressing the design challenge. TSAs are the actions that can be realized with the help of technology and are important in deriving design ideas from the forms-of-life. The design-relevant attributes meaning, relevant rule-following actions and form-of-life attributes helps define the TSA. After investigating a form-of-life, and finding the RFAs and attributes (facts and values), and then deriving design-relevant attributes based on the RFAs, the next step is to differentiate the actions that can be supported by technology in some form or the other. These constitute the TSAs or technology supported actions. To create a structured technical description, the following elements need to be in place to describe the problem and issues that need investigation.

The hierarchy of the information collected and analysed can be assembled in the following manner:

- TSAs: Technology supported actions and goals
- The agents
    - o Design Relevant Facts
    - o Resign-relevant Values
- The context
    - o Physical
    - o Social
    - o Emotional/Psychological, etc.
- Technology possibilities
    - o Hardware
    - o Software, etc.

The Figure 12 depicts the flow of the arrangement. The first step is the defining of Form-of-Life (FoL). This helps create the Rule Following Actions (RFAs). The RFAs in turn help generate the Technology Supported Actions (TSAs). Design relevant facts and values are identified and the context from physical, social emotional perspective is described. Technical possibilities from hardware and software perspective need to be evaluated based in the insights thus gathered. Technology driven functionalities can be derived based on this evaluations. It is important to note than Life-based design conceptual framework is not necessarily and an exclusive technology building framework and hence technology supported functionality need not be an obvious outcome.

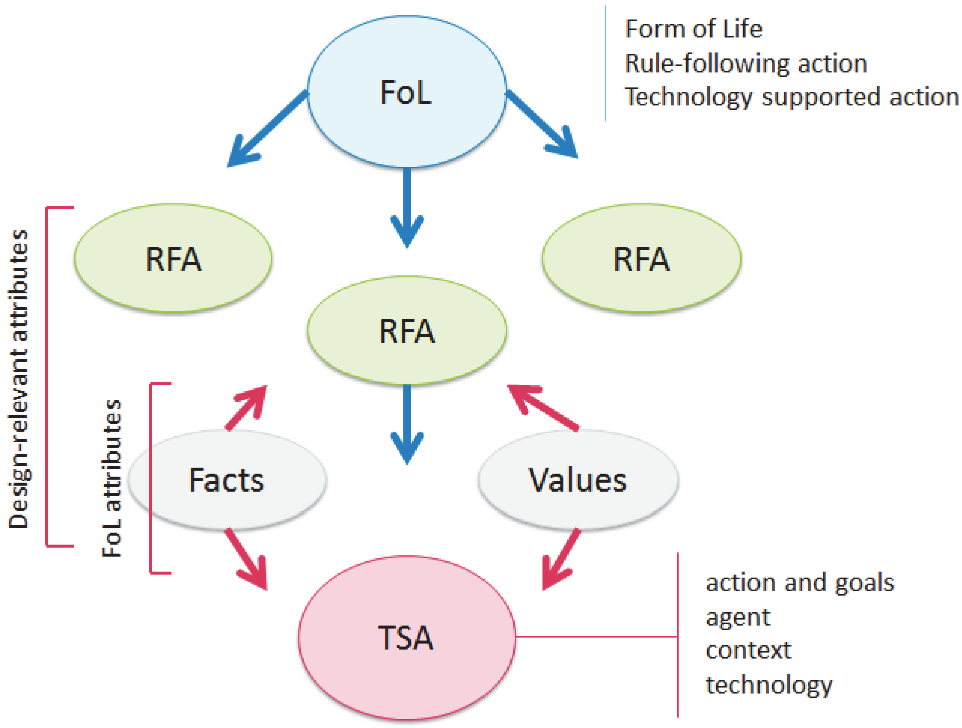


Figure 12: Generation of design ideas from a form-of-life (Leikas, 2009, p. 166)

6.3.4 Design Alternatives (Sub-Problem analysis)

It is rare that we are able to identify a problem in isolation without any dependencies or offshoots. As the design process moves forward, multiple sub-problems get generated or identified. Design thinking entails a reflective mode as proposed in "Content-Based Analysis of Modes in Design Engineering" (Saariluoma, Nevala, & Karvine, 2006). To analyse the TSAs better, we need to go back to the original problem and divide it in to a set of sub-problems. The sub-problems can be divided in two categories- conflicting or complementary.

6.3.4.1 Conflicting sub-problems

Conflicting sub-problems lead to conflicting solutions. It is upon the designers to choose the possible solutions based on multiple possibilities. It is not possible to use conflicting sub-problems in the final solution for the lack of functionalities requiring different things in similar situations. Resolution to the conflicting solutions can be found using attributes and information to distinguish between parameter of usability, ethics, social acceptability, user performance or perceptions etc. (Leikas, 2009).

6.3.4.2 Complementary problems

Sub-problems that are not conflicting but are targeted for different roles in the final solution and have different functions in these roles are complementary problems and help in the smooth realisation of the final solution. The identifying and addressing of the sub-problems by choosing between conflicting solutions and combining complementary solutions aids the design process to weed out any possible failure points and create a more robust technical possibility. The design process is synthetic and its task is to integrate the solutions into the final conceptual design output (Leikas, 2009).

6.3.5 Construction of design (Concept Design)

A satisfactory product or service concept, as a result of addressing all the TSAs, through design requirements, is the construction of design phase. This results in tangible goals for the technology design. The final concept of the product needs to be connected in a detailed manner to the TSAs and to the form-of-life of the target group. Any gaps will lead to challenges in the design plan and need to be addressed early enough to avoid risking possible solution failures.

In the construction of design phase, problems need to be identified and solved to avoid a random solution process beginning in a non-planned and non-aligned production phase. The risk becomes even greater when the engineers who try to address the problems later on in the production phase may not have skills, insights, knowledge, and sensitivity or expertize to address these problems. This may even lead to complete solution failure from the point of perspective of form-of-life.

> "The criterion for the goodness of the concept description is in its fit to the actual TSAs and the form-of-life they are supposed to support. The criterion for the concept description is how suitable it is when it is embedded into the form-of-life. Thus the form-of-life and its rule-following actions and relevant factual and value attributes are important along the whole conceptual design process". (Leikas, 2009, p. 170)

6.4 Conclusion and further reflections

In this chapter, I conclude the final part of the literature review, which started with Design Thinking which was primarily arts and crafts before systematic engineering processes were proposed, defined and implemented. This in turn underwent a fundamental change with the advent of the computer age, where the human became a part of the puzzle that designers needed to solve. Life-based design approach further enhances the role of the human by placing the human life as the core to even start the design process, which aims to create solutions that are result of the need arising from a real life situation in form-of-life that the humans participate. This also concludes the journey of the literature review to modern times where new concepts and methodologies are presented regularly in order to address the Design Thinking challenges. I have chosen to follow the Life-based design approach towards designing a practical application in my research because it holistically approaches the design challenge. It places the human participant not only in the centre of the design process, but it places the human participant as the root cause of the design process itself. The idea and the framework revolve around the core concept for the various forms-of-life (FoL), which we humans participate in, and the needs, opportunities and challenges arising from them (Leikas, 2009); which in turn need to be analysed primarily to enable designers to create solutions. This approach takes the HCI Design Thinking to the next level (as depicted in Figure 13) where the life-based challenges are solved by human being where technology is a mere enabler or tool. It can so happen that the tasks are completed by technology or humans but all in all they address a real life challenge that form-of-life throw up. Technology is a tool or enabler to enhance and aid human life. It cannot exist by itself, without any relevance or integration with life itself.

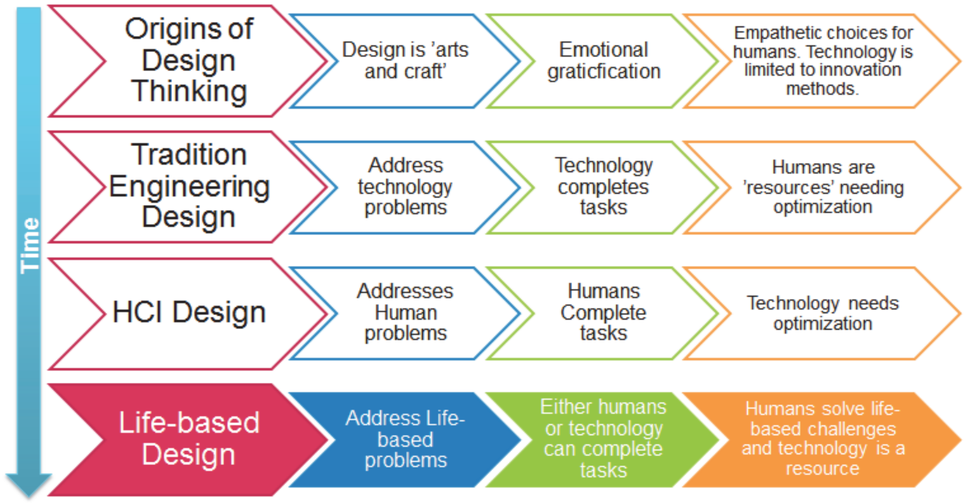


Figure 13: Life -Based Design Approach

Leikas (2009) provided the concept, the framework and the methodology for designing solutions using the Form-of-life as the core concept for the process. The next step is to effectively use the conceptual thinking to create practical solution. In order to use the artefacts that come out of the Life-based design approach, it is necessary to figure out how to concert this approach and derive practical technology solutions. The obvious question is to figure out how to derive real life application or solution functionality from the technology supported action that are the outcome of the Life-based Design process. This requires the development process to tie the empirical data that is the outcome of the conceptual work to the functional question that need answers in the physical design of the products.

In the following work, I describe the actual implementation of the conceptual framework proposed by Leikas (2009) in practical development of a solution by tying up the evolving TSA's (Technology Supported Actions) to technical functionalities, that translate into an application that address the challenges thrown up by a form-of-life in form of a practical application. These in turn are verified using traditional usability methodologies to validate the improvement in effectiveness, efficiency, learnability and perception of the solution.

7 APPLICATION DEVELOPMENT USING THE LIFE-BASED DESIGN APPROACH

7.1 Background

In the previous chapters, I have presented the literature review of the evolution of Design Thinking from the Arts and crafts time to modern day theories and methodologies surrounding Human Computer Interaction. Lastly, I have emphasised the choice of Life-based design concept and methodology for developing solutions based on the conceptual framework proposed by Leikas (2009). In this chapter, I will describe the practical implementation of this concept and methodology theory in live development of a solution. The solution I have tried to develop is in the area of social work. This sector mainly functions towards addressing issues concerning various causes that can be difficult to classify in any given order. However, it is easy to understand this sector, in form of their work in the areas of environment, human relief, diseases, poverty, global warming, support towards people with disabilities or even old age etc. Normally the social sector or the NGO (Non-Government Organisation) sector steps in and offers their services where the government or the commercial sectors are unable or unwilling to intervene. Since this sector is not as organised as the commercial sector or the government sector (Public Sector), nor is this sector taxed or monitored by any form of government, it is commonly known also as the Informal or the Unorganised Sector (Wikipedia, 2012b).

In the digital world, Social Sector (Wikipedia, 2011f) organisations have found themselves in a situation where they have access to many more funding and resource generation possibilities than before. At the same time, the organisation and entities that are interested in investing in social causes are also finding their options expanding greatly. The social sector is not limited to resource generation from individuals, associations and government agencies anymore but also is finding strong support from the corporate sector. Of course, the availability of resources to the social sector from the corporates is dependent on the availability of resources and their sustainability in the first place. For example, the funding corporate entity needs to be profitable in the first place in order to be able to invest in a social cause. It is not uncommon anymore to see corporations set up their own vehicles to channel their social spending (Bhattacharya, 2006).

The NGO's have a huge advantage of the possibility to identify the needs, generate resources and deploy aid in a very short period of time. On the other hand, the Sponsors (Institutional and Individual) are able to do target funding. NGOs not only receive resources and support from their sponsors but also have additional resources at their disposal in form of concessions and indirect support from their local governments. One of the challenges that NGOs face on the other hand, is not only do they compete for resources with each other but also compete for the beneficiaries that they are targeting. There are often finite numbers of beneficiaries, limited by geography, type of need, type of intervention and support needed, etc., encouraging the competition between the NGOs for support and resource distribution. On top of this, the beneficiaries often like to work with more than one NGO or grassroots agency (Michael, 2004). In recent years the obvious examples have been the massive help that has been generated for natural disasters, be it Tsunami (numbers), earthquakes (numbers), or cyclones. The digital channels have been very useful in carrying the message urgency, generating support by driving opinion, generating resources, managing logistics, reaching the aid to the needy and in the monitoring and follow-up activities.

In 2004, the Indian subcontinent was hit by the tsunami. The islands of Andaman and Nicobar were the first hit, followed by the costal districts of Tamil Nadu, Andhra Pradesh, and Pondicherry. The large geographical area affected was over 12000 deaths as per the UN report in 2005. In response to this massive natural disaster, there was an extraordinary resource mobilisation for humanitarian relief. Individuals, NGOs, government organisation, corporations and others were not limited to local regional or national level alone in India, but were supported by the global community. It was a relief operation on an unprecedented scale (Karan & Subbiah, 2011). An operation of this scale would have been impossible without a huge communication and networking effort globally. The intervention and relief operations started within hours of the disaster. This rapid end-to-end influence of the Social Digital Channels works very well in this case, which require rapid response. On the other hand, these channels do not seem to have been very broadly leveraged in the sustained, planned and long-term interventions, which is the long stay of the relations between the NGO's and the Donors.

The solution I have tried to create is to build the bridge between the various stakeholders of the social sector. There are many efforts already done in this area to build tools to help people from these areas to gather information, view the latest news, follow-up projects, market projects, seek and give funding, social networking, etc. These are either available as standalone tools on the internet or then as part of portals that cater to the needs of this sector. While working in this sector for over 8 years and talking to various people in this sector representing all the stakeholders, I have identified that even with the presence of multiple options of digital tools, there is a gap between the stakeholders. The motivations, the drivers, the social and cultural stimuli, the psychological stimuli of the stakeholders are different while associating with this sector. The purpose of this exercise was to identify the fundamental gap between the stakeholders and build a technology solution based on this understanding to minimise the void and create a better understanding between the stakeholders of the unorganised sector by organising the information in manageable and digestible chunks, which can be used for decision-making.

7.2 Who are the stakeholders?

The three main stakeholders in the Social work environment can be broadly classified as NGO’s, Sponsors, and Beneficiaries. NGOs are the individuals or organisation that are involved in working in the not-for-profit sector towards the betterment of the society at large, in the area of their choosing. While the Sponsors are the individual or organisations or groups of people who are contributing resources of any kind towards the cause that the NGO’s are working for. The beneficiaries are the recipients of the benefits of the work NGO’s do and the Sponsors support. These are not the only stakeholders in this eco system. This is the broad classification that most stakeholders fall into. For a broad array of interventions that the NGOs get themselves into, not only the society at large become a stakeholder, but also inanimate and animate objects and elements become stakeholders; though at times not consciously. For example, it can be argued that the universe is the stakeholder in the ecosystem of activities and associations of SETI- Search for Extra Terrestrial Intelligence (SETI, 2011). On the other hand, in the Baltic Sea, the flora, fauna, soil, rocks, water, algae, microorganisms etc. are all the beneficiaries in a direct or indirect way for BSAG- Baltic Sea Action Group, an NGO based in Finland working towards cleaning the Baltic Sea (BSAG, 2012). In the following sections I have tried to put all these major stake holders into perspective.

7.2.1 NGOs

Definition 1:

> “A non-governmental organization (NGO) is a legally constituted organization created by natural or legal persons that operates independently from any government. The term originated from the United Nations (UN), and is normally used to refer to organizations that do not form part of the government and are not conventional for-profit business. In the cases in which NGOs are funded totally or partially by governments, the NGO maintains its non-governmental status by excluding government representatives from membership in the organization. The term is usually applied only to organizations that pursue some wider social aim that has political aspects, but that are not overtly political organizations such as political parties. Unlike the term "intergovernmental organization", the term "non-governmental organization" has no generally agreed legal definition. In many

> jurisdictions, these types of organization are called "civil society organizations" or referred to by other names" (Wikipedia, 2011e).

Definition 2:

> "The term, non-governmental organization or NGO, came into currency in 1945 because of the need for the UN to differentiate in its Charter between participation rights for intergovernmental specialized agencies and those for international private organizations. At the UN, virtually all types of private bodies can be recognized as NGOs. They only have to be independent from government control, not seeking to challenge governments either as a political party or by a narrow focus on human rights, non-profit-making and non-criminal" (Willetts, 2001).

7.2.2 Sponsors/Donors

Sponsors are more difficult to define than NGO. The primary reason being that anybody or any organisation can be, or become a sponsor. Any entity that is involved in the social cause, directly or indirectly contributing to the 'sponsorship' of the cause, becomes a stakeholder.

Definition of Sponsorship:

> "Sponsorship is a cash and/or in-kind fee paid to a property (typically in sports, arts, entertainment or causes) in return for access to the exploitable commercial potential associated with that property, according to IEG.
>
> While the sponsee (property being sponsored) may be non-profit, unlike philanthropy, sponsorship is done with the expectation of a commercial return.
>
> While sponsorship can deliver increased awareness, brand building and propensity to purchase, it is different from advertising. Unlike advertising, sponsorship cannot communicate specific product attributes. Nor can it stand-alone. Sponsorship requires support elements. Moreover, while the advertiser controls advertising messages, sponsors do not control the message that is communicated. Consumers decide what a sponsorship means" (Wikipedia, 2011g).

Definition of a Donor:

> "A donor in general is a person who donates something voluntarily. Usually used to represent a form of pure altruism but sometimes used when the payment for a service is recognised by all parties as representing less than the value of the donation and that the motivation is altruistic. In business law, a donor is someone who is giving the gift, and a donee the person receiving the gift" (Wikipedia, 2011c).

7.2.3 Beneficiaries

Ultimately, the Donors and the NGO's are both working towards achieving goals that will benefit the beneficiaries in some way or the other. Beneficiaries under most legal explanations are described in a way that it is easy to imagine them as only human beings. However, in reality, the social sector works with multiple beneficiaries. Although the ultimate beneficiaries may end by being human beings in some way or the other, but in terms of short-term objectives, which could be tangible, the social sector is working with all kinds of elements that may benefit from their activity, and the sponsors are supporting them in their cause or mission. A good example of the beneficiary group can be organisation like PETA- People for Ethical Treatment of Animals. It is the largest animal rights organization in the world, with more than 3 million members and supporters. This organisation works for animal rights (Wikipedia, 2011a) and focuses its attention on the four areas in which the largest numbers of animals suffer the most intensely for the longest periods: on factory farms, in the clothing trade, in laboratories, and in the entertainment industry. They also work on a variety of other issues, including the cruel killing of beavers, birds, and other "pests" as well as cruelty to domesticated animals. They work through public education, cruelty investigations, research, animal rescue, legislation, special events, celebrity involvement, and protest campaigns (PETA, 2011). It is very difficult to imagine how human being are going to benefit from the activities of PETA, but at the same time PETA is a NGO working with its sponsors and donors towards the betterment of their beneficiaries- Animals.

Definition of Beneficiary:

> "A beneficiary (also, in trust law, cestui que use) in the broadest sense is a natural person or other legal entity who receives money or other benefits from a benefactor" (Wikipedia, 2011b).

On the same page of Wikipedia, the beneficiary is defined in the context of development aid as "the entities that development-aid projects attempt to empower by dispensing development assistance or humanitarian relief".

7.3 What are their needs and why?

In this research, I have considered the broad definition of the NGO's and the Sponsors. I have not taken into consideration sub categories or micro taxonomies that are associated with these broad groups. The primary focus has been individuals playing the role of the NGO's or the Donors or organisations associated with these broad definitions. The research centres on understanding the needs of the PEOPLE who play the roles of the sponsors or the NGO's rather than the organisation or the bodies and entities. This has also been the major decision-influencing factor for me to choose the life-based design approach towards the tool creation for satisfying the stakeholder expectations and needs. The beneficiaries are not represented in this research as active stakeholder. The workflow does not touch the beneficiaries directly. They are represented by the NGO's and hence the NGO's are representing or acting on behalf of the ultimate beneficiaries. Even though the whole sector is centred around the needs of the beneficiaries, more often than not the NGO's and the Donors share a relationship and the relationships with the Beneficiaries of both these stake holders vary dramatically depending upon the need or the cause.

7.3.1 The NGO (Social Sector) perspective

The social sector is strongly driven and motivated by the following ideals:

- They are able to see a 'need'
- They are able to identify the shareholders (beneficiaries) who are the 'needy'
- They are passionate about addressing the need or finding a solution to a problem or exploiting an opportunity towards the betterment and benefit of the beneficiaries
- They believe that organised sectors are not able to effectively address the challenges of their beneficiaries
- They have various levels of skills and resources that they bring on the table to be able to aid in the work they want to do
- Their entire focus is on EXECUTION (in the classical sense). Of course, there will be NGOs that play different roles and may not completely focus on execution alone. They may play different focused roles like fund generation, resource aggravation, advocacy, awareness building etc.
- They may play niche roles in the process of addressing the needs

On the other hand, the NGOs also need support and help. With their strong execution focus, they need the Donors or Sponsors to bring to the table and the equation, much needed resources. The resources could be anything from money, services, goods, networks etc. The NGO's need help to match the requirements from the beneficiary's side with the possible resourcing options from the Donors side and choose the right donors or sponsors as partners towards their activities. With the wide variety of donors and available resources, it gets extremely complicated for the NGOs to choose the right partners. Not only are they to choose the right partners, but also the relationship should be mutually beneficial and symbiotic. It is common situation that the NGO and Donor cooperation is not very long lived because of the misalignment in objectives, expectations and deliverables. The objective of this research is to create a tool that will align the needs of the NGOs and the resourcing available to the social sector from the Sponsor or Donor perspective. In this research, I have tried to deep-dive in to the 'NEEDS' of NGOs and map them to the resourcing options from the donors.

7.3.2 The Donor (Sponsor) Perspective

There are various reasons why individual, organisation, and other entities play the Donor's role in the social sector. They could have very diverse motivations ranging from the passion to address specific needs of the beneficiaries, becoming good corporate citizens, earning brownie points on the stock exchange, adhering to the stipulations of a trust towards dispersal of resources etc. These diverse motivations lead to diverse policies, processes and engagement model needs from the Donors towards the NGOs. A singular view of the NGOs and the work they do is not enough. There is a dire need to make the information visible from multiple perspectives to address the reporting and monitoring needs of the Donors. There is no possibility of one-form-fits-all situation even from the 80-20 rule perspective (Reh, 2005). This diversity also is one of the reasons why the sector derives its name as the Unorganised Sector (Nigam, 1997). In the research I have tried to understand, assimilate and address the varying and diverse needs of the Donors in creating a tool to support the decision making process of aligning the resourcing plans, with the options of execution available from the NGOs.

7.4 Methodology and Approach for developing the technology solution

I have broken down this work in to 2 parts:

- *Mapping*: Understanding the challenges and needs of the stakeholders (Donors and the NGOs) when using technology to make their decisions. This is based on the conceptual framework provided by Leikas through the Life-based Design approach (Leikas, 2009).
- *Solution*: Looking at creating and modifying the tools and their applications to suite and full fill the needs of the users (from both the stake holders- NGOs and Donors) by deriving technological functionalities based on the Life-based design framework.

Thorough out the process of this research and solution design, I have used the life-based design (Leikas, 2009) as an approach, mind-set and tool-set. The process started by exploring the traditional design approach, but the detour came about, when during the course of the research I discovered that the traditional approaches were not enough. It was necessary to explore the design and the solution phases by diving deeper in to the roles people play during the tasks they undertake, and not address the task in isolation. It became necessary to understand the people and their environments, their motivations and their empathetic needs, even before starting on the tasks rather than just looking at their efficiency and ease at completing the tasks. In order to set the targets and goals for the design, it is necessary to understand the motivations, needs, driving forces and goals of the people who are performing some actions. In this case, the Donors and the NGOs were real people who had multifaceted goals as individuals and it was necessary to approach the process from their individual goals perspective. One example of the surprises that I came across during this process was that one of the major decision making factor for choosing a partner for either of the stake holders was the emotional connect and the *feel good factor* similar to the consumer behaviour of connecting to and choosing brands (Woods, 2004).

This research is organised based on the fundamentals described and proposed in the following texts:

- Life based design: A holistic approach towards designing human-technology interaction (Leikas, 2009)
- Life-Based Design - An Approach to Design for Life (Saariluoma & Leikas, 2010)
- Life-Based Design as an Inclusive Tool form managing Micro Innovations (Rousi, Leikas, Saarilouma, & Ylikauppila, 2011).

7.5 Life-based design framework: Practical implementation

Following the Life-based design principles, I proceed in the following steps to address the solution. The problem as perceived by me was that the social sector/NGOs do not have a tool-set to map their expectations with each other. Without accepting this as the actual problem definition, we went through the following practical steps from definition of the problem with early user involvement to the final solution design and testing with multiple iterations.

7.5.1 Defining the form-of-life

In the starting phase of this research, we defined the form-of-life based on the initial user group identification and fact-finding stage. For the purpose of this research and with the given sample of participants, we concluded that the definition of form-of-life is:

> Form-of-life of diverse aged group people, with diverse professions, diverse interests and motivations, distributed globally having diverse technical skills and internet skills; engaged in the social sector with needs or having possibilities to give and contribute; having multiple choices and having difficulty to form opinions and hence educated choices.

To verbose, the definition of form-of-life we went through the following fact finding exercise with the volunteering participants. During the focus group with participants representing both the stakeholders, real life situation that the people in this sector and its context, was described. It was noted that the people participating in this form-of-life came from very diverse age groups. Age was not a factor for people performing in this form-of-life. Young as well as older people are equally associated with the decision-making processes in the social sector. They may play different roles, based on which stakeholders they represent. It may also be so that they are acting as donors as well as NGOs, in different timeframe. For example, this is especially true for people involved in foundations, where there is a need to generate funds and allocate funds to the right cause. BSAG (Baltic Sea Action Group) is one of the organisations that I have studied closely for the roles during this work (BSAG, 2012). BSAG is a foundation, which seeks and encourages different stakeholders to play a role of donors and make commitments towards cleaning up the Baltic Sea . On the other hand, the same commitment makers can also be the NGOs in this context, where they are unable to complete their commitments and are dependent on other commitment makers to help them during the course. One example can be Tieto Corporation. Tieto Corporation has made a commitment to make its technical solutions directed towards sustainability, available free for use to any other commitment maker that is willing to use them, directly or indirectly, to help the process of cleaning the Baltic Sea. In this role, Tieto is a donor. However, in order to fulfil their commitment, some other commitment maker needs to take the role of receiver and implement the solution in their IT landscape (BSAG, 2012). One more example could be that of photographer Janne Gröning. The commitment is to allow any other commitment maker to use the photos shot by Janne to communicate the issues surrounding the Baltic Sea (BSAG, 2012). The only exception being that they cannot be used for commercial purpose. In this case, Janne is the donor but needs another receiver to agree and commit to use the photos offered (BSAG, 2012). This is a very normal scenario that is visible in the unorganised sector, where transactions are carried out through networking and often roles are interchanged in order to ensure that the ultimate stakeholders namely the beneficiaries are addressed.

The next important attribute of the people that I was looking at was the diversity of professions, interests and motivation. It is common for people to be involved in the unorganised sector as their second job. So these people are working during the day or most parts of the week as professionals in some industry or the other, but participate in this form-of-life in the time they have other than their work time. In the research that I detail out in the following sections, I will detail out the usability tests and the focus group results. One of the respondents is a dentist from Germany working during the day in a dental clinic and out of her remaining time, she dedicates five hours in a week towards advising German charities that work in Africa in affordable housing related issues, since it has been a hobby for her, for over last 20 years or so. As we can clearly see, the original profession of this participant, has no connection whatsoever, in social sector form-of-life. Another example is that of an investment banker in India who helps in finding resourcing opportunities for a charity during his non-banking time. He is able to use the financial skills from his original trade to be able to bring value to the NGO to find funds and resources for driving and implement their programmes. On the other hand, people who take this participation as a profession can also have other professional interests. One of the participants in the focus group was a Corporate Social Responsibility Officer (CSRO) working for a large corporation, who started her career as a Human Resource Management professional but changed her job to Marketing and Communication and finally for the last two years has been specializing in the CSR area. Though this participant shares the same form-of-life with other respondents, it is clear that her professional interest originates from that of marketing and communication. The motivation of a student, to participate in this form-of-life was to gain extra credits in his university work, by contributing to the social sector. While another student was involved in the social sector on a regular basis because it allowed her to travel to foreign locations as a volunteer and experience other cultures, while being of some use to the places she travels. Taking forward the diversity of motivations, the motivation of the CSR professional mentioned earlier was clearly to ensure that the brand of the company she worked for was best represented, in the media of choice and it helped complete her job as a CSR officer. One more example of diversity of motivation is a retired couple who wanted to retain an active lifestyle by participating in social work activities on one hand. On the other hand, they had lost their son some years back to AIDS and wanted to contribute to that area in any way they could. Both of them in their working lives worked in the retail business and have excellent communication skills. They run a small NGO with the mission to spread AIDS awareness and sensitize society around this issue.

The respondents came from different geographies, from Asia and Europe. Nevertheless, the common factor was that even with their varying rate of computer literacy, they were connected and working with other people globally using internet based tools like email and social networking sites. The degree of the involvement of their global role was varied from information gathering, referencing, ideation, funding, implementation, networking and so on. However, all the respondents had some sort of link to the world outside their immediate geography. The technical skills and attitude towards technology differed greatly. Some respondents found technology the greatest enabler in this form-of-life, others found it a complex system to cope with, while still others found it marginally useful but mostly a 'nice to have' possibility. Most respondents agreed that the internet had made marked changes in their form-of-life than earlier, for better and not worse. Some younger respondents found it hard to empathise and comprehend how people of the previous generations functioned without the internet. The participant group represented both the main stakeholders in the social work sector as NGOs as well as donors. The participants were playing a decision making role in either or both the two premise. Their responsibilities contained making or influencing the decision regarding creating alliances or resource management possibilities, as givers of the resources or receivers of the resources. This is no easy task. The donors find it difficult to come to an educated decision of where they would like to invest their resources given the endless possibilities. On the other hand, the receivers find it difficult to make a decision on where to receive the resources from, again due to the endless possibilities. The donors can have a multitude of criteria on which they can make their decision. For example if it is a corporate donor, the decision-making process had criteria like how does the cause compliment or connect to their business. The connection can be geographical, people related, business domain related, or even marketing and branding related. For example, one respondent who was representing a media group operating out of German had a defined CSR philosophy to invest in adult education activities in the places where they source newsprint paper. They sponsor self-help groups in Asia where their paper is sourced in order to educate and train the underprivileged women in the society to generate income and become self-sufficient. Another example was of a Scandinavian company, which had operation in China to invest in NGO's that provide day-care services to working parents. Since both members of family were working in the company, they believed that they are not only helping provide care for the children of working parents, but also specially targeted at the their own employees. This was reflecting positively in terms of higher retention rate among the employees in a market prone to high employee turnover. One respondent represented a company, which was a manufacturing company and had no clear CSR strategy defined. They invested in the social sector in form of annual contribution to a global foundation that works with deprived children in the third world countries. Their main driver was to make sure that their CSR activities are visible to their investors and shareholders, and the company is able to earn brownie points on the stock market for their social contributions. One Nordic company representative said that the employees and the board members of the company have very strong concern towards the environment. Moreover, even though as a consulting company they have no real business connection to addressing environment issues, they still invest in an NGO that consults companies in helping them reduce their carbon footprint. Individual donors or sponsors had two main drivers for choosing their investments. Firstly, they invested in a cause that they were emotionally linked to. Secondly, they invested in a cause that was highly recommended by people influencing them. The actual decision on which NGO to volunteer with or provide resources too, were dependent on multiple factors, that they look back at reflectively, but were more often than not considered consciously, when making the commitment. One main influencer that is evident, is the personal connection due to association or working with the NGO. This gave them a feeling of security that the resources will not be misused or wasted.

All the NGO participants agreed, that making a decision on where exactly to invest the resources at their disposal, was very tricky. The representatives from most of the larger NGO groups, which were also financially stable, did not have particular notions about where the resources come from. Their resource generation teams had targets and an efficient process was in place to generate resources. They seemed to work with the philosophy that as far as the resources are put to good use, they do not bother too much about where the resources come from. On the other had the smaller NGOs, though they had a constant struggle towards generating resources for addressing their needs, were more picky on where and how the resource generation was happening. The common factor between these agencies was that they did not have a strong resource generation team, but were more focused towards executing their programmes. They prefer to make sure that the goals and objectives of the businesses that donate resources to them have some connection with the cause. It is necessary from their perspective to ensure that the donor is not doing this as a one-time activity, but the commitment time is long. They do not want to invest time repeatedly to generate the same funds. They would like to concentrate on their main goal of addressing the needs of their beneficiaries.

These inputs put together helped create the form-of-life that the decision makers in this sector operate in. The common thread of course is the sector itself and its uniqueness. An activity that revolves around resources like any traditional business, but is complicated by the emotional quotient associated with the causes. The complication compounds with the fact that the ROI (Return on investment) is not very tangible in most cases and needs to be arrived upon; based on intangible and often elusive results. Often the emotional aspect seems to outweigh the logical aspects of decision-making. The intangibility of the ROI and the various choices also make the decision making slow since the decision makers want to believe that they have taken into consideration all the possible angles during the decision making process and their decisions are educated decisions. The complexity and diversity of the actors in this form-of-life and their environment, adds to the challenge of the solution design process. However, by understanding the form-of-life in details and in its true hues and colours, is the main cornerstone of leveraging the Life-based design framework towards creating a solution that solves a real-life challenge.

7.5.1.1 Identifying of the user group

The group of people I was looking for to contribute to this process needed to fulfil diverse criteria. I needed the sample from both the NGOs and the Donors. The users needed to represent the decision makers in their respective organisation or as individual when it comes to giving or needing aid. With my experience from Identity Foundation (Identity Foundation, 2007), I wanted the geographical coverage to extend to the countries where most of iF's stakeholders were present, either the donors or the partnering organisations and individuals. I also needed to cover the diversity from age perspective since the stake holders came from diverse ages. A healthy diversity of gender is needed to ensure that gender biases did not compromise the results of the research. One more critical factor was to identify the people who were conversant and users of internet in their decision-making processes; or at least passive observers of the events on the internet with sufficient skills to use the computer. Though the whole process was designed to be qualitative in nature, I have consciously used a large sample size. The reason for a more broad based approach was to ensure that some commonalities could be determined for such a diverse group of participants.

7.5.1.2 Research to map sample participants in the group

The initial part of the research was to map the shortlisted people participating in this iterative journey to get a better understanding of their backgrounds and demographic factors. The methodology used for this task was personal interviews and practical usability tests, run face-to-.face or remotely using Morea tool set from TechSmith tools (TechSmith, 2011). The following is the broad view of the participants.

- Out of the 77 total participants, 39 came from India and 38 came from Europe
- Females formed 39 of these participants and males formed 38

- The age diversity was broken down as- 26-35, 36-47 and 48-55
- The NGO representatives were 39 and the Donor were represented by 38 participants
- Out of the total sample size, 54 participants were having medium to high computer literacy mapped on the mode of usage and frequency of Microsoft Office or similar programmes, Social networking sites, usage of digital tools in daily life (both personal and office related), usage of social networking sites and tools in work related tasks, communication, job hunting, following digital presence of organisations and entities, fundraising, volunteering, knowledge updating etc.. The performance of the users on using these tools was not a criterion used in this process.

7.5.1.3 Focus group to map the – social and emotional issues

Morgan (1997) recommends the use of focus groups when there exists an ethical risk; where there is a power difference between the participants and decision makers. The difference between the understanding an interpretation of realities between the participants and professionals leads to a gap that needs to be addressed and focus groups can help bridge the gap. Focus groups also reveal the complexities related to behaviour and motivation by encouraging an open dialogue in a neutral environment. The insights received during the focus groups help in mapping the diversity of opinions by understanding the degree of consensus regarding an issue (Morgan, 1997).

Based on the finding and shortlisting from the mapping of the original sample set, 77 participants were used as representative samples for focus groups.

- There were 7 focus groups conducted
- Each group had 11 participants
- The group results were then harmonised across all 77 participants
- Each group was a homogenous mixture of people from all diversities
- The moderator group consisted of one researcher, one designer and one programmer.

In Figure 14, an example of the classification criteria used to distinguish the participants and form groups based on the level of expertise of computer usage. The participants were divided based on their ability, willingness and experience of working with digital tools as Early Learners, Basic Ability, Good Ability and Digital Natives. This was done by mapping their use of digital and software solutions. Email usage, purpose and mode of access (desktop and other devices), usage of Microsoft Office Programmes or other business specific digital tools, usage and purpose of Social Networking tools for business and personal purposes with the complexity of tasks involved, and perception of participants of their own digital skills, were criteria for pegging the skills of the participants in the focus groups.

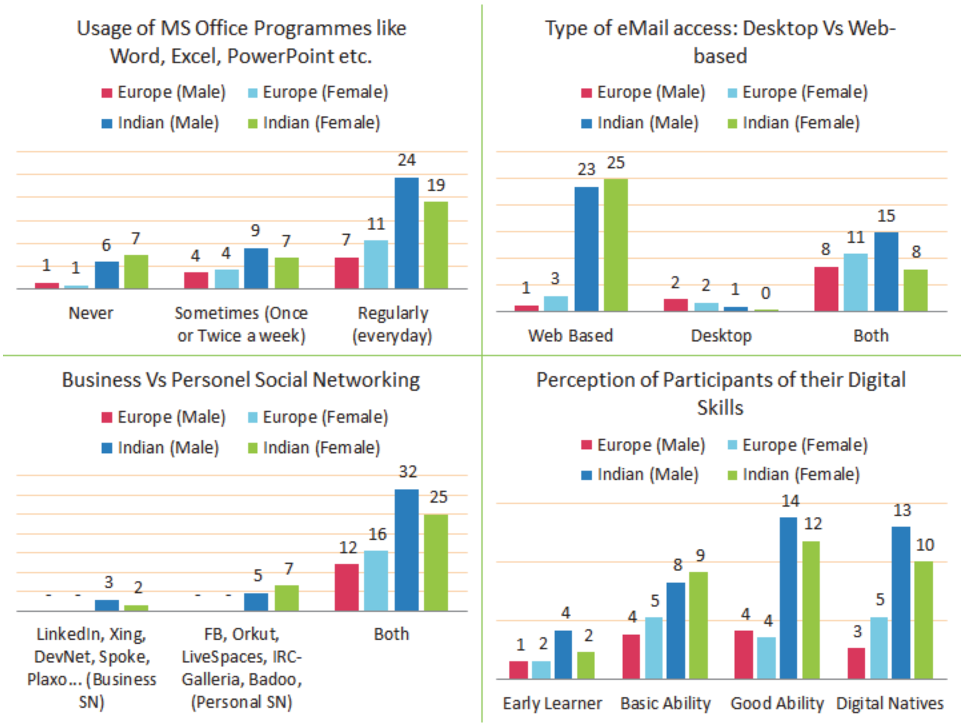


Figure 14: Participants according to their computer usage abilities

Methodologies and guidelines that focus on usability and not having marketing focus can be effective tools for collecting usability data (Rosenbaum, Cockton, Coyne, Muller, & Rauch, 2002).

> "Our primary distinction is that usability focus groups, are task-based, so that we can observe the participants' actual behaviour with products." (Rosenbaum et al., 2002, p. 702)

Challenges of focus groups in terms of moderator's impact, interpretation of results and consensus building in the group needs to be mitigated. Sullivan (1991) recommends the use of focus groups during usability research as a complimentary and converging method.

> "The need for complementarily is great in research methods that address the usability of computer interfaces. Since the focus in such studies is on speed and richness of feedback on issues important to the interface (such as accessibility, intuitiveness, look and feel, and navigation), multiple methods that complement each other and can be stitched together quickly are desirable to usability researchers." (Sullivan, 1991, p. 111)

I have used focus groups in convergence with the usability tests to get better insights of the user's performance as well as perceptions. Mazza (2006) holds that focus groups reveal potential problems and highlight useful information in a graphical representation while evaluating information visualization applications. I believe that this has given me a rich feedback and played a mission critical role even with identifying and defining the form-of-life definition, the problem statement and the intangible expectations of the users. For ensuring participation by the users as a cohesive group, audio-visual format is necessary (Murgado-Armenteros, Torres-Ruiz, & Vega-Zamora, 2012). The focus groups where the participants were remotely logged-in were conducted using video conferencing tools to accommodate both audio and visual formats of communication.

7.5.2 Defining the Rule-following Actions (RFAs)

Focus group discussions were carried out to help define the Rule-Following Actions. The user groups prioritised the RFAs as follows:

1. **Overview**: ability to see all the stakeholders either needing or giving commitments – see the big picture (Unanimous). The participants of the focus group could not agree on a single tool, that is already present which fulfils the needs comprehensively. Their need was to be able to see the options for investments, either from the giving perspective or from receiving perspective, mapped to the causes and the stakeholders as a way to provide decision support. The wish and need was to have some sort of a comprehensive way of being able to view all the options available to help the decision making process.
2. **Sort and compare**: ability to sort and compare the needs or the giving commitments, from multiple perspectives- cause, geography, effort, progress etc. and cross-compare between these different perspectives. The ability to sort and compare various options, either from the investment perspective or from a receiving perspective was expected. Meer listing of the options was not enough. Comparison possibility on multiple parameters was expected. The comparison could be on different parameters like geography, size, sector, cause etc. There was not a clear consensus on what the common parameters could be, however, the needs for having the possibility was universal.
3. **Visual and emotional cues**: would like to get a visual clue of the information and not reading long texts and at the same time get some kind of emotional cue on specific commitments or causes. Descriptive text alone, was not perceived as enough. Pictures or comparative charts or some sort of visual cues that could help create empathy towards the artefact would be greatly appreciated. The time required for doing the research according to the participants was extremely time consuming. The general feeling was that a lot of time is spent on research that does not yield any tangible results, but is exhausted in doing the preliminary research in order to arrive at a subset of opportunities that could be termed as the nearest fit to the area of interest to the users.
4. **Verify**: verify the information and get insights. Also allied information to make own judgement. Majority of the participants did not think this to be important, but specially, the Donors tended to have this on their

priority. The NGO participants did not consider this a very high priority since they were not able to see how the historical data of the donors could be verified. However, when proposed with the idea of the ROI generated by the investments of the donors as one verification methodology, they too saw the value in having this information available. One participant proposed and the rest agreed that this would help the relationship from both ends. Not only will the donors have the visibility of monitoring the performance of their investments, but the NGO's too could have the visibility of how the investments of the donors are performing. This could give valuable insight in to the future needs and expectation of the donors to the NGOs and reflect on their involvement and keenness to follow-up and monitor their investments. The NGOs mentioned the need to balance the involvement of the donors so that they are involved on one hand but are not intruding on operations on the other hand. The same sentiment was voiced also by the donors. They too did not want to be involved in the operations, but agreed that there was always a temptation to do so if the expected results were not met.

5. **Track**: The stakeholder's progress- not monitor or influence it. Only track on high level how is the commitment progressing. This was not a priority at all but more of a wish. The tracking need is very similar to the verifying need. While the verification is more targeted towards history, the tracking function requirement was more targeted towards on-going projects that were currently in the mode of execution. Some sort of millstones could be agreed between the donors and the NGOs and the progress could be made visible to the community at large. This could serve a double purpose. On one hand, it created some sort of an on-going public interface of the activity and on the other hand, it allowed non connected stakeholders to offer support in any form necessary if there was a gap in meeting the milestones, and if the other stakeholders were in a position to support in any way possible.

One of the major challenges was the technology itself used for the running of the user group discussions. The challenge was to set-up a common sharing platform where all participants distributed between Europe and India could participate in an interactive way. Skype was used to share voice and desktops in order to get every participant on the common grounds. All participants were familiar with social networking tools in the social sector. The three most common usages of people using social networking tools of any form were in the following areas:

- **Funding/Resource management** (all 77 participants): Looking or following funding related activities.
- **Knowledge Building** (all 77 participants): Understanding and checking out the latest news and activities in areas of interest in the social sector as well as validation of own ideas.

- **Communication** (all 77 participants): usage of tools to network and ideate with fellow practitioners in the social sector as well as allied sectors.

Funding and resource management turned out to be the most common and frequent activity (everyday). This activity was also classified as the most difficult to follow-up.

The following parameters were identified as the main 'challenge areas'

- **Information overload**: It was noted as a challenge to browse the world wide web through the millions of choices available and find the relevant information
- **Decision Complexity**: Both the NGOs and the Donors agreed that the choices from both their perspectives were enormous and complicated to sort the choices and make decisions
- **Lack of transparency**: The date presented on individual websites as well as well as he compiling of portals was not always update, could be conflicting and validation possibilities were limited
- **Lack of comparability**: The data and the information was good and easy to read and understand, but it was difficult to compare information between stakeholders or participants
- **Fragmented and distorted**: The data is very fragmented and verbose. It is not uniform and easy to navigate through. It takes heavy investment of time to try to syphon the data.
- **Data Formats**: the format in which the data is presented is different for different organisation even though they may be presented on the same portal
- **Emotional Distortion**: Without lack of some sort of uniformity in the presentation of the data and facts, participants believed that their perceptions were often misplaced.

7.5.3 Comprehensive problem statement

The problem statement derived in consensus with the participating users who represented the form-of-life of both the stakeholders- donors and NGOs- was as follows :

> "As **stakeholders** in the social sector, the **priority** for us (**NGOs and Donors**) is to full-fill our commitment to **commit/give** resources or **receive help** towards our (our beneficiaries) needs in order to get the **best ROI**.
>
> We want **help to make decisions** with **up-to-date information** which is **visually easy to digest**, **easy to sort**, **transparent**, **simple**, **traceable**, **comparable, valid-able** and that can create some **emotional connect**."

This problems statement was developed based on the focus group inputs. In an interactive workshop with the participants, the problem statement was formulated, where agreement towards its description was reached unanimously with all the participants. This was an important phase to put in concrete words, as the overall take away from the focus group. Additional verification steps to confirm the problem statement was deemed necessary because of the diversity of the stakeholders and the different approaches they have in their form-of-life; though all of them participate in exactly the same form-of-life. It is worth noting that even though the stakeholders play different sub-roles in this form-of-life, there is a constant revision of the roles and a NGO could easily become a Donor and vice-a-versa depending upon the need. The solution needs to take in to account the need to maintain the fluidity of the sub-roles.

7.5.4 Technology Supported Actions and goals (TSAs)

After the RFA's were in place, we started working on creating the list of technology supported actions and goals. We set out with the challenge of creating a technology solution for each of the identified RFAs. We looked at technology solutions as the best way to address the problem in the form-of-life and for the given RFAs since the participants were already using technology to address the problem in one way or another. The following TSA's were identified, as the outcome of the deliberation based on the initial research.

- **Visibility**: Get an overview of all the available option to get a feel of overall commitment and activity level. See the big picture. Technology could help create an overall picture of the landscape in which the stakeholders were participating. A tool, which allowed the users to meet the RFA of visibility, needed to be created or identified. Visibility of the available options was earlier identified as the RFA.
- **Sorting and Comparison**: Support the need to sorting and comparing data from diverse perspectives of cause, geography, effort, progress etc. and cross compare between these different perspectives. Sorting and comparison of options was a unanimously identified RFA and a TSA for the same need to be created. Technology solution that we need to identify or create must be able to help the users fulfil this.
- **Visual and Emotional cues**: Build ability to visualize the data in a way that the users can get some visual and emotional cues without reading long text. Present the date in a visually decipherable way. Long text and descriptions were not what the user are interested in the primary stage. They are more interested to see if they are visually able to understand the available landscape and get some emotional cues based on the same. Since existing tools do not have a way of catering to this RFA, a new and out-of-the-box thinking is necessary during the design phase to come up with a solution or identify an existing solution that can cater to this requirement.
- **Verification**: Get updated views on the progress, commitment, character and the nature of the commitment directly from external news published on the web. Though it is possible to surf the internet and find out latest information anonymously or even communicate with the concerned

stakeholders to get an insight, the RFA identified needs the users to be empowered to do the verification on the fly and just-in-time with relation to the stakeholders or then the history and background related to the commitment or project. Verification is not meant to be a detailed insight, but a rather a neutral view from non-connected people, to gather insights which surround the topic or the stakeholders.

- **Tracking**: A simple and easily comprehensible way of displaying the status of the commitment or engagement between the donors and the NGOs is to be created. The expectation is not an elaborate monitoring system, but a simple way to understand which direction the engagement is going in. The RFA was to be able to see the progress of the commitment and an easy and topical help-driven technology aid to follow and track the status of the commitment, the progress so far, the challenges faced, the milestones reached and the support needed in order to reach the missing milestones or to progress towards new milestones.

At this stage, the problem statement is defined. The Rule-following actions (RFAs) are defined and the Technology supported actions (TSAs) are defined.

7.5.4.1 The agents

After the definition of the TSAs, the next step was to define the agents. When defining the agents, I have to again highlight the fact that we have a very diverse user group and it is necessary to focus on the most common and fundamental issues that are influencing their usage. Ignoring one of the criteria or overlooking one of the diversity angle, we could easily alienate an entire sub group and render the form-of-life incomplete.

7.5.4.2 Design Relevant Facts

- *Age range from 26-55*: The representative group between age group 26-55 was selected since this reflected the real life situation. In this form-of-life there are people becoming stakeholders staring from the beginning of their career all the way to retirement. However, the most distinct range is around 26 to 55. People, younger than 26, even if they are participating in this form-of-life, and the older than 55, who are closer to retirement, do not form the majority of the stakeholders. Hence, they have been left out, at this stage, of the study. The age groups were divided in participants from different geography.
- *Medium to Good ICT skills*: The user's skills range between medium to good levels. Pre-set parameters about the usage of IT systems was identified, and used as a calibration scale, on which to peg the user's skills. Some users have limited IT usage like checking emails or reading news. While the users that have good IT skills are able to use computers in many aspects of their daily lives like social networking, financial

transactions etc., no special fluctuations were noted, related to nationality or culture when it came to ICT skills. It was observed that the participants from Asia were more involved in social networking activities than their European counterparts. This was not considered a major difference and hence no special attention was paid to this fact.

- *Older users can suffer from motor-skills and other physical challenges (coordination issues):* Some older users have either age related or then condition / disease related motor-skill challenges. Hand-eye coordination, tremors, weak response time, rapid fatigue, failing eyesight, colour differentiation challenges and pain and stiffness after using computers were some of the challenges noted and accounted for during the exercise. The Asian participants had marginally higher motor-skill related challenges than their European counterparts. Again, this was not a major anomaly and has not been addressed with any special focus.
- *Memory can be weak:* Mostly this challenge was related to the older age groups but this was not exclusively so either. The participants also attributed the weakened memory to the situation that more and more digital systems do the remembering and reminding part. Hence, they have observed the weakness of memory set in over a period of time and thus driving increasing reliance on the digital systems. Many respondents associated remembering the telephone numbers of friends and family as rough way of measuring memory capability. The feedback was that with mobile phones, where we end-up of storing multiple numbers associated to the same person as mobile number, home number and office number, it is no longer necessary to remember them anymore. Neither do we need to remember the appointments with office colleagues, friends, family, doctor and others anymore. We simply enter them in our phone, computer or both and the device takes care of the remembering and reminding part.
- *Patience to cope with tool learning can be a challenge:* The respondents mentioned that new digital tools could prove to be a learning challenge. For younger participants it was the case of liking to use some tool in the first place, and then having to relearn a new tool, which proved challenging. The challenge was more in terms of resistance to change rather than a real learning challenge. It was not perceived as challenge of the capacity or the capability to learn new tools, but the reluctance of doing the same work with a new tool with no obvious advantage over the tool, that they already know how to use. On the other hand, the older respondents also have similar feedback. The moderators of the focus group noted that the older respondents were merely more humble by blaming the challenges to learn new tools as a learning challenge. On deeper discussion, the reason for shying away for learning new tools was more or less resistance to change exactly as the younger participants suggested more obviously. At the same time, real learning challenges did

exist in the participants too. No geographical specialties noticed around this topic.

7.5.4.3 Design-relevant Requirements

- *Simplicity*: The participants preferred simple to use tools. Simplicity had different meanings to different user groups. The younger users did not mind, cluttered interfaces like portals. The information overload was perceived as empowering them in helping make decisions and execute workflows. Lesser number of steps required to complete a workflow were considered as a way to describe a simpler workflow. On the other hand, the older respondents preferred a non-cluttered interface with easy to follow steps. More steps meant more options to break the workflow if they desired so and hence it was commented as a good idea especially; if addressing financial transactions. From a regional perspective, the participants from Northern Europe associated empty spaces on the interface with simplicity. Often the term 'clean design' was used to refer to simple design.
- *Guided help to complete tasks:* This value also has similar connotations as the precious simplicity value. The older users preferred interfaces like wizards. These were considered as guided help in order to complete tasks. The younger respondents preferred to complete the tasks on their own, but some sort of intuitive insights in helping the flow of the task was expected. TAB key taking the cursor automatically to the next field, to be filled in a form, rollover help on buttons and links, highlighting or cursor placement on the control that needs to be used next and such were mentioned as examples of guided help to complete tasks. Nothing special was noted from a regional perspective towards this design value.
- *Need to feel in control and not lost while navigating between high level of information and then deep diving in to details:* This was a unanimous requirement of the users in all age groups and from all regions. In this form-of-life, it is common to be presented with lot of information. Nevertheless, at the same time, it is also common for respondents to complain that they are still not able to find relevant information easily. A good example of this could be a portal, which presents categorised causes from geographical, intervention type and size of project perspective. On drilling deeper, the users are presented with details around the project. The sorting of the data is useful, but the detailed information is not structured in an easily digestible format. In addition, users feel lost when they have to go back and modify their choices. This design value was very difficult to understand from the expectation of the users. No clear artefact could be noted or identified to reflect and demonstrate this value.
- *Comparing data should not feel like needing manual effort:* As mentioned in the previous value explanation, existing tools that the respondents were using, were perceived as highly effort intensive. To compare and sort

data was perceived as a manual task and the result was more often not the expected outcome. The ability to compare and sort options was unanimously agreed by all respondents as the most important activity that the design should support.

- *Visual data presentation as a decision support system and not a sales oriented presentation:* A neutral presentation of information is the expected outcome of the search, sort and compare functions, that the tool carries out. Most tools that the respondents are exposed to have the underlying function of *selling* the idea. NGOs present their work in a way where they are pitching for new investors to invest in their projects. While the donors are wording their commitments or support, to promote and sell their 'brand'. Expectation of both the stakeholders is to be presented with neutral information without the coating of a sales pitch. The- *sounds too good to be true*- factor from the information needs to be omitted, in order to be taken seriously. The respondents in their criticism compared this to an *American used-car sales man talk*. This research did not cover geographies other than some countries in Europe and Asia. The rest of the world will of course have different values to adhere too and is recommended as a separate study since it is omitted from this research.

7.5.5 The context (Physical and Emotional)

A tool that can be used in office or from home office is expected. It will not be used in free time. It is not expected to run on smart phones. Nevertheless, mobile devices like iPads and webpads are ok to be supported. Desktops or laptops are the preferred choices at home or office. A technology driven tool, which uses internet capabilities and is able to find updated information, using search functionality, not limited to any particular database, to verify and cross match data is needed. Fine balance between commercial sense and emotional appeal is the underlying expectation. Feeling of foolishness if having to ask too many questions and help is to be avoided. Slow learnability curve but high adaptability for using new technologies for the want of feeling modern and connected is noted.

7.5.6 Technology possibilities (Hardware and Software)

Desktops, Laptops, preferably large screens need to be supported. Smart phones NOT OK. Hand held devices like iPad were not expected to be supported. The systems was expected to be visually driven, easy to use, easy to learn and would help if it had the possibility of handholding the users to complete the tasks in a step-by-step approach. The expectation was also to accommodate user errors.

7.5.7 Design Alternatives (Sub-Problems)

Post development of the TSAs, the defining of the agents, the context definition and technology possibilities in an iterative manner with the participants and the moderators, we started by stating and defining the sub-problems.

7.5.7.1 Conflicting and Complementing Sub-Problems

- Wizard based systems may be good solution for older users but can be boring for younger users
- The learnability diversity of the user group may alienate one or more user group diversities
- Focus on simplicity may be a barrier to drill down deeper when there is a need felt or interest generated

No obvious complementing sub problems can be visualized at the current stage of the project.

7.5.8 Concept Design: Detailed Design and Functional Prototype

The concept design phase did not have the wireframe stage following the traditional sense of Human Centred Design approach. It was a conscious choice to skip the stage and directly build the functional prototype. It was decided to build a functional prototype using OPPS methodology (Wegner, 1990). The idea was to build reusable components that could be changed on the frontend quite rapidly to try out new layouts and designs. Thus, the design iterations were as follows.

- Iteration 1: Early Design- A non-detailed demo with basic functionality was built to do the pre-research using the wizard interface model (MSDN Library, 2012h). This phase was also used as a mode to validate the TSAs and the functionalities as recommended by Leikas (2009)
- Iteration 2: iReach 1.0- a link (junction)-table based approach (Wikipedia, 2011d).
- Iteration 3: iReach 2.0- a pivot based approach using Microsoft Pivot (MSDN Library, 2011a)

7.5.9 Early Design Phase

The stakeholders in the FoL are diverse from age, ethnicity, geographical, ICT expertise and gender perspective. A simplistic design that would cater to the needs of all the users was sought to be created. In the early design, I decided to use a wizard approach (MSDN Library, 2012h) for developing the interface design. My idea was that the functionality that the wizard format uses to guide the users (as depicted in Figure 15) through the workflow, will help the users to complete the workflow and at the same time give them good visibility of the overall workflow at all times.

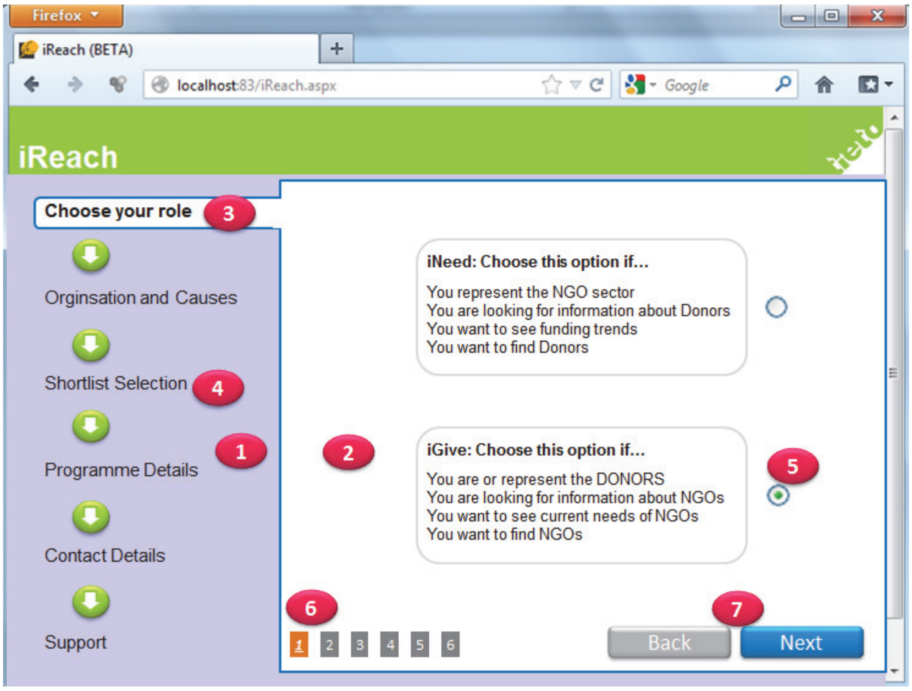


Figure 15: Early Design- start-up screen

As shown in Figure 15, the wizard consisted of the Left Hand Side (LHS) panel (1) and the Right Hand Side (RHS) panel (2). The LHS displayed upfront the steps necessary to complete the workflow. The current step (3) was highlighted in the same look and feel as the RHS. The following steps were not highlighted (4). Input options like the radio button (5) were used to make choosing a mutually exclusive option (Hempel & Altinsoy, 2004). In the RHS panel there were also clickable buttons (6) that acted like bread crumbs which are of great use for backtracking (Nielsen & Pernice, 2010). The 'back' and 'next' (7) navigation buttons also allowed the users to move between the screens. The back button in the first screen was disabled because this was the starting screen and was not to be used (Lazar, 2007).

Figure 16 is an example of the screen in the wizard where the users only navigates from the page without any actions. The only action performed by the users is to verify the selection she has done so far. The breadcrumbs (1) on RHS indicate the page the user is on with yellow, completed pages with green and pending pages with grey colours. Similar visual cue is also included in the LHS (2) with the last two steps in black colour indicating action pending while the previous steps in green to mark action completed. The Back and Next buttons on this screen are both active because the forward and backward navigations are possible.

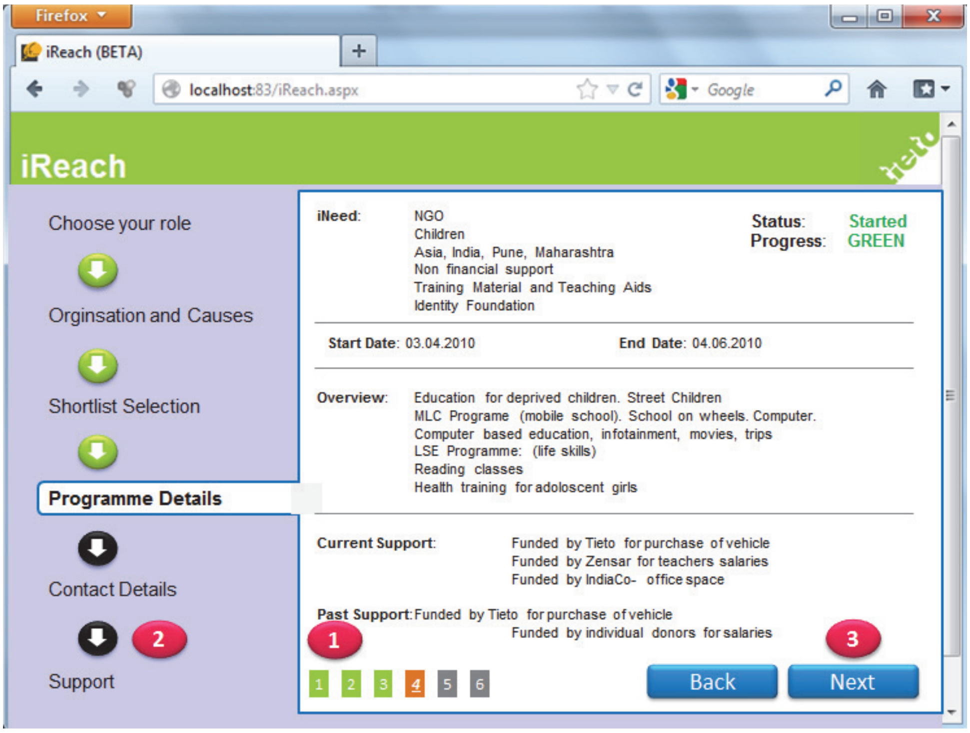


Figure 16: Early design: compiled data

7.5.9.1 Findings from Early Design

There was a mixed reaction to the wizard control from the users. Too many steps were required to complete the workflow. Visibility of the big picture was missing. Moving between the steps in the wizard was confusing and stressful. This was not because of the inability to do so, but because of the feeling that the users had made a mistake and hence they needed to *correct the mistake*. As Colborne (2010) says,

> "Whenever a user has to correct an error, it breaks his concentration and makes the experience feel more complex". (Colborne, 2010)

The hybrid combo boxes and collection grids were perceived as cumbersome to use and need to be relooked when designing the following iterations. The collection panel, the logo of the organisation with link to website, and breadcrumbs were the elements that the users found very useful and are a good input to carry forward in the following iterations. As Rubin and Chisnell (2011) recommend, I have used focus groups and interviews at this stage of the work to gather user insights.

> "Use focus group research at the very early stages of a project to evaluate preliminary concepts with representative users". (Rubin & Chisnell, 2011)

The findings and observations are evaluated from a heuristic perspective and not a deterministic perspective.

7.5.10 iReach 1.0

The needs of the NGOs needed a nomenclature for easy and obvious connection. The data for the needs was simply named as iNeed. On the other hand the offerings from the sponsors also needed a similar easy to understand nomenclature and was named as iGive. Both these words were chosen with the view of making the users easily connect their form-of-life of giving or needing resources to the action of giving or needing. The concept of iReach 1.0 was developed as a link-table sorter with a child-table result. Traditionally, portals offered a drill-down possibility of searching and sorting options using components like drop-down menus, combo-boxes, open search or even a combination of all the mentioned elements. List boxes are also used in some tools. In order to drive the selection and the sorting process in a visual way, link-table components were chosen marked as 4 in Figure 17. They were also supplemented with open search possibility on both iNeed and iGive marked as 2 in Figure 17 data tables.

iReach 1.0 was developed using Microsoft SharePoint. Elements from Early Design Phase were re-used in creating this interface. This was done using fast prototyping approach, since the original components and the framework was developed in an object-oriented manner. At this stage multi-browser support, or rather browser independence was not sought. I believed that technical compatibility could be addressed once the design had reached a level of maturity that was tolerable to be released for actual use. Major component changes were not sought. Using the feedback from Early Design Phase, the entire workflow was brought together in a single form. Navigation of the form was possible using the keyboard exclusively or the mouse exclusively. This feature was specially built in this iteration after observing that some users prefer to use the keyboard exclusively for moving between the elements of a form. Most functionality that appears in standard Microsoft components was emulated in order to allow the users to leverage their knowledge of working with Microsoft interfaces. The interface was self-adjusting to the screen size of the device that the users were using. Since the users were using their own devices for usability tests, this allowed me to gather inputs of their usage in a realistic way. It also highlighted the challenge of users who had large screen and visually had to move back and forth reading the lines that ran across the whole screen. This also created many empty spaces, which gave the impression of an incomplete solution. This insight was used for further improvement in iReach 2.0, even though the users did not mention it explicitly in their feedback.

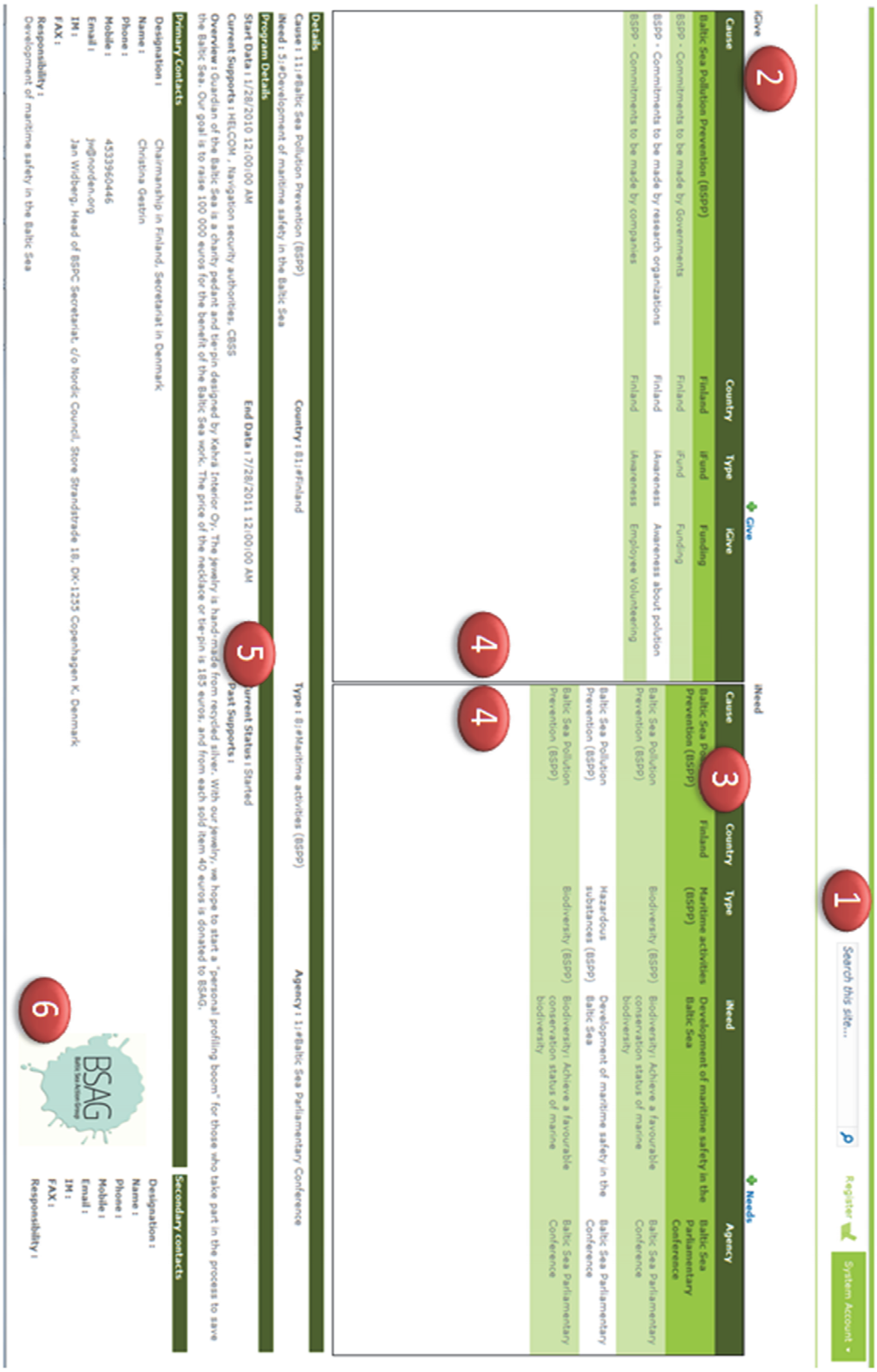
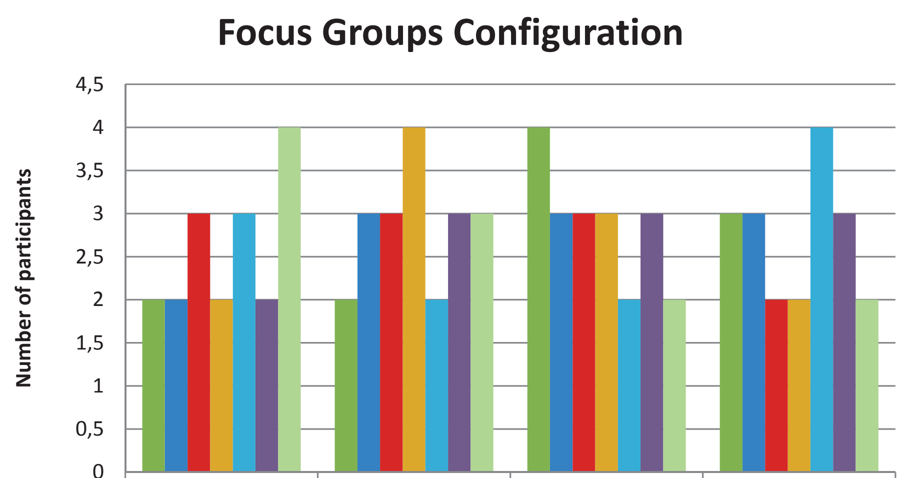


Figure 17: iReach 1.0 elements

The users could choose to approach their search and sort using either the iNeed table or the iGive table based on their role. Once they had searched and made a choice on either of the tables, the linked table filtered and highlighted the connection in the result child-table as seen in highlight 5 in Figure 17, based on the original choice. In the link-table, the user can browse the results and choose any one for drilling down deeper and getting details. The columns on the link tables were filterable and movable as seen in highlight 3 in Figure 17, i.e. had the possibility to change the sequence in which they appeared. This permitted the user to do some top level sorting without any choice being made. The result child table not only displayed the textual information but also had the possibility of displaying the logo as seen in highlight 6 of Figure 17, of the organisation or the entity, hence making a visual association of the brand to the user. The base technology used for creating this functional demo was Microsoft SharePoint Portal 2007.

7.5.10.1 Results of the usability tests

The tests were conducted with 77 people divided between 7 user groups of 11 each as seen in Figure 18. The groups consisted of male (38) and female (39) participants with European (38) and Asian (39) backgrounds.



	Europe (Male)	Europe (Female)	Indian (Male)	Indian (Female)
Group 1	2	2	4	3
Group 2	2	3	3	3
Group 3	3	3	3	2
Group 4	2	4	3	2
Group 5	3	2	2	4
Group 6	2	3	3	3
Group 7	4	3	2	2

Figure 18: Demographics of the participants in the Focus Groups

As seen in Figure 18, each group was formed to get a balanced representation of the types of users from geographical perspective, ethnicity, gender and age. The seven groups thus formed represented in themselves a good cross section of the complete sample base too. The sample selection was extensive from numerical perspective to ensure that granular details could be addressed in the iterative design process. Since I was not trying only to identify major usability issues but also look at details, a smaller sample group of 3-4 users was not enough as recommended by Tullis and Albert (2008). For identifying larger challenges and when the application to be tested has a large and varied users, it is recommended that 15-30 participants are tested to get the basic results in place. However, it may be wise to use a higher number of participants between 50-100 for getting granular details that is relevant to the following parameters:

- Magnitude of the effect
- Significance level
- Repeated measures / Paring
- Expected variation of the sample

Tullis and Albert (2008) recommend that during early design phase, there is a need for fewer participants in the usability tests. On the other hand, risk appetite to accept errors also determine the number of participants. With increasing number of participants, the margin of error decreases. As referred in the Figure 19, (Tullis & Albert, 2008), the confidence intervals between the top and bottom move closer with increased number of participants.

Number successful	Number of participants	Lower 95% Confidence	Upper 95% confidence
4	5	36%	98%
8	10	48%	95%
16	20	58%	95%
24	30	62%	91%
40	50	67%	89%
80	100	71%	86%
Note: These numbers indicate how many participants in a usability test successfully completed a given task and the confidence interval for that mean completion rate in the larger population.			

Figure 19: Example of how confidence levels change as a Function of sample size (Tullis & Albert, 2008, p. 18)

The cross section of users from different geographies and representing different cultures is used in the research in order to make sure that the outcome addresses the needs of cross-cultural requirements and is not based towards the intrinsic understanding and sensibilities of designers representing any single culture (Winschiers-Theophilus, 2009). Winschiers-Theophilus (2009) propose that a tighter integration of the cultural model with the user's feedback is necessary to overcome the cross-cultural challenges from traditional engineering process as seen in Figure 20.

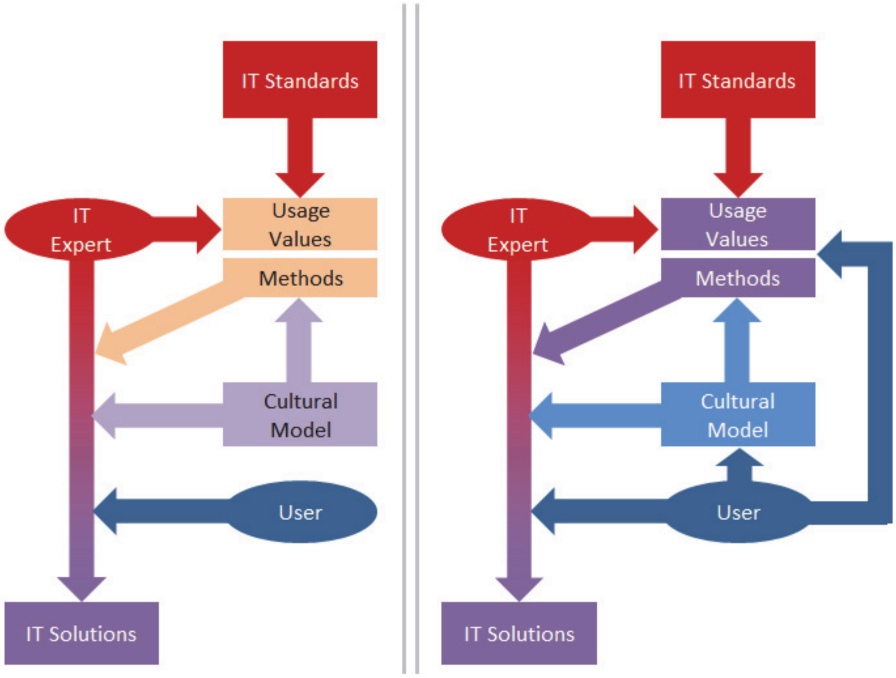


Figure 20: LHS- Cultural Flow of traditional process. RHS- Cultural Flow of integrated process

7.5.10.1.1 Completion rate of tasks (Unaided)

Task completion (Figure 21) is one of the primary metric for usability studies (Albert, Albert, Tullis, & Tedesco, 2010). This is a binary function and a task is either completed or incomplete according to Albert et al. (2010).

As seen in Figure 21, the participants in each group were able to complete the tasks with approximately the same efficiency. The participants in group 6 were the most challenged with 39% of them being able to complete the tasks unaided while the group 3 participants were the most efficient with 48% of them being able to complete the tasks unaided. Majority of the aid was required in the following two areas:

- Navigation back to change the parameter of the choices that they had made earlier and
- Understanding the parameters themselves in order to make a choice, which would give them the way to move to the next step.

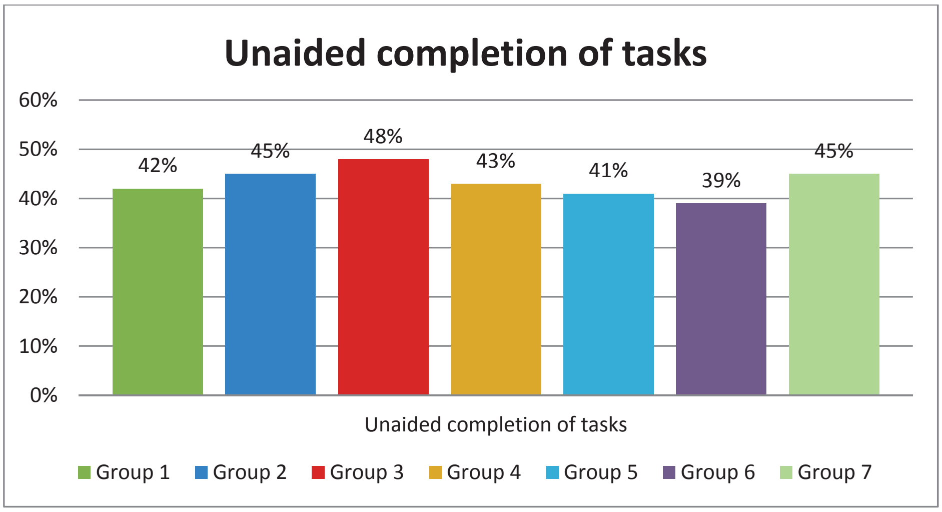


Figure 21: Unaided completion of tasks

Moderation was not involved in these tasks and this is a result from unaided work carried out by the users. Subjective judgement needs to be covered separately as unaided tasks (Albert et al., 2010). From a heuristic perspective, I conclude that the unaided completion rate of tasks in not at acceptable level and a better score is needed and design improvements specifically aimed at bringing more overall visibility and visually driven interface needs to be explored.

7.5.10.1.2 Completion rate of tasks (aided)

As seen in Figure 22, aided or assisted completion of tasks is measured as the users have failed to perform the task and the moderator provided pointer to help the participant. I have used aided completion of task as a metric wherever the users has been provided help to take the next step or towards completion of the tasks as recommended by Dumas and Loring, (2008).

There was a bigger delta in completion of the tasks with the moderator's aid, compared to the completion of the tasks without the moderators help. The range was between 52% and 61% as seen in Figure 22. Group 6 though had relatively more challenges of completing the tasks unaided, they were able to reach the completion of the workflow with 61% results. On the other hand, with intervention by the moderators, group 3 were unable to maintain the performance and they completed their tasks with 52% results. Group 2, group 4 and group 7 were on similar levels – between 55% and 57% results, while group 1, group 5 and group 6 were on the top performing groups with results between 58-61%.

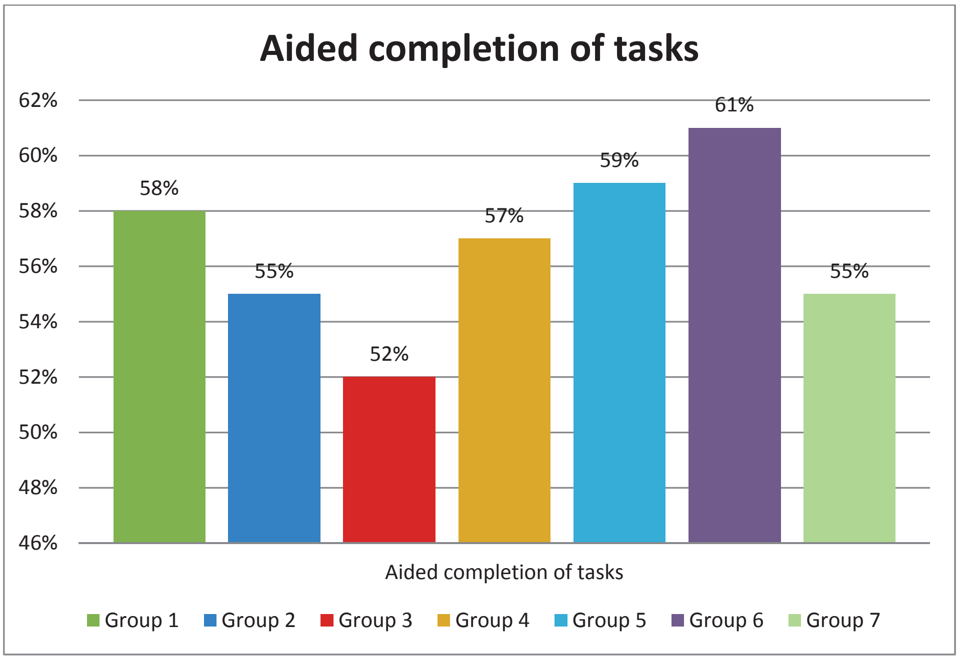


Figure 22: Aided completion of tasks

Though the margins between the groups in percentile value looks and appear small, the actual intervention by the moderators is used to harmonise the data. The aided task completion results cannot be looked at in isolation, but needs to be viewed together with unaided task completion results (Kunert, 2009). As a conclusion, the interface needs to be simplified on one end but more data needs to be presented upfront to the users in order to make the interface more visually driven than having small-steps approach.

7.5.10.1.3 Learnability: Speed of completion of tasks 1 to 5 times

> "Learnability: The system should be easy to learn so that the user can rapidly get some work done with the system." (Neilsen, 1994, p. 26)

The speed of completion of tasks helps in understanding how easily are the users able to learn the system in subsequent tries. Multiple tries also allows the users to get familiar with the system and reuse their knowledge. The speed of completion of tasks by group 3 was the fastest in the first try and it improved by 20% in the fifth and sixth try, as seen in Figure 23. On the other hand, group 1 has the slowest starting point and was able to show significant improvement in the second and third try. Sharpest improvement in performance was 30% points – from 10% to 40% for both group 1 and group 2.

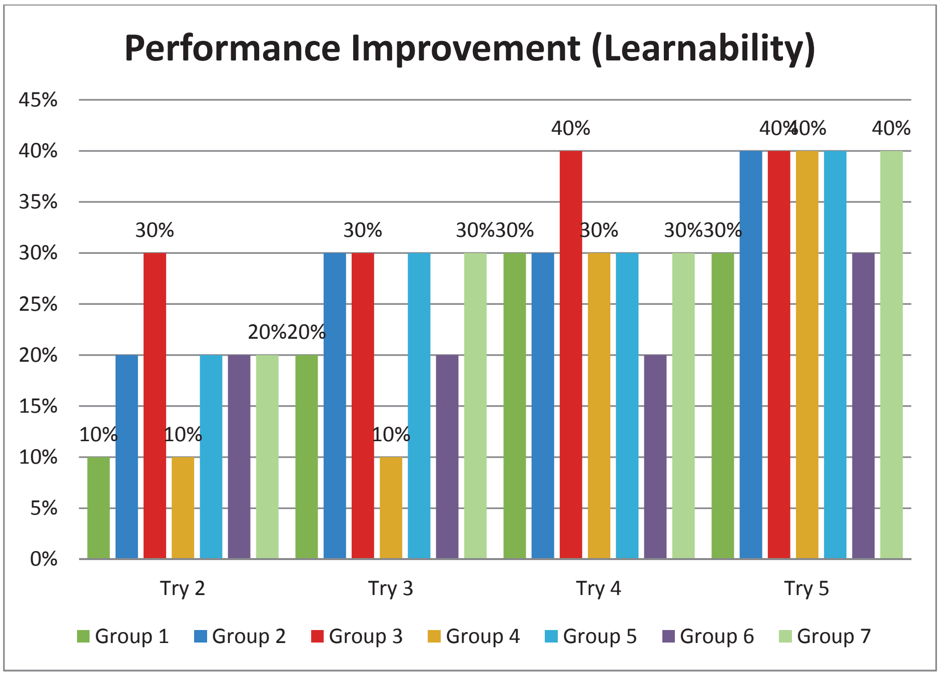


Figure 23: Performance improvement (Learnability)

Learnability plays an important role for systems used by older adults. LEMES standing for Learnability, Efficiency, Memorability, Errors and Satisfaction has been re-coined as:

> "Let Every Mature Elder Succeed" (Charness & Jastrzembski, 2010, p. 15)

The speed of competition is relatively high. This too is a heuristic observation and no empirical conclusions can be accounted from. Intuitionally, I conclude that the learnability rate is acceptable. However, users' dis-satisfaction towards working with smaller steps and need to see the *big-picture-upfront* needs to be considered while developing future design concepts.

7.5.10.1.4 Number of actions required to complete the task

Efficiency and thus performance improves if less number of steps is required to complete task flows. However, on the other hand increased number of input options to help the users to complete tasks faster can also mean higher perceived difficulty as quoted by Lidwell and Manascsa (2009).

The optimum number of steps to complete the tasks was 11 steps. The users in all the groups took between 18-19 steps in their first try as seen in

Figure 24. All the groups were able to reduce the steps required for completing the tasks to lower than 15 steps. As seen in Figure 24, group 2, group 3, group 4 and group 7 were able to reach the optimum steps of 11 numbers by the fifth try.

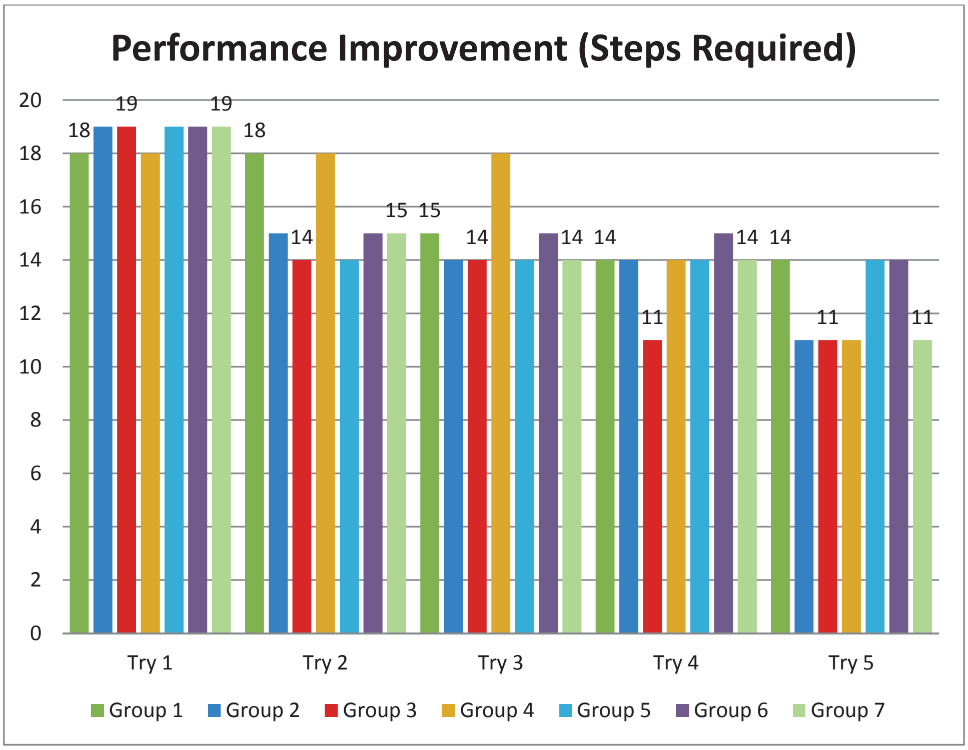


Figure 24: Performance Improvement (Steps Required)

The moderator observed that once the users in various groups got the idea of how to work with the tool, they reacted differently. For example, group 3 tried to optimise their performance to get to a decision point as quickly as possible and in as less steps as possible. While the users in group 6 were more curious of alternatives to their choices and were content in completing the workflow with more steps than necessary. However, it was their conscious choice and they agreed that they could have completed the task faster in fewer steps if they wanted to. Nevertheless, they did not want to ignore other possibilities and hence flexibility of selection with alternative workflow-selection possibilities, needs to be designed as recommended by Heinl, et al., (1999).

Even though 11 steps was the optimal number of steps required to complete the task, it was not mandatory to use only those many steps. Users moving between screens and changing their selection criteria was acceptable. The scores should not be viewed as empirical evidence towards user performance with the interface, but needs to be looked at as an insight in to their behaviour. As a conclusion, I would want to defocus from this parameter completely. The users approach is exploratory and not subject to a particular workflow. I would go to the extent of saying that this parameter mapping may not be necessary for further development.

7.5.10.2 TSA Mapping Perceptions

7.5.10.2.1 Visibility of Overview

Cognition process forms the three stages - formation of goals, selection of goals and actions selection (Kitajima, 2003). Visibility of the overview helps users to create a mental map of goals and actions and build the holistic comprehension of the system.

As seen in Figure 25, the participants perceived the visibility overview of the information presented to them as good. None of the participants was excited by the information presentation. Ten percent of the participants also were critical of the presentation. They mentioned that the interaction was similar to other solutions that they had worked with and did not see any added advantages. While familiarity leads users to believe that they have all the knowledge to use a system (Ayanoglu, Duarte, Noriega, Teixeira, & Rebelo, 2012), in this case, the users expected the new solution to overcome the shortcomings of traditional solutions.

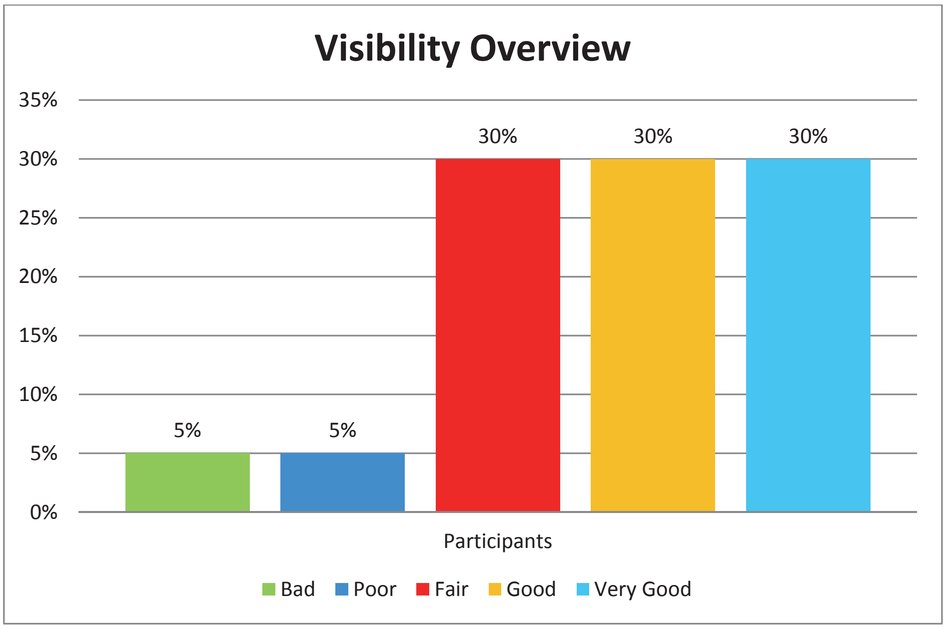


Figure 25: Visibility Overview

The moderator asked a pointed question to the participants if they had rated the Visibility overview as 'fair' because they did not want to be specifically describing it as Bad or Poor. The participants stated that they had no idea why they should call it Good or even call it Bad. It was 'OK'. The participants who had rated the visibility as Good and Very good also changed their stand after this feedback from the participants who had marked the visibility as Fair. This change of opinion is common in a moderated focus group (Hennink, 2007), and hence in-depth interviews were also conducted.

Even though the score towards Visibility Overview is encouraging, it was obvious after the focus groups, that it should not be taken as hard fact. I would like to conclude that the information presentation needs to improve much more than both the Early Design Phase and iReach 1.0 Design Phase. The linear approach towards information presentation is not the right approach, but an exploratory approach needs to be looked at in the next design iteration.

7.5.10.2.2 Ease of Sorting and comparing

According to Mortensen (2009), features that allow the users of an intelligent systems to sort and compare information provide additional functionality beyond ease of use.

As seen in Figure 26, 30% participants pegged the sorting and comparing possibilities of the solution as Very Good, while 40% pegged them as Good. Twenty percent participants on the other hand thought that the function were nothing new and pegged it as Fair.

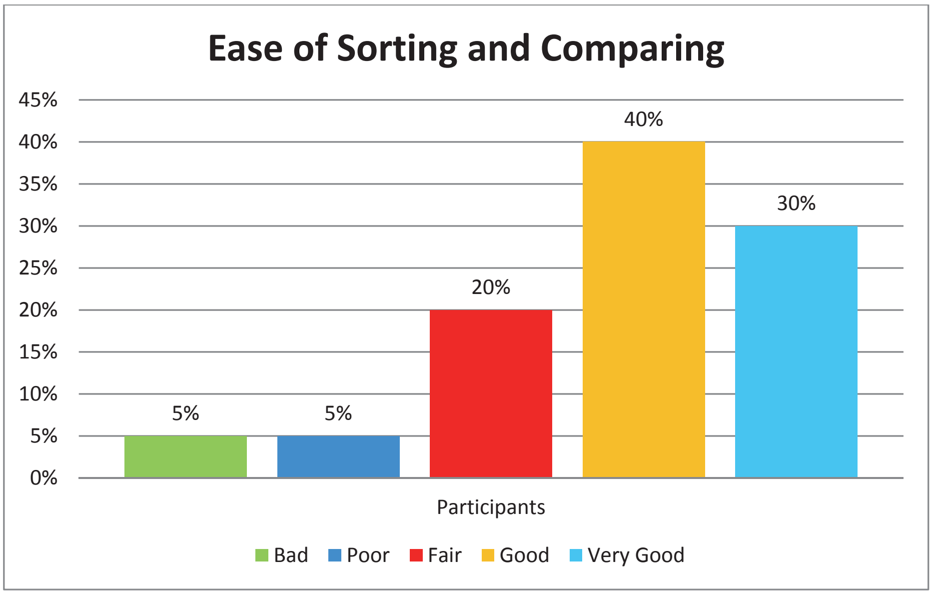


Figure 26: Ease of Sorting and Comparing

The results look promising, but are not optimal in my opinion. Ease of Sorting and Comparing is one of the main TSAs from the users' perspective. A healthier score is needed. Traditional UI elements of combo-boxes, list controls and grids may not be the optimal. Completely new and out-of-the box thinking is needed to have a visual driven approach that is non-linear in nature.

7.5.10.2.3 Visual and emotional cues

In his book Emotional Design, Don Norman gives insights of how HCI can work with emotions (Norman, 2005). At the same time, according to Palen and Bodker (2008), emotions are not detached from efficiency, safety, security and other traditional HCI parameters.

Overall, there was a mixed reaction to the visual and emotional cues parameter, as seen in Figure 27.

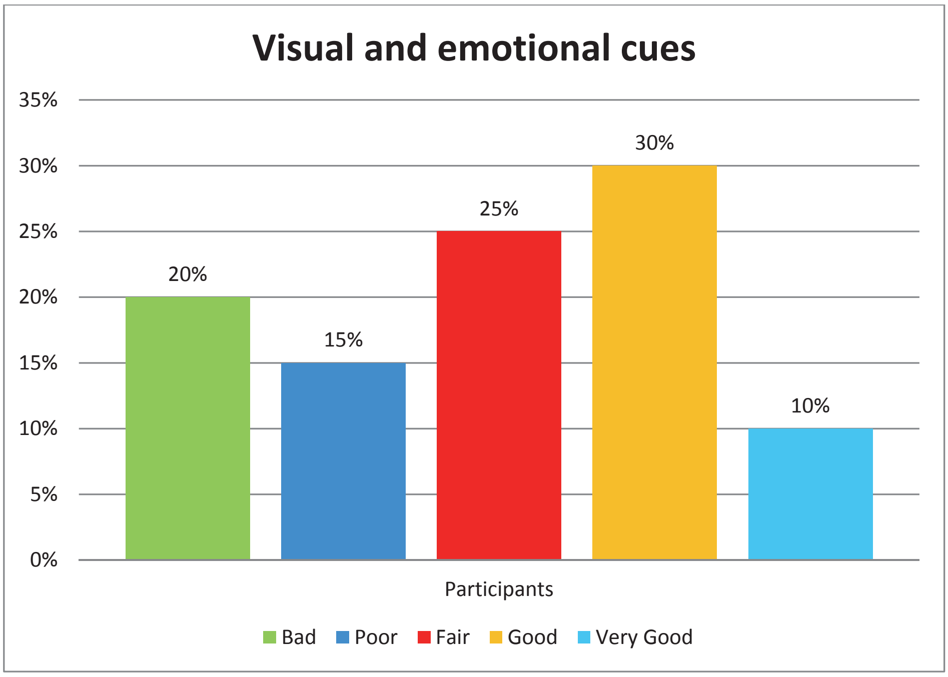


Figure 27: Visual and Emotional Cues

Ten percent participants thought that the solution offered Very Good visual cues followed by 30% users saying that it was Good. Bad (20% and Poor (15%) were reaction of the participants who felt that the logos and the visual identity of the companies was only visible in the collection panel and missed looking at the brands and the elements together for a visual and comparison. Brands and logos were expected to create the feeling of familiarity (Cyr, 2011). On the other hand 25% participants pegged these parameters as Fair and were undecided if there was any real emotional cue to be had from the design. It was obvious during the discussion that this was a sensitive issue for majority of the participants and they wanted the solution to offer more insights visually and emotionally. Emotional responses influence the decision making process (van Gorp & Adams, 2012). During the discussions, the participants reinforced their openness and need to be influenced. The topic is emotional as much as rational hence an emotional trigger was welcome. Example of organisations working with deprived children who promote their work with lot of photographs to create an emotional connect with their patrons was quoted multiple times.

The participants emphasised the need to be able to visually see the organisation together with their brand identities. Branding and brand recognition influence decision making and is part of the overall user experience (Schumacher, 2009). The rational quoted was that the brands stand for the values of the organisation and hence the need to see them together. This helps to create an emotional connect between the users, the task and the brand (Gobe, 2001).

In conclusion, I have to admit that we had underestimated the power of branding. In the next version of the design, we need to find a way to bring the brand upfront and make them more visible. Even more interesting will be a design that will be able to make all the brands visible at the same time. This will also allow the users to make sorting and comparing based on the emotional cues they get from their perceptions associated with brands.

7.5.10.2.4 Ease of verification

Links took the participants to the webpages of the organisation who was a sponsor or a NGO. Moreover, it landed on the page where the latest status and progress of the activities was mentioned. This generated the feeling of verification at runtime. Participants also mentioned the fact that some webpages contained old or outdated information with no regular updates (Albert et al., 2010), created a feeling that the participating organisation was not fully committed. Real-time updates and fresh content is a standard expectation from an online tool (Neilsen, 2000). However, they also felt that over-communication on some websites was more of a sales effort towards the audience of the organisation rather than real progress report.

As seen in Figure 28, majority of the user pegged the ease of verification as Good (30%) or Very Good (35%) while only 5% users pegged it at Bad or Poor. 25% users were undecided and pegged it as Fair.

Spool (1999) holds that the research results can be counterintuitive and this is what makes it controversial and fascinating. Absence and the solutions inability of providing unbiased feedback on the status of the activities was a void pointed out by the users. This was a wish, but not necessarily a mission critical feature. There was willingness to do homework regarding the status of the highlighted organisation using a web based search engine, independent of the tool.

Even though the users generally found the idea of verification plausible with the links to the participants websites, an interesting modification would be to get live data from the internet from independent sources to the users in the details collection panel. This will save the effort of clicking and going to the website of individual participants. This will also help the improvement of the tracking as seen in the next sub-section.

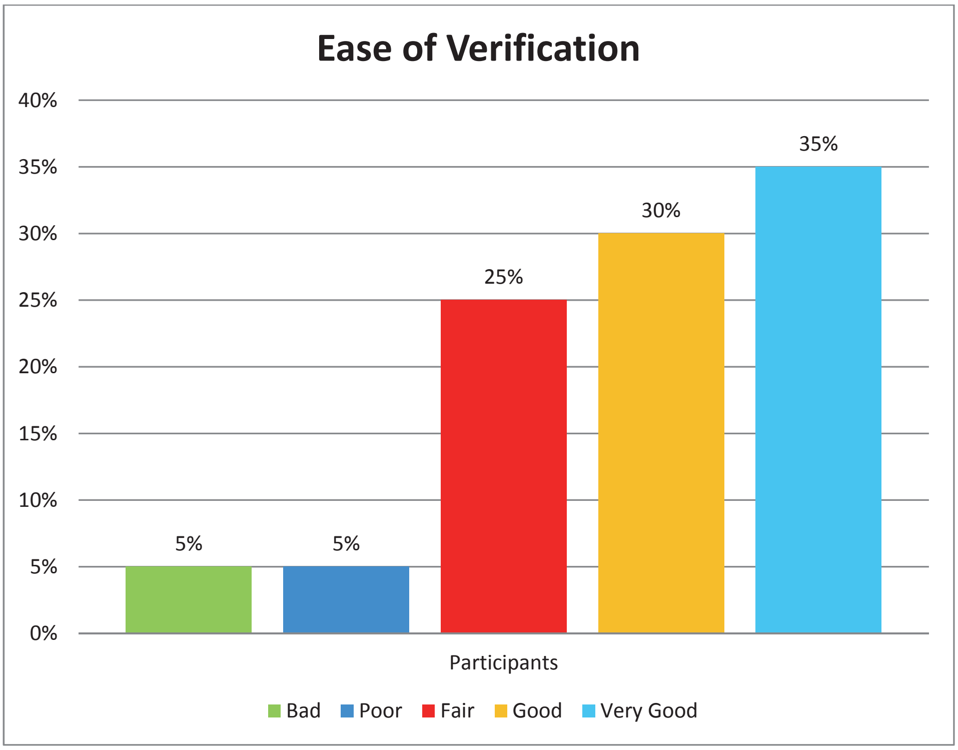


Figure 28: Ease of Verification

7.5.10.2.5 Ease of tracking

Feedback mechanisms help the users adjust their behaviour while working with the system, making tracking an important parameter (Rosson & Carroll, 2001).

As seen in Figure 29, 10% users felt that the ease of tracking was either Bad or Poor. 20% participants pegged it as fair while the remaining pegged it as Good (40%) or Very Good (20%). Two features that were perceived to help the tracking function were the status of the activity in the details panel and the link to the website of the activity on the organisations website. This is a need to remember that introduction of features that might frequently break or disturb workflows with excess information can be irritating (Rosson & Carroll, 2001).

The results from tracking parameter were not optimal according to the feedback I received from the users in the focus groups. In conclusion, as mentioned in the previous sub-section, runtime updates from participants and the progress would help the users track the progress of the commitments better. One more design feature could be the addition and integration of search engine in the interface, which pulls independent feedback from the internet around the commitment and activities of the participants. This will also help in influencing the ease of verification from independent sources.

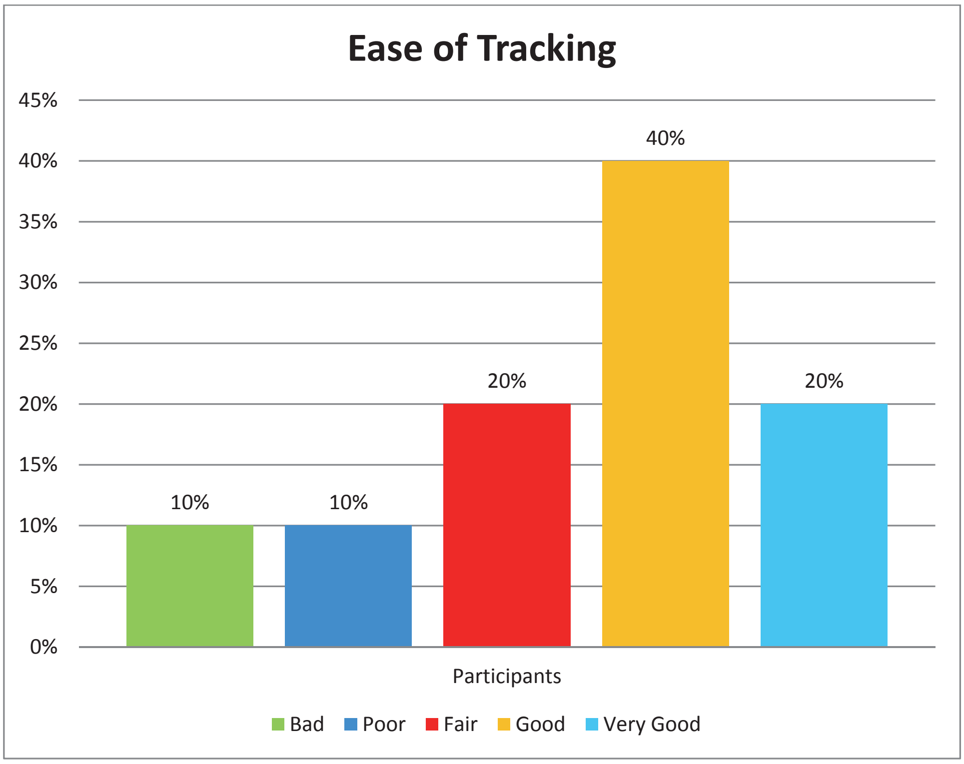


Figure 29: Ease of Tracking

Though, this means addition of a feature on one hand, it will also reduce the workload on the users who now have to click on the link of the participants' website or use a search engine, independent of the tool, to drill down in to third-party sites. An integrated search engine is recommended for the next version of the design to reduce the steps taken by the users for independent verification as well as making it easy for tracking the progress of the commitment.

7.5.10.3 Design Facts mapping

7.5.10.3.1 Age diversity

There is no standard parameter to understand the impact of age on performance. Furthermore, it cannot be assumed that age only has adverse effect on performance hence needs verification (Badre, 2002).

As seen in Figure 30, the participants in the age groups 26-35 and 36-47 had a similar performance with 40% and 35% Fair performance. About 40% users in both these age groups performed at Good or Very Good level while 20-30% performed at Poor or Bad Level. The older users on the other hand more challenge. Sixty percent 30% Bad and 30% Poor) users faced difficulties with scrolling in the lists horizontally and vertically. They also faced the challenge while shifting between the origin of the workflow between iNeed and iGive. Switching between applications or workflows is a major usability challenge for designers (Sandweg, Bergmeier, Pedell, Knapp, & Kaiser, 2003).

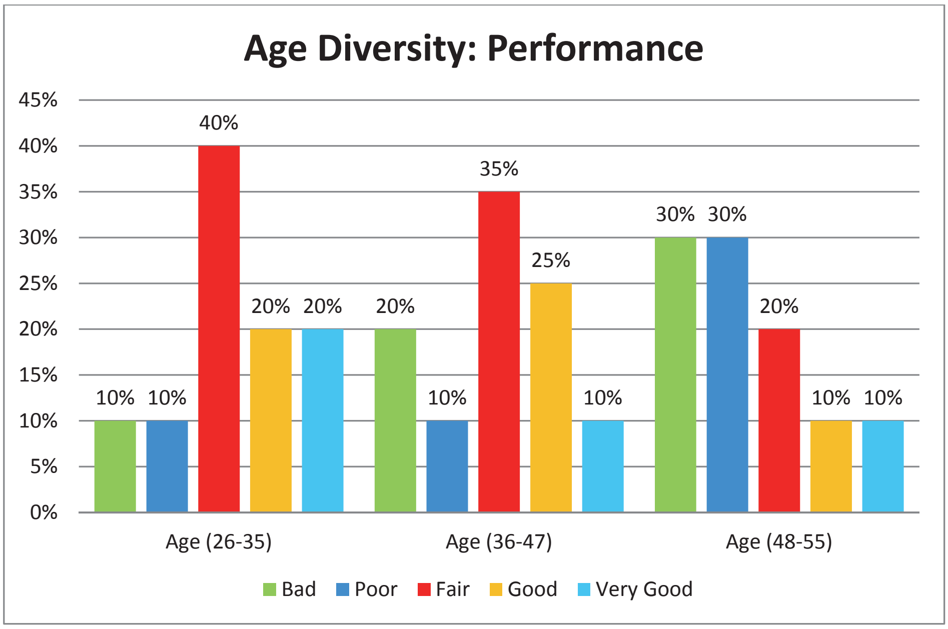


Figure 30: Age Diversity

Overall, the users were not able to use the search function effectively. Dropdown boxes and search functionality can be confusing (Theofanos & Mullligan, 2006). This could also be due to the lead-time requiring to populate the search box which did a post-back after every character was typed by the user.

As a conclusion, the next design should look at alternative design elements other than hybrid combo-boxes. Even though they are feature rich, they are difficult to work with. The user interface element of search functionality integrated with the combo-box and the grid-control also need to be relooked at for the same reason.

7.5.10.3.2 Knowledge and expertise in ICT skills

As we move forward in the digital age, the differentiation of digital natives and digital immigrants will lose its importance (Prensky, 2011). However, today it is relevant to track the impact of skill differences.

The ability to perform at Good (10%) or Very Good (10%) level was similar between the participants with Good Ability, Basic Ability or Early Learners as seen in Figure 31. The Digital Natives were able to perform better with scores pegged at 20% each for Good and Very Good performance. Simply having access and technology faster and using it for longer times may not reflect on users understanding and performance with digital tools (Prensky, 2011). However, participants from the Digital Natives and Good Ability groups performed the tasks at Poor or Bad level at 35% and 40% respectively as seen in Figure 31. The Early Learners and participants with Basic Ability had more challenges with 50% performing at Bad or Poor Levels.

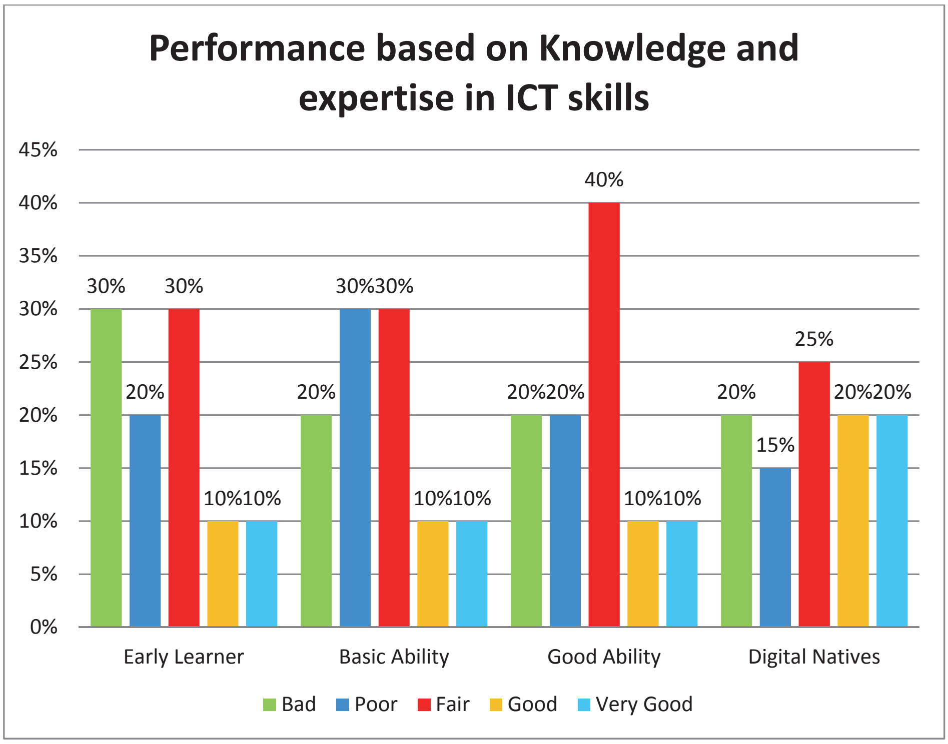


Figure 31: Knowledge and Expertise in ICT Skills

It was observed that the performance challenges diminished as the users found out how to work with the elements on the screen. Repetitions of tasks improve performance and affect the usability measures (Jordan, Russel, Jensen, & Rogers, 1989). After the second try, the users were comfortable using the user interface elements.

My conclusion is that there is a need for thinking out of the box. The users in this form-of-life come from diverse ICT skills. Interface elements that are easy to handle for Early Learners and Basic Ability users and at the same time exciting and rewarding (in terms of deliverables) for Good Ability users and Digital Natives needs to be explored. My take-away, again is the need to go back to the drawing board and think out of the box for choosing an interface design that caters to diverse user profiles.

7.5.10.3.3 Challenges (Motor-ability/coordination issues)

Age plays a role in development of motor skills (Kail, 1991) so it is necessary to map the performance on the motors skills parameter with reference to the age of the participants.

Early Learner and Basic Ability participants surprisingly have better performance (60% and 40% respectively) than participants that had Good Ability (20%) or were Digital natives (20%); as seen in Figure 32.

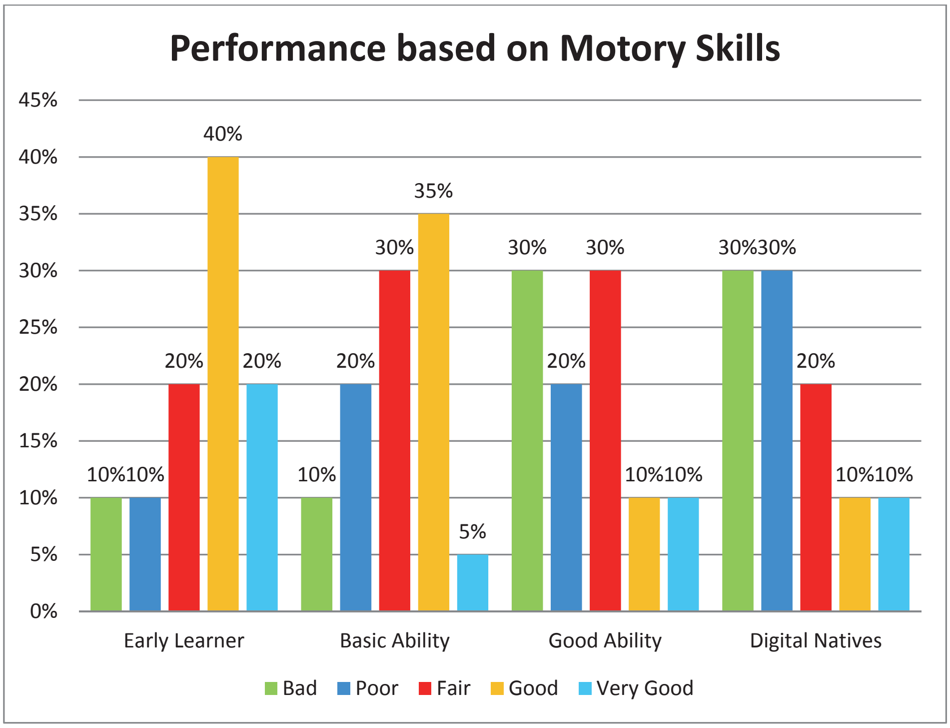


Figure 32: Challenges (Motory/Coordination Issues)

This was consistent even when the older age group people dominated the Early Learner and Basic Ability participants. Normal expectation would have been that digital natives perform better than other (Prensky, 2011). One factor that could have been responsible for this was that the older people were more careful before taking any action on the tool, while people who had worked with IT systems for more time wanted to act fast and complete the tasks faster. Normally, older people would have higher performance challenges (Nielson, 1994).

As a conclusion of these inputs, in the next design iteration, I need to think of a more accommodative interface. The grid and list controls, for example, with the need to scroll horizontally and vertically by clicking on the little arrow-buttons on the scroll bars are difficult interface elements to handle, for people with motor-ability challenges- and needs to be re-looked at.

7.5.10.3.4 Perception of being in control (Memory can be weak)

Again, this was a surprising find that the Early Leaner and Basic Ability participants perceived that they were in better control of the task flows and the solution in general. Twenty-five percent Digital Natives and 10% Good Ability participants had a feeling, that it was challenging to keep track of the workflow and they had to move up through the hierarchy by trial and error as seen in Figure 33.

> "…it has remained undisputed that the ability of kids and adolescents to master complex cognitive tasks is varied, dependent in part on their stage of development, and, for that matter, more limited than that of most adults." (Palfrey & Gasse, 2010, p. 329)

Nevertheless, what I observed here is that affluent users of digital systems tended to experiment with the interface and try different options. On the other hand, people with less experience tended to follow the instructions and not deviate. This resulted into the difference in perception of control and hence results in a skewed finding. In the next design iteration, care needs to be taken to address the workflows in a nonlinear format for users who want to surf the content and information on one hand, and the possibility of completing tasks in a linear format for users who prefer to follow a linear path. From a heuristic perspective, in the next version of the design, information needs to be presented upfront and choices and options visible all the time to reduce memory-load on the users.

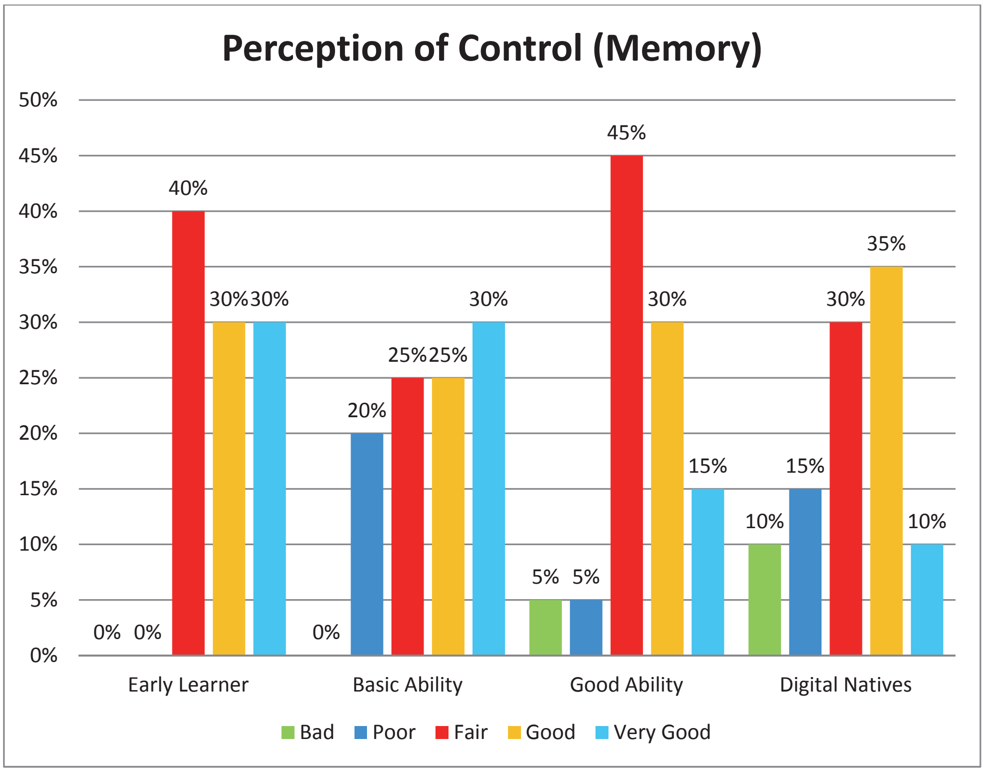


Figure 33: Memory Related Challenges

7.5.10.3.5 Learning challenges

As seen in Figure 34, overall, the participants found the solution easy to use. Thirty percent participants, pegged the task as not challenging while 50% felt that they only faced minor challenged and that too in the first or the second try. Learnability is also related to human memory and trying new features helps humans learn systems through generalising and understanding the systems as a whole (Smith-Atakan, 2006).

Learnability was not a major challenge. The interface was perceived as simple enough, but not broken in very small steps, as in the Early Design phase. One learning from this input is that the users are willing to learn and adapt a level of complexity since they expect the data to be complex. In the next design iteration, users willingness to experiment with the interface should not be underestimated.

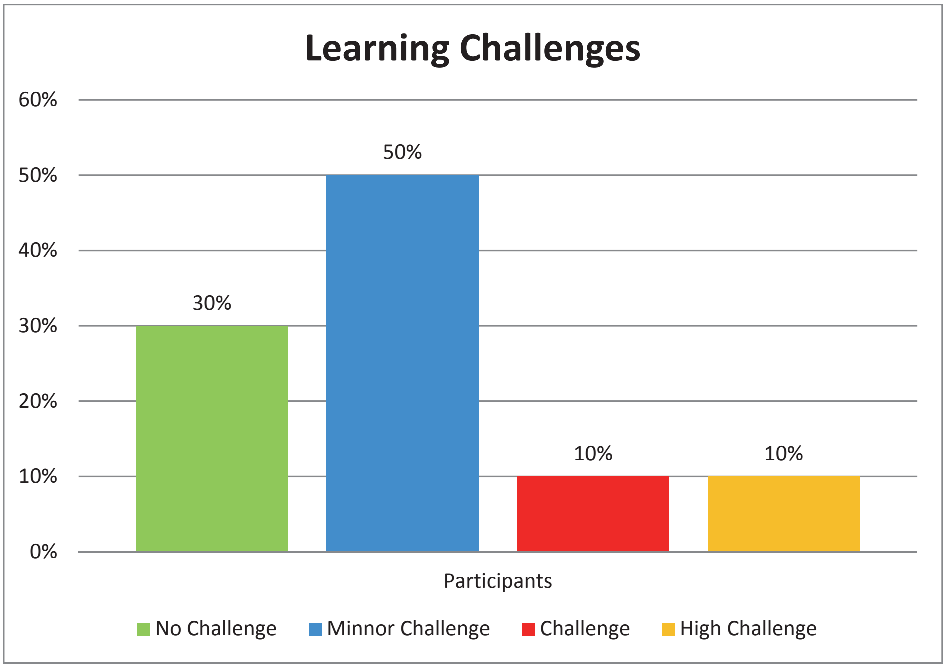


Figure 34: Learning Challenges

7.5.10.4 Design Values mapping

7.5.10.4.1 Perception of Simplicity

According to Obendorf (2009), value of simplicity is widely accepted. However, it is more common to find complex systems than simple ones.

As seen in Figure 35, 30% participants pegged the simplicity of the solution as Very Good and 40% as good. Only 15% participants pegged the solutions simplicity as Bad (5%) and Poor (10%).

The participants overall found the solution simple to use and the workflow also simple to execute the tasks. Since, all the user-interface elements were known to the users, there was a feeling of simplicity. Obendorf (2009) holds that consistency works as an alternative to simplicity.

> "If most of the new design is already known, or consistent with a known design, only new additions have to be learned and mastered. Thus, the impression of even extremely complex systems can be simple- if they adhere to standards set by legacy systems. " (Obendorf, 2009, p. 109)

The next design iteration could be even simpler to use, provided the data requirements are not compromised and the 'form' approach as well as the linear workflow approach is re-examined. Alternatives for hybrid search and combo-box controls need to be explored.

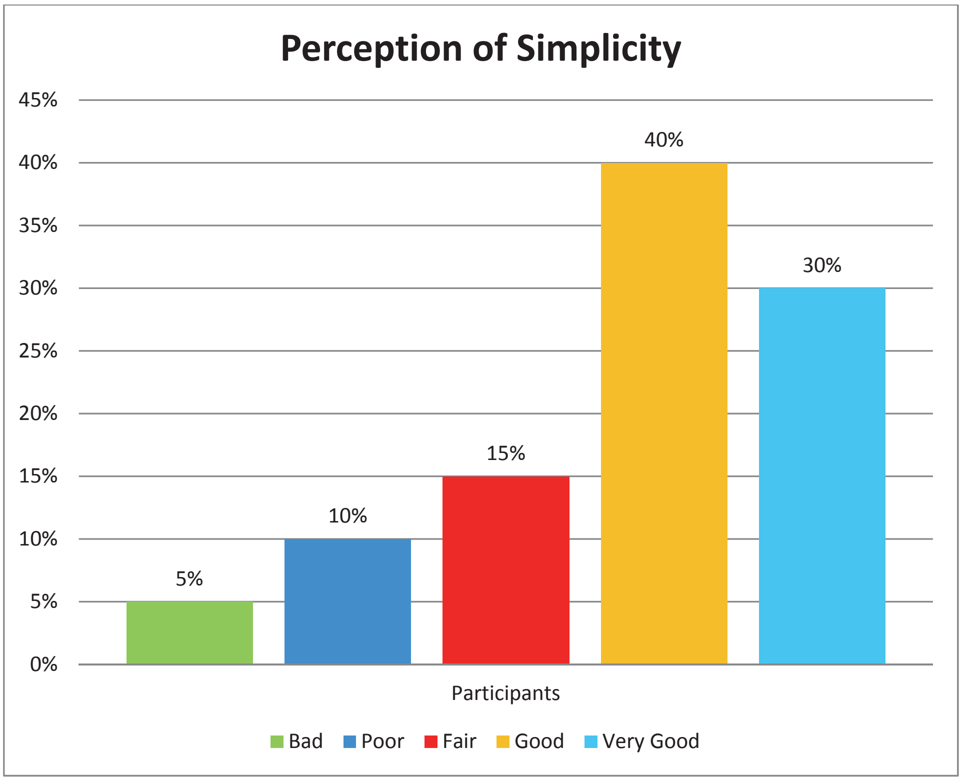


Figure 35: Perception of Simplicity

7.5.10.4.2 Perception of guided help for task completion

Twenty-five percent participants believed that guided help was Not Required or then Never Required while 30% believed that it was Mostly Not Required as seen in Figure 36. Even though more number of participants had required guided help during actual completion of the tasks, the perception was different.

The users believed that they would have been able to navigate through the workflows without any help, provided they were working on their own and help was not available. The possibility of having help-at-hand tempted them to ask for it even when it may not have been necessary. Experiment suggests that, for users who are not familiar with tasks, contextual help is more useful; however, it poses the danger of creating cognitive overload (Capobianco, 2003).

As a conclusion of this parameter, the interface could be more intuitive and confidence building. It needs to overcome the users fear that they might do something wrong. The next iteration needs to concentrate on finding a way to create the feeling that the user is in control of the interface by increasing error affordance.

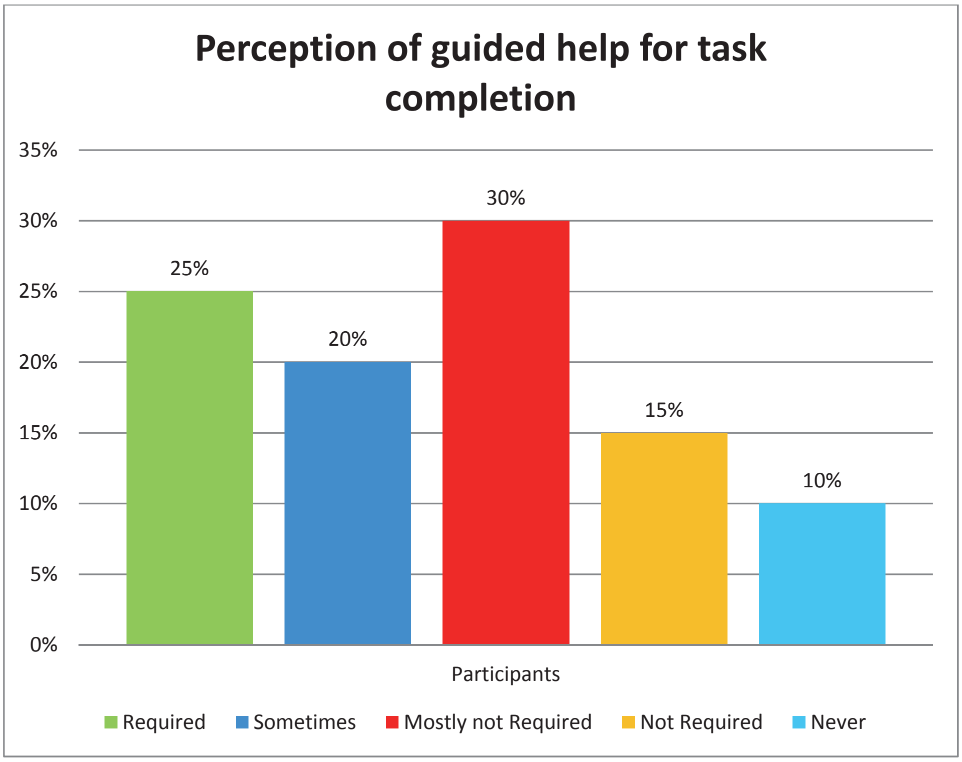


Figure 36: Perception of guided help required for task completion

7.5.10.4.3 Perception of ability to move between hierarchies of the information

Participants had mixed feelings and perception about moving between the hierarchies. As seen in Figure 37, 50% participants felt that it was easy to navigate between the information hierarchy while 25% felt it was not so.

Even though, information structuring is difficult, hierarchically presented information is relatively easier for users (Dix, Finlay, Beale, & Beale, 2004). The dynamically shrinking and expanding link table was perceived as a very good utility on one hand, which did not overload the users with information. However, on the other hand the same control was perceived as difficult to navigate between information hierarchies, because not all the information was visible.

My conclusion is that even though there is an improvement in the ability of users' perception of moving between hierarchies, it may not be enough. An alternative approach of presenting information that can be looked from a holistic perspective with the ability of deep-diving, just-in-time for details needs to be built into the interface. The breadcrumbs are perceived as useful chunks of information for the users trying to locate themselves in the workflow and need to be continued in the following design iterations.

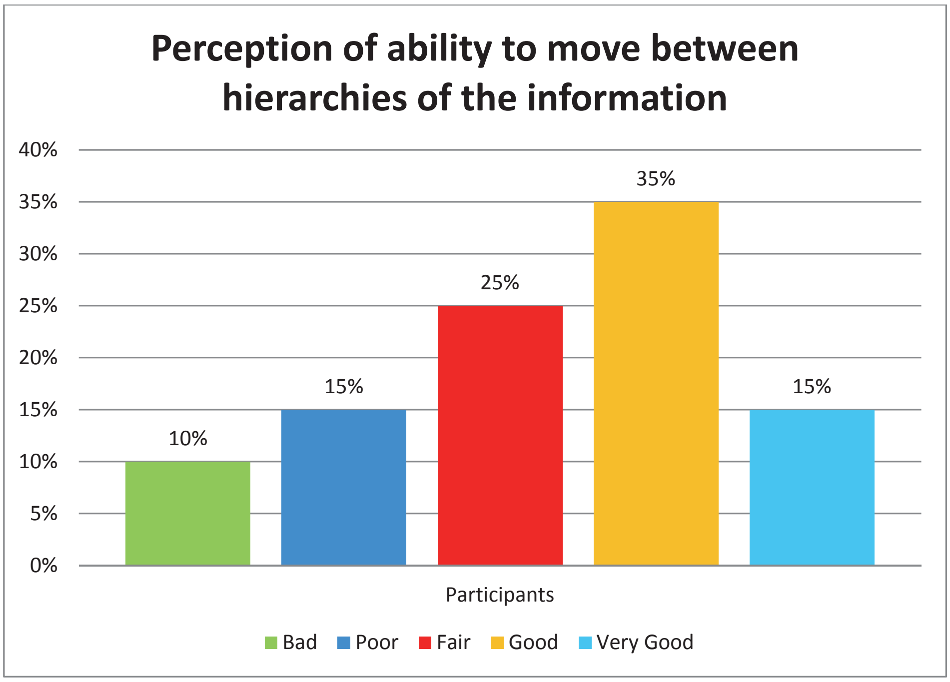


Figure 37: Perception of ability to move between hierarchies of information

7.5.10.4.4 Perception of effort (manual)

The perception of manual effort was divided with 40% participants not feeling it was low or no effort while 35% users felt it was a high or medium of manual effort as seen in Figure 38. The participants mentioned that the perception of effort was not directly relational to the comparative effort they need to make when doing a search on the internet- that was perceived as manual effort.

Overall the participants expect a more automated systems or solution that will help them in the decision making process. Presentation of large and complex data, results into user interaction becoming an effort (Huang, Lee, & Hwang, 2009).

My conclusion is that a simple way of presenting this complex data needs to be explored. As mentioned in the earlier subsections, integrated search engine with the capability of polling data at run time will increase the feeling of low effort involvement.

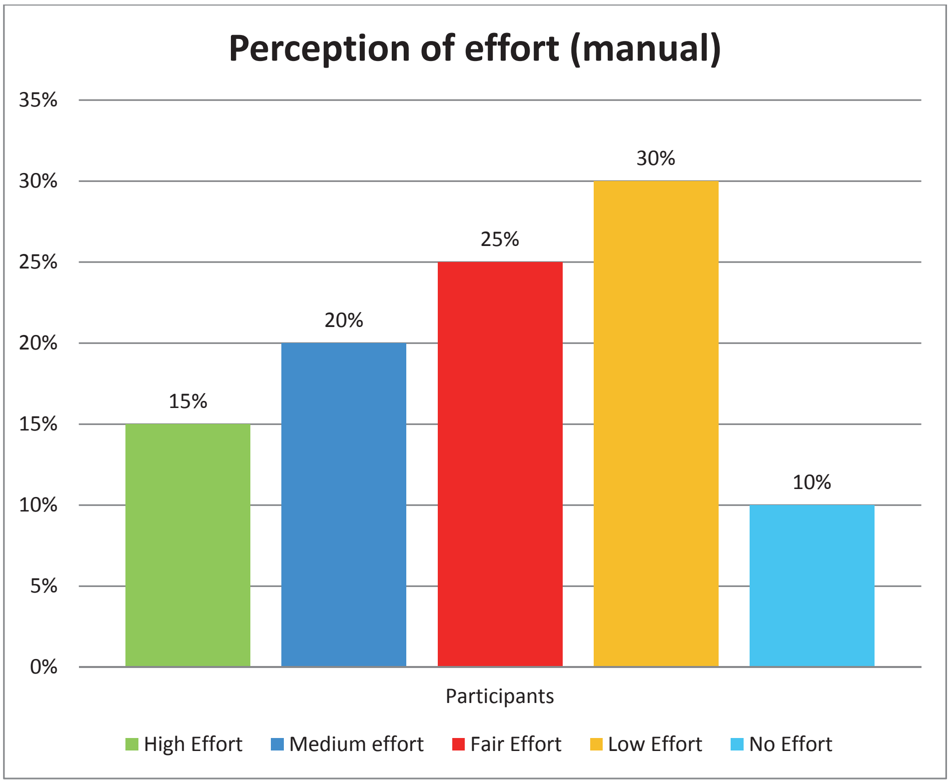


Figure 38: Perception of Effort (Manual)

7.5.10.4.5 Sales oriented vs. Decision Support Orientation

The users felt that the system was more sales oriented than a decision support system as seen in Figure 39, with 50% participants saying that the system was sales oriented (20% Sales Oriented and 30% Somewhat Sales Oriented). Only 10% participants believed that the system was Decision Support Oriented , while 15% believed that it was Somewhat Decision Support Oriented. This perception was rooted in the fact that the workflow was linear in nature with a single element as the result. For future development of design a non-liner workflow needs to be investigated in order to get rid of the sale oriented feeling. As the participants mentioned that, they are open to influences but they do not expect the solution to make the decision.

My conclusion is that a liner workflow gives the perception of shortlisting various options and arriving at a specific solution- which is not the expectation. An out-of-the-box approach as mentioned in earlier sub-sections, which allows linear as well as non-linear task completion possibilities needs to be identified.

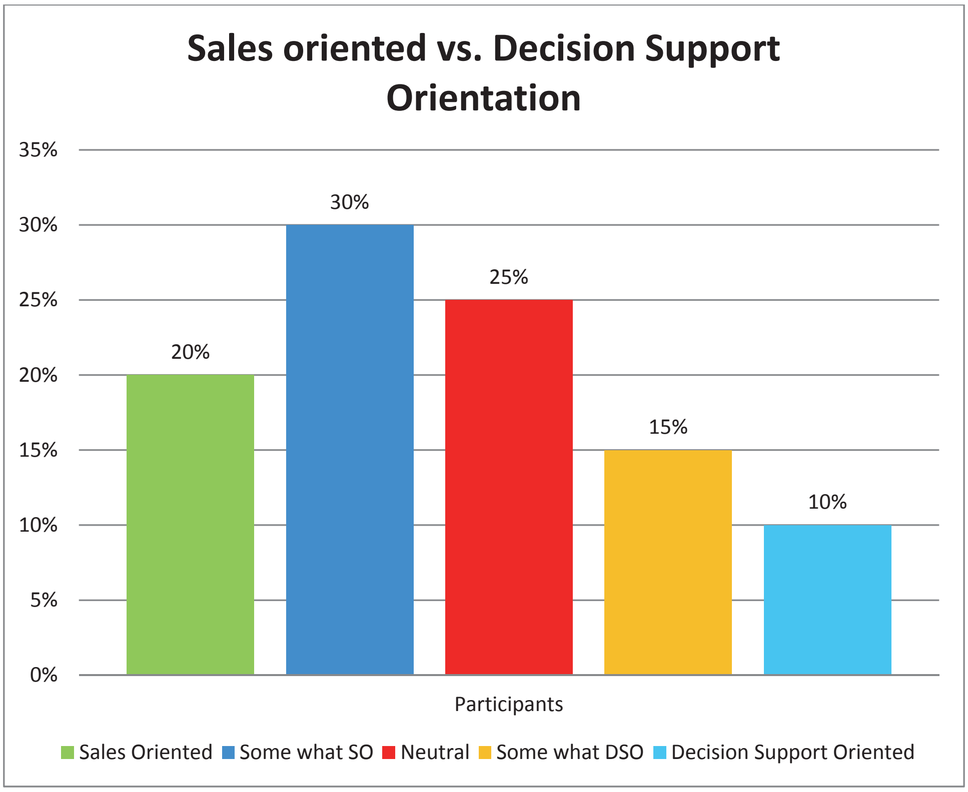


Figure 39: Sales Oriented vs. Decision Support Oriented

7.5.10.5 Findings from iReach 1.0

The moderator's findings were that iReach 1.0 was moderately successful in catering to the challenges posed by the investigated form-of-life. The participant's performance and perception was encouraging but not optimal, since it was not possible to define an optimal limit.

One important consideration that was not identified during the initial fact finding phase with the participants was that the users did not consider the activity of mapping the resources to needs as *must-do-work* or *must-do-tasks*, They considered this activity as *nice-to-do-research*. This was also the driver for their feedback during the focus groups after the usability test that the tool was not *fun to use* and felt too *engineering oriented*.

Improvements are needed in the visual and emotional cues TSAs. iReach 1.0 was not perceived to have the capability to cater to this TSA. Nonlinear workflows where, the perception that the users are sorting and filtering the data, but are not coming to a conclusion are expected. This should not lead to a conclusive highlight of any specific element or activity by an organisation. The issues highlighted in during this phase were considered as the building base parameters and building blocks for iteration iReach 2.0.

All findings and observations are heuristic in nature. More evidence that is empirical is necessary to be gathered by developing and implementing Life-based Design approach in real life application development in order to verify, validate and fine-tune these findings. The findings presented are not empirical in nature, but situational insight in the behaviour, attitude, performance and perception of a set of users in the set framework.

Statistical comparison of results with iReach 1.0 is available in Annexure 1.

7.5.11 iReach 2.0

The second iteration needed thinking out of the box because of the findings we had from the iReach 1.0. The feedback was very valuable in order to change my perspective and not look at traditional tools and components provided in development environments. It was necessary to check the possibilities of beta technologies that could be applied for tool creation instead of traditional ones. During the exploring of these technologies, I discovered Microsoft Pivot, a beta tool running on Silverlight. It was then still in beta stage and promised a good potential for data visualization for pictorial elements like photos. The developer community was already exploring this tool for cataloguing purpose as well as shopping decision support system purpose. Nobody had tried to use the tool in the context of social sector so far.

We modified the tool and used the original SharePoint framework and modified the database in excel to suit the needs of the pivot tool. The final output of the system is presented Figure 40 (landscape view) and Figure 41 (graphical View).

Figure 40: iReach 2.0 (Land-scape view)

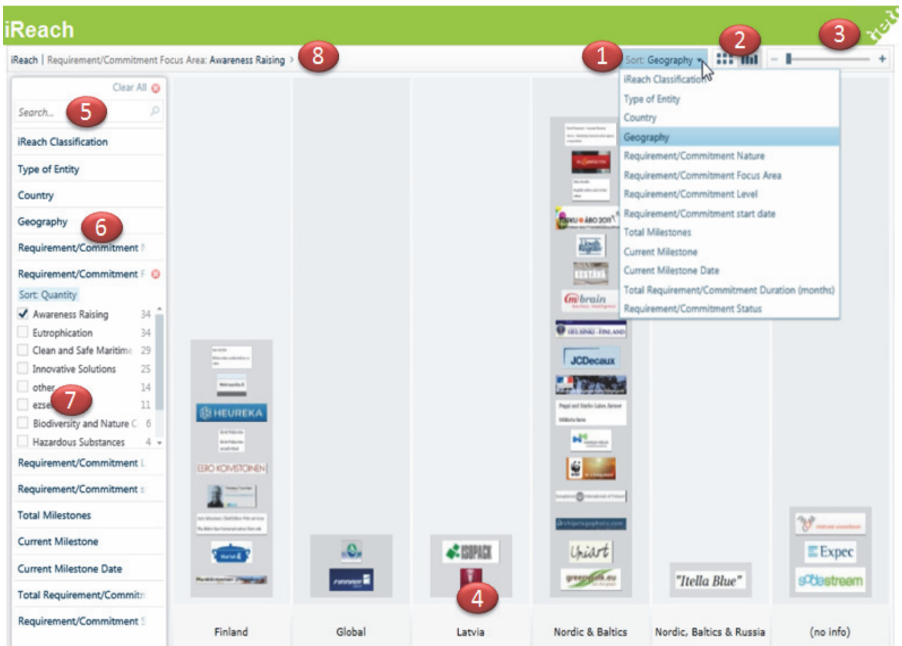


Figure 41: iReach 2.0 (Graph view)

7.5.11.1 Explanation of the UI elements

- Sort category drop-down box: Helps the user choose a parameter on which the visual data needs to be sorted
- Formatting of the data: The data can be formatted in a landscape view as seen in Figure 40 or a graph view as seen in Figure 41 against parameter chosen from the accordion component.
- Slider control: Allows the user to change the size of the images in the canvas plane
- Canvas Plane: The main container for displaying the data
- Search Component: Allows free search on the data
- Accordion control: Allows the user to expand and collapse the possibilities on the various parameters that the data is mapped on.
- Accordion child window: Allows the second parameter to be chosen by the user to compare and sort data with the sort category drop-box (1).
- Breadcrumbs: Users are able to see their selection process and pathway until the current sorting visible in the canvas plane.

7.5.11.2 TSA mapping perceptions

7.5.11.2.1 Visibility of Overview

The participants perceived that iReach 2.0 was visually appealing and inviting. It felt that they were able to see the *big picture* immediately. As seen in Figure 42, 85% participants perceived that the visibility overview was Good (35%) and Very Good (50%). This is a marked improvement over iReach 1.0.

None of the participants rated the visibility as Poor or Bad. The options are all presented at the same time without organisation or filtering in a landscape mode when the solution runs for the first time creating a complete overall visibility for the participants. Even after selecting the graphical view, all the elements appear sorted out based on the sort selection.

The high performance and perception of the Visibility of Overview helps in the cognition process. As Kitijama (2003) holds, it aids the formation of goals, selection of goals and actions selection.

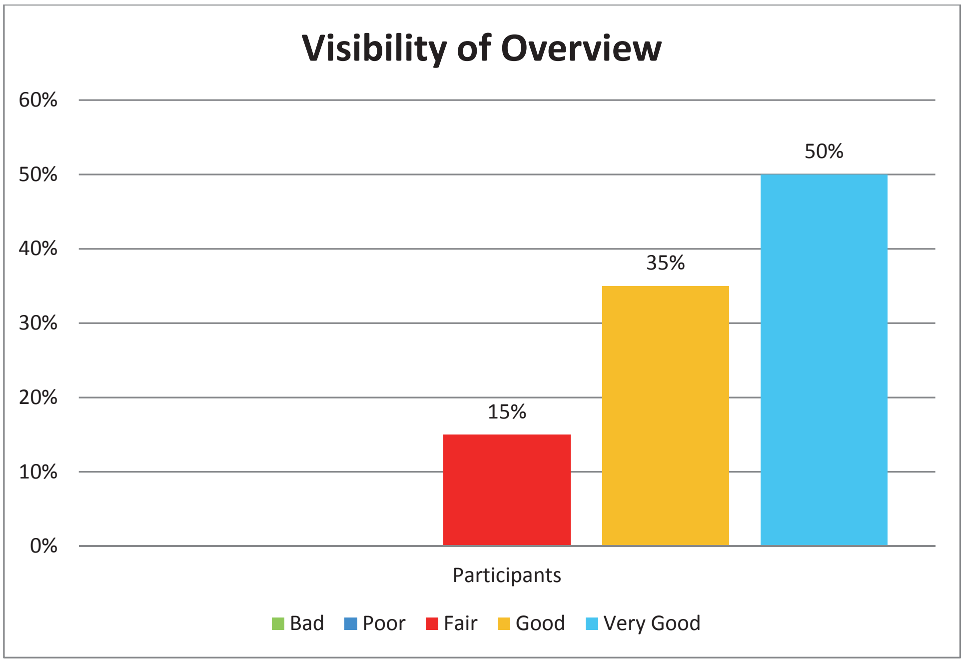


Figure 42: Good improvement in Visibility of Overview

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Visibility Overview score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -4.616$, $p < .001$ (two-tailed). The mean of Visibility Overview score for iReach 2.0 was 4.35 and iReach 1.0 3.74 (-.610 difference).

7.5.11.2.2 Ease of Sorting and comparing

The sorting and comparing was perceived to be very intuitive and felt that it did not take any learning efforts to understand how the tool works. One important feedback was that the participants felt that whatever they did with the tool, they never felt that they had committed a mistake. All actions resulted in some information and even surprise, for being able to see the information and comparison they had not thought of. As seen in Figure 43, Ease of Sorting and Comparing, was pegged at 45% for both Good and Very Good Levels.

None of the participants pegged it as Poor or Bad. The sort parameters and subsequent options are always visible and changes can be done simply by clicking on alternatives. Both the graphical and the landscape modes offer insights into the sort and filter order. The ability to choose multiple parameters on the fly and the result set being visible dynamically created the perception of ease of sorting and comparing. Thus, the sort and compare possibility provides additional functionality beyond ease of use (Mortensen, 2009). This parameter also shows a marked improvement over iReach 1.0.

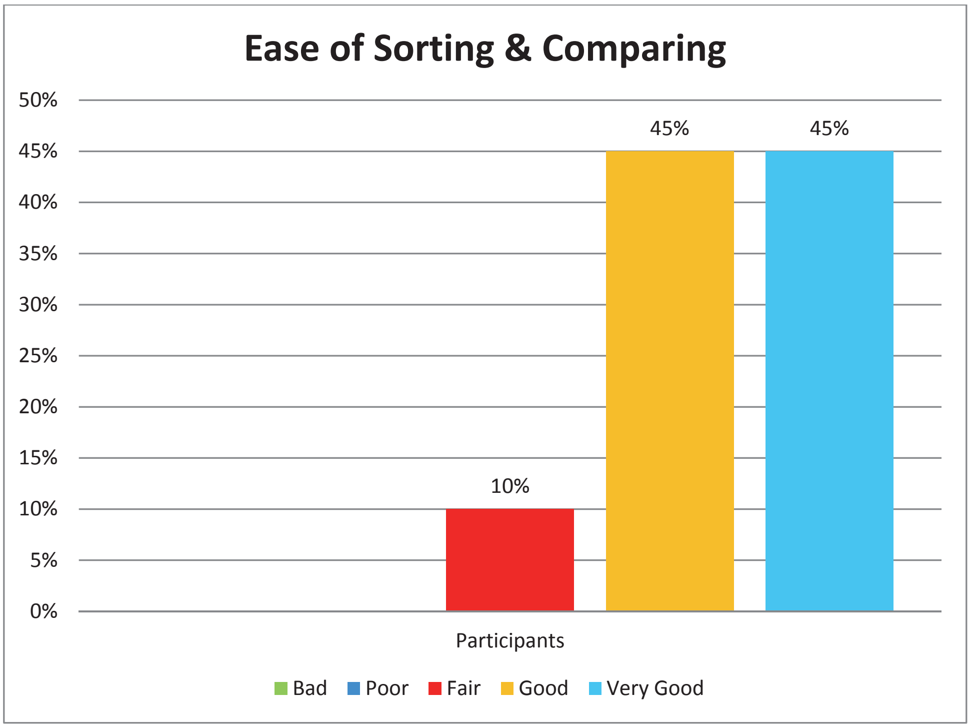


Figure 43: Improvement Ease of Sorting and Comparing

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Ease of Sorting and Comparing score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -6.190$, $p < .001$ (two-tailed). The mean of Ease of Sorting and Comparing score for iReach 2.0 was 4.36 and iReach 1.0 3.84 (-.519 difference).

7.5.11.2.3 Visual and emotional cues

The presentation of the logos in the canvas plane helped the participants make an emotional connect with the data. They could recognise the brands and the logos of the involved stakeholders and derived some feeling from that information. And since they were not watching in isolation every individual brand, they also gave feedback that the visualization was able to impact their perception of the brand in different light when presented on the same platform and compared to other brands.

Visual and emotional cues perception also increased dramatically over iReach 1.0 with none of the users considering it Poor or Bad. As seen in Figure 44, 50% participants pegged the TSA as Very Good followed by 35% pegging it as Good.

Fifteen percent participants considered it to be fair. Unanimously there was an agreement that the solution presentation was capable of making an emotional connect and creating triggers of influence to the users regarding the organisations displayed as their brands. This confirms comment by Cyr (2001) that brand and logos help create the feeling of familiarity. The display possibility of comparing the brands on different parameter with dynamically changing comparison modes also helped the participants to create emotion perceptions and preferences.

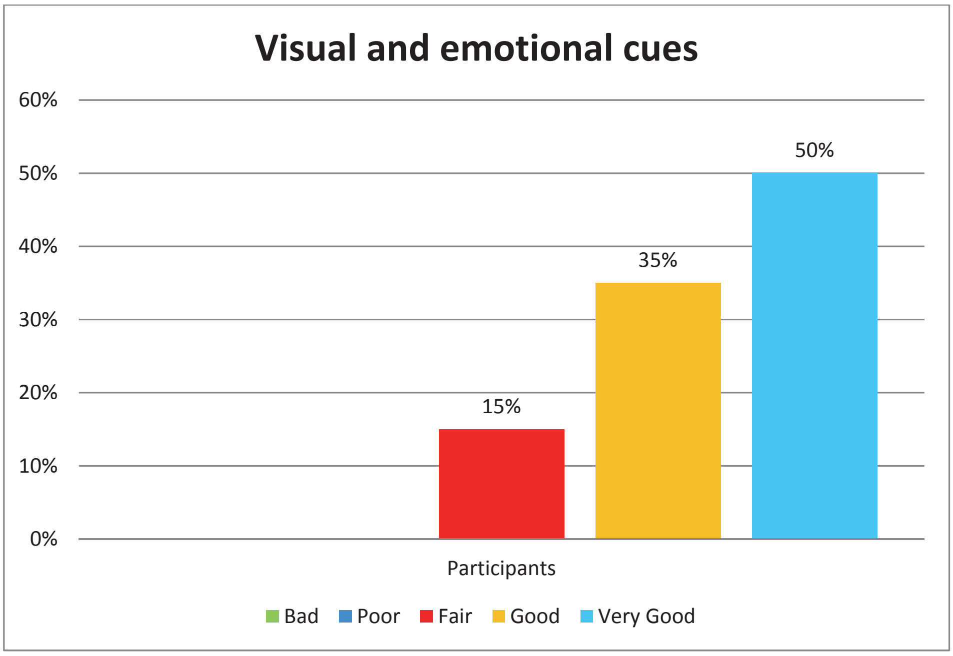


Figure 44: Visual and Emotional Cues are marked improved

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Visual and Emotional Cues score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -13.688$, $p < .001$ (two-tailed). The mean of Visual and Emotional Cues score for iReach 2.0 was 4.35 and iReach 1.0 2.96 (-1.390 difference).

7.5.11.2.4 Ease of verification

The presence of the integrated component of bing.com to display the latest news and updates from the internet was perceived as a very good checking tool to see how the data makes sense. It gave a feeling of the date being live and verifiable. Ninety percent users thought that the ease of verification was either Good (35%) or Very Good (55%) as seen in Figure 45. None of the participants believed that it was Poor or Bad. The positive user's response to the real-time update, is in line with Neilsen's (2000) proposal.

The participants appreciated the visibility of latest results from the search engine visible after the detailed description of the iNeed or iReach elements. The presence of this clickable data that took them to the webpages where the latest news was detailed out created the perception of fresh unbiased inputs.

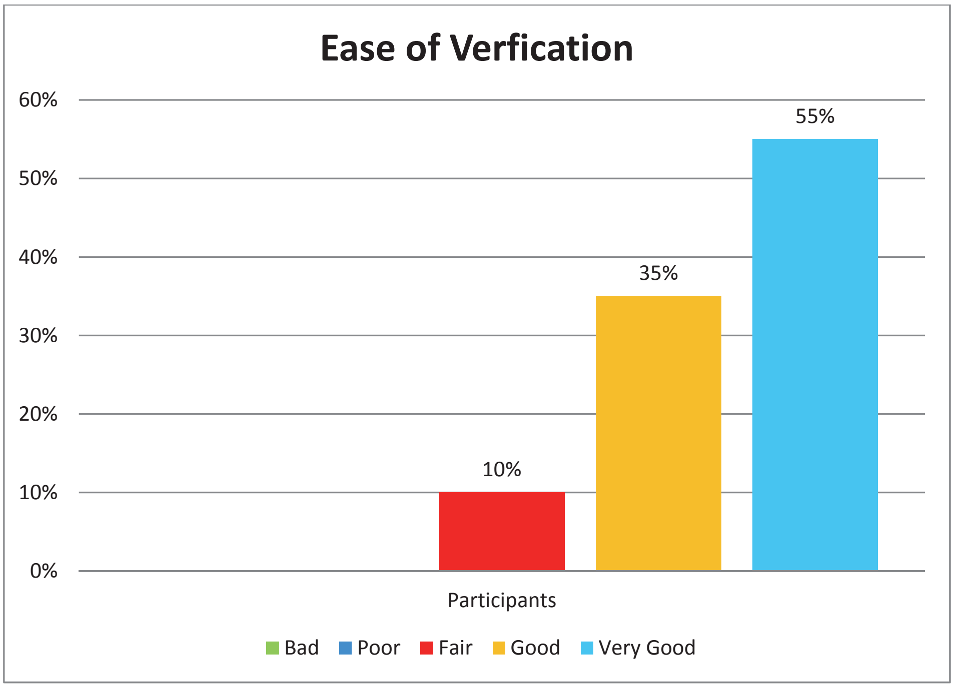


Figure 45: Big improvement in Ease of Verification

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Ease of Verification score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -5.780$, $p < .001$ (two-tailed). The mean of Ease of Verification score for iReach 2.0 was 4.44 and iReach 1.0 3.84 (-.597 difference).

7.5.11.2.5 Ease of tracking

The accordion subpart, which is able to allow the users to move the slider to check the progress of the commitments, was the wow factor for the users. The perception was that the commitments and engagements with this way of displaying information came alive and easy to track. The new design with iReach 2.0 showed a huge improvement over iReach 1.0. As seen in Figure 46, 75% of the participants pegged ease of tracking as Very Good while 20% pegged it as Good.

This overwhelming perception of being in control and being able to track the progress of an activity was credited to the clear milestones, based information presented in the Right Hand Panel, which also gave updated description. This was further supported by the search results pulled directly from the Internet about the activity or the organisation. This created the perception of freshness of information. As Rosson and Carroll (2002) recommend, the feedback mechanisms help the users adjust their behaviour while working with the system making tracking an important parameter.

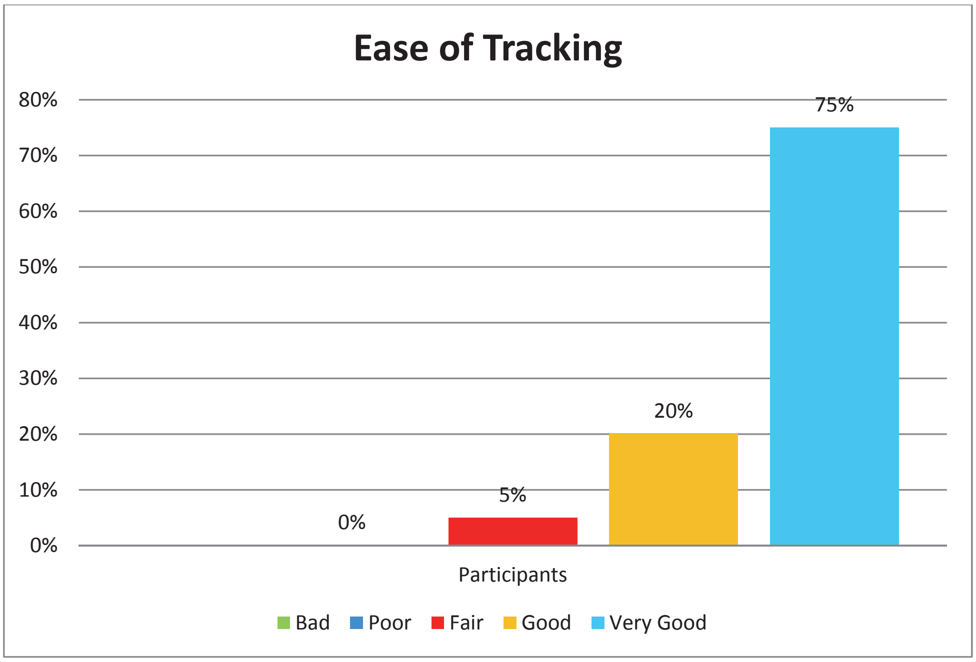


Figure 46: Huge improvement in Ease of Tracking

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Ease of Tracking score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -11.743$, $p < .001$ (two-tailed). The mean of Ease of Tracking score for iReach 2.0 was 4.70 and iReach 1.0 3.48 (-1.221 difference).

7.5.11.3 Design Facts mapping

7.5.11.3.1 Age diversity

The multiple entry points offered by this interface were able to accommodate the perceptions and needs of the users across all the three categories of age. None of the users highlighted discomfort with the interface as seen in Figure 47. In fact, the feeling was that the tool was very accommodating and user friendly.

The performance of participants in the age group 36-47 was the highest with 65% participants at Very Good level, as seen in Figure 47. None of the age groups had performance at Poor or Bad level. Even the older age group had 45% participants performing at Very Good level and 55% at Good level. This performance was very similar to the younger age group of participants in the age group 26-35.

The users pointed out the absence of hybrid combo-boxes from iReach 1.0 and mentioned that this interface was certainly more user-friendly. As Theofanos and Mulligan (2006) suggest, dropdown boxes and search functionality can be confusing. Overall performance dramatically improved over the performance of the participants compared to iReach 1.0. The users commented that even though they had a plan to follow a particular workflow and they did not follow it, it was did not feel like a mistake, since the detour and the results gave them new insights and allowed the solution to create new feelings and emotional cues.

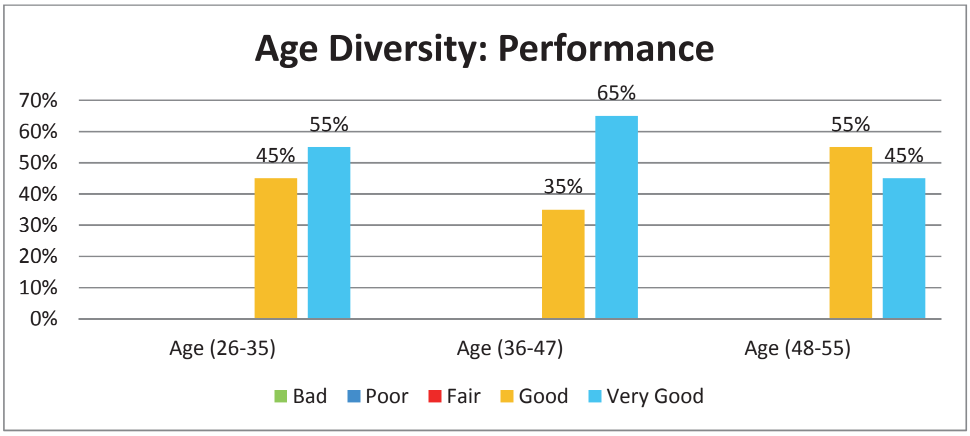


Figure 47: Improved performance (Age)

7.5.11.3.2 Knowledge and expertise in ICT skills

Since the interface was more click based with no real need for doing complex workflows in order to get some results, the perception and the performance of the users was supporting the fact that with the given skills of our participants, it is easy to use the application.

Digital natives performed at a very high level with none having Bad, Poor or Fair performance as seen in Figure 48.

Eighty percent participants performed at Very Good level and 20% at Good level. Early Learner (10%), Basic Ability (5%) and Good Ability (5%) groups had few Fair performances but the rest were either Good or Very Good.

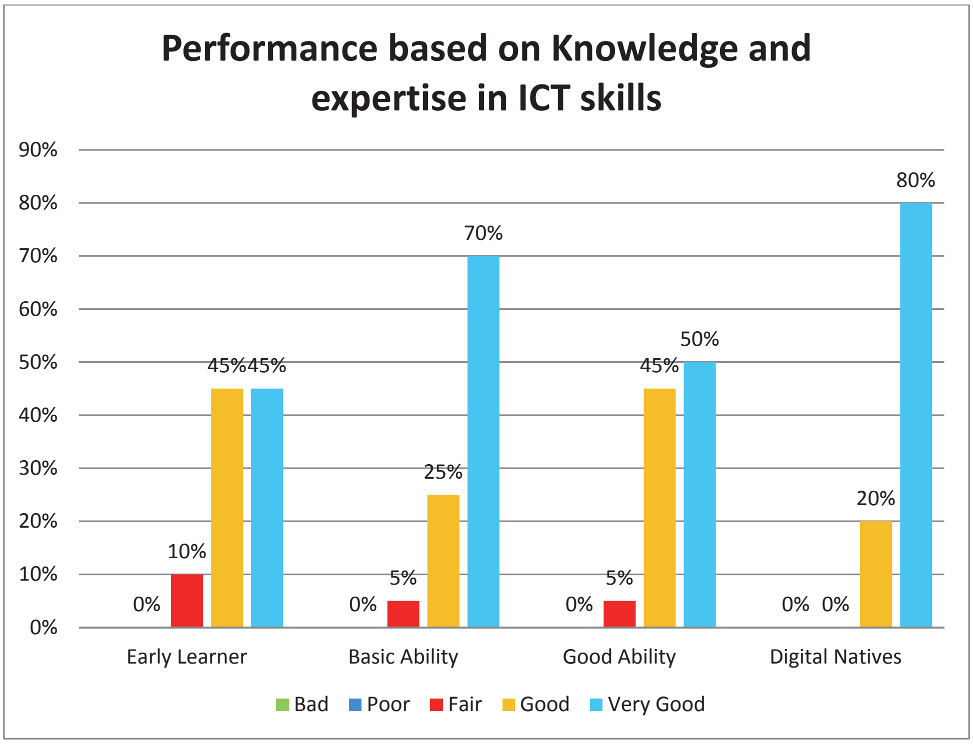


Figure 48: High performance improvement based on Knowledge and ICT Skills

Even though the performance is marked as Fair for these participants, they were experimenting with the tool and exploring it by deviating from the workflows on their own because they found the results interesting. Jordon et al. (1989) hold that repetition of tasks improves performance and affects the usability measures.

7.5.11.3.3 Challenges (Motor-ability/coordination issues)

No challenges were observed by the moderators or perceived by the participants, as is visible in Figure 49. Every action/click performed on the tool gives some result and information was perceived as usable or informative. Normal expectation would have been that digital natives perform better than others, according to Prensky (2001). However, in this case it was observed that the other performed better. The Digital Natives intuitively expected more functionality based on their experiences from other systems.

Early learner and Basic ability groups had the least challenge in performing with iReach 2.0. As seen in Figure 49, 90% were at Very Good level. Surprisingly the Digital Natives had 80% participants performing at Good level but only 10% at Very Good Level on the motor-ability skills parameter. This observation is similar to the previous version even though according to Prensky (2007), it should have been the Digital natives performing better than others do. It was observed that the participants who had challenges expected to click and drag the elements on the screen which was creating the illusion of some motor-ability challenges, even though it was not so. It can be safely concluded that the Digital Natives were more proactive in using and experimenting with the tool than the others were. There is no click and drag functionality associated with the elements on the main canvas and this could be a feature for further development.

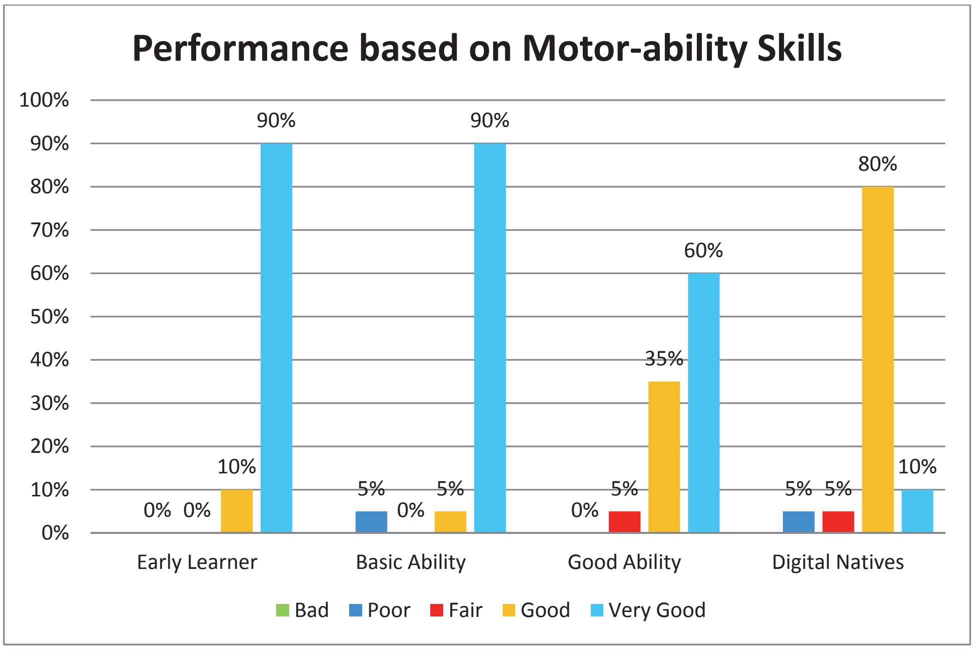


Figure 49: Vast performance Based on Motor-ability Skills

From iReach 1.0, I had concluded that there is a need to re-look at the interface elements in order to make it more accommodative. There was a need observed to get rid of the overhead of scrolling in complex controls like the grid and lists. With iReach 2.0, the interface is driven mostly by clicking and selecting with all the data visible upfront to the users. The users perceived this as an improvement.

7.5.11.3.4 Perception of being in control (Memory can be weak)

Again, the click-and-see approach of the interface leading to an easy to consume and interpret data was perceived as being in control. Nothing that the users do leads to any mistakes or errors or breaks in the workflow.

Similar to the Motor-ability Challenges parameter, Early Learners and Basic Ability groups had only Good or Very Good pegging towards motor-ability support as seen in Figure 50.

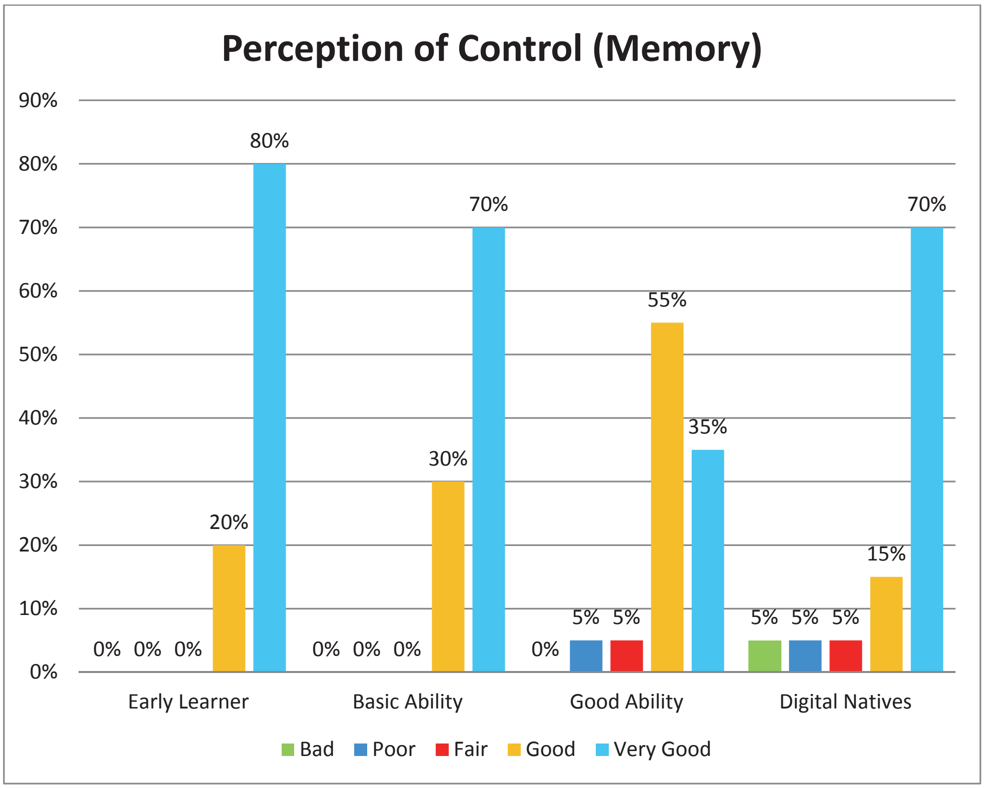


Figure 50: Improvement in perception of Control (Memory)

Minor challenges were observed in the Good Ability and Digital Natives groups. Again this was due to the expectation of behaviour that the participants had of being able to click and drag the elements on the main canvas. Once the participants in these groups realised the non-availability of this functionality, they believed that this was a non-issue. According to Nielson (1994), the older users would have higher performance challenges, but no such distinction was obvious. From a heuristic perspective, the availability of information at all-time minimized the memory load on the users.

7.5.11.3.5 Learning challenges

The click-and-see approach of the tool takes care of the learning curve. Even a misplaced click will lead to some data being sorted and gives an alternative view of the data. The users perceived this as a useful feature rather than a limitation of the tool.

As seen in Figure 51, 75% participants perceived that the tool posed no learning challenge while 20% believed that there was a minor challenge. The participants who perceived that the tool was challenging mentioned that they had never used a tool like this hence it took some time to understand how it worked.

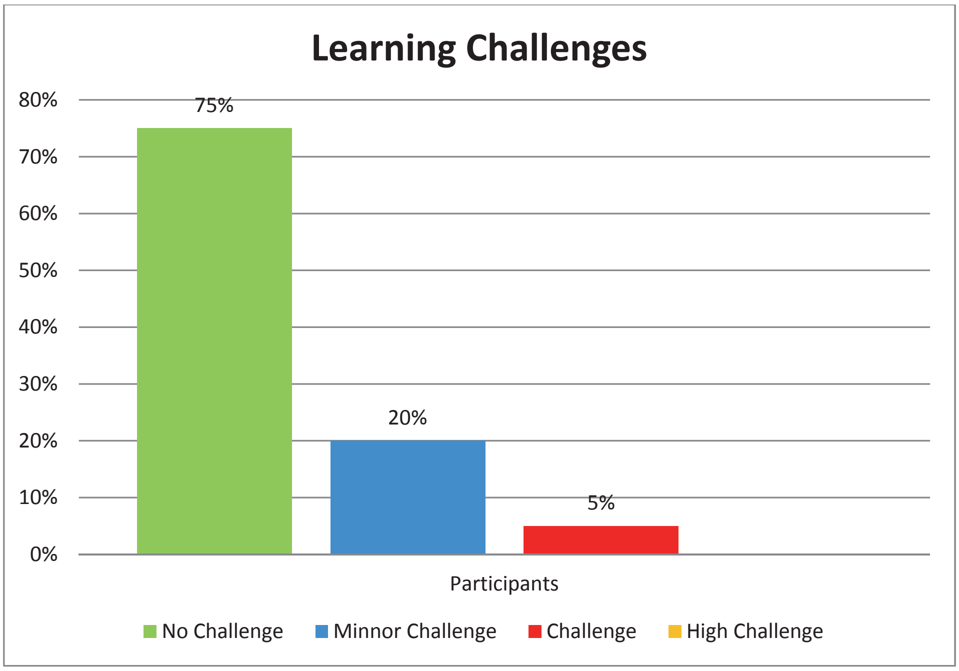


Figure 51: Lowered learning Challenges

They further stated that it took a while for them to understand that the information presented could be viewed from different perspectives and it was possible to make changes and variations in selections. Even though this was perceived as a challenge, it was an acceptable one due the benefit that the tool presented. From a learnability perspective, iReach 2.0 can be seen as a marked improvement compared to iReach 1.0. According to Smith-Atakan (2006), learnability is linked to memory; encouraging the users to try to experiment with new features gives them a holistic perspective and understanding of the system. In addition, there was mention of the challenges as acceptable because of the interesting presentation of information and the ease of learning the usage of the tool.

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Learning Challenges score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = 10.024$, $p < .001$ (two-tailed). The mean of Learning Challenges score for iReach 2.0 was 1.30 and iReach 1.0 2.01 (.714 difference). Please note that the lower score indicated faster learning possibilities.

7.5.11.4 Design Values mapping

7.5.11.4.1 Perception of Simplicity

The interface and tool was perceived as very simple to comprehend and use. As seen in Figure 52, 95% participants found the tool to be simple and pegged simplicity parameter at Very Good (75%) or Good (20%).

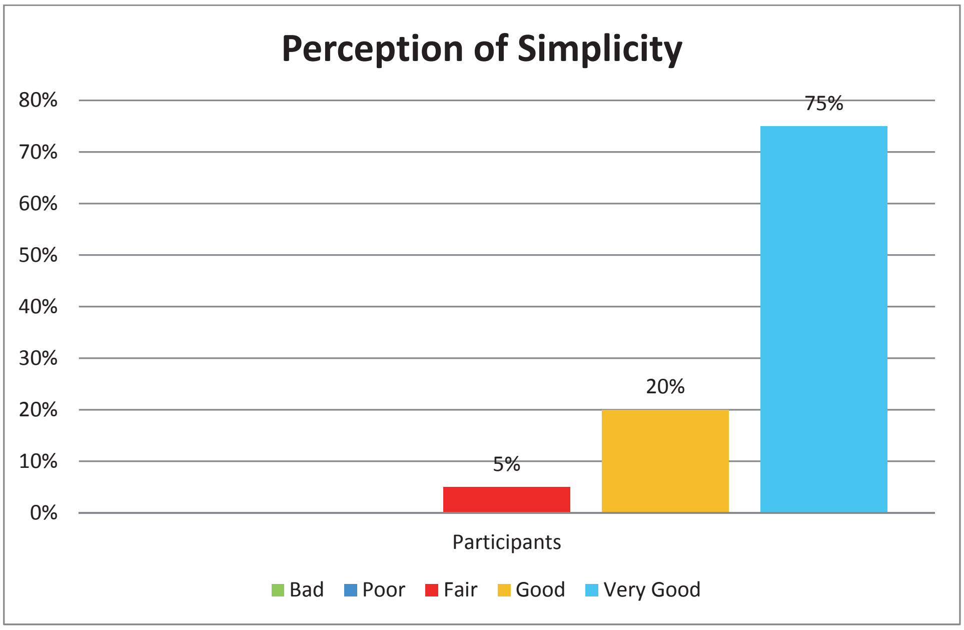


Figure 52: Improved perception of Simplicity

The ability to click anywhere on the canvas or the panels and get relevant information was perceived as a simple and easy to use feature. The feeling that the participants did not make any mistakes, even though they did not follow a particular workflow, increased the feeling of simplicity. As Obendorf (2009) suggests, that consistency works as an alternative to simplicity; iReach 2.0 was perceived to be delivering consistent user experience and even though the quantity of the data was high, the users found it simple to work with. The simplicity of interaction also balanced the complexity of the tasks.

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Perception of Simplicity score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -8.509$, $p < .001$ (two-tailed). The mean of Perception of Simplicity score for iReach 2.0 was 4.70 and iReach 1.0 3.77 (-.935 difference).

7.5.11.4.2 Perception of guided help for task completion

The participants appreciated self-explaining nature of the tool. Only 5% participants thought that the solution required guided help (Sometimes) for working with it as seen in Figure 53.

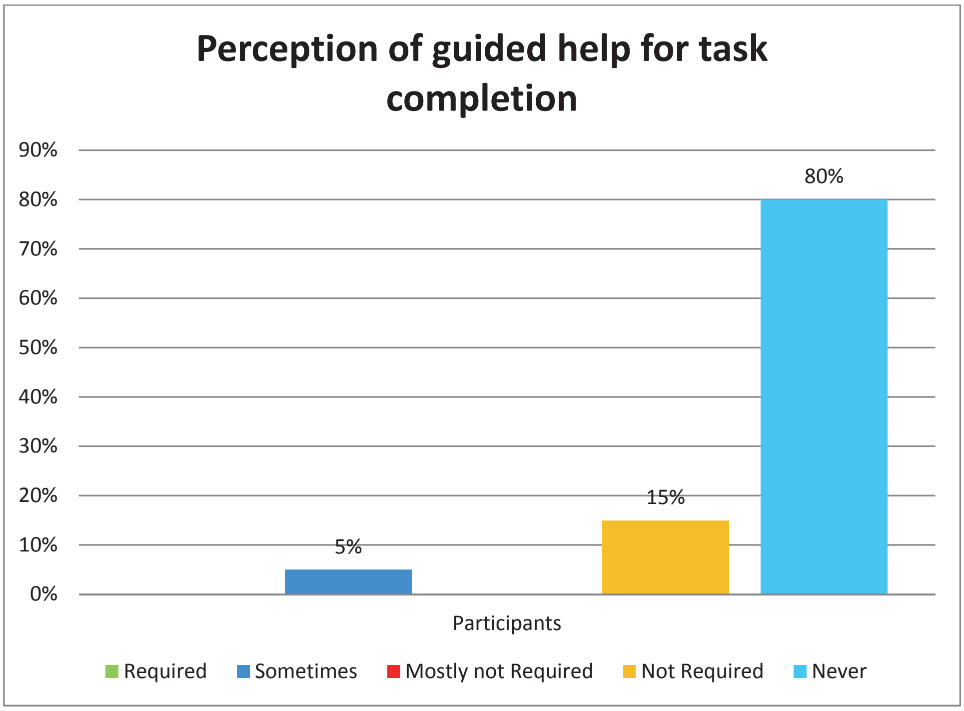


Figure 53: Perception of guided help for task completion

It was observed that even while asking for help the participants kept clicking on and exploring the tool. The perception was created because the participants asked for help even when they were able to solve the challenge or find the solution on their own. In-sync with the observation from Capobianco (2003), to avoid cognitive overload, contextual help was not included in the interface. The actions that the users perform on the interface are not linear and they always generate results in form of perspective. Majority of the users perceived the interface as completely self-explanatory and they did not feel the need for any additional help.

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Perception of Guided score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -12.532$, $p < .001$ (two-tailed). The mean of Perception of Guided Help score for iReach 2.0 was 4.69 and iReach 1.0 2.68 (-2.013 difference).

7.5.11.4.3 Perception of ability to move between hierarchies of the information

The ability to compare the data on multiple parameters and navigating through the data visually was perceived by the participants as a big value add. One thing that was appreciated, was the fact that the data is not a hierarchy addressed through a narrow linear approach, of entry-points and exit-points, but a flexible framework that is able to accommodate the needs of the users based on the visual insights they get from the results displayed in the canvas. As seen in Figure 54, 5% participants thought that the movement between hierarchies of information was poor.

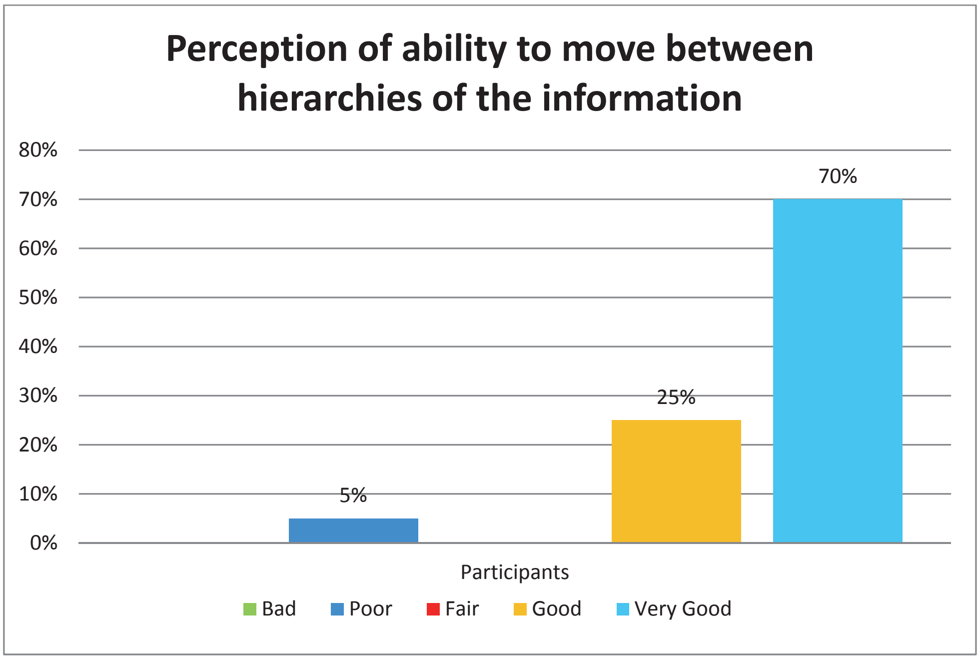


Figure 54: Huge improvement in perception of ability to move between hierarchies of the information

The feedback received was that the breadcrumbs on top of the tool were not obviously visible and could come with a bigger font to solve this issue. This was not directly comparable to the feedback from iReach 1.0 because of the non-hierarchical nature of the information presentation. Even though hierarchical information is relatively easier for users to comprehend and work with (Dix et al., 2004), the users did not want the information to be presented in a strict hierarchy and in a tight linear workflow as observed in iReach 1.0. However, in iReach 2.0, the users have the flexibility of working with the information and deciding the hierarchy or structuring of the data on their own. The users perceived the interface to be flexible and their ability of working with it as simple and intuitive where they felt in control of the information.

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Ability to Move Between Hierarchies score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -11.780$, $p < .001$ (two-tailed). The mean of Ability to Move Between Hierarchies score for iReach 2.0 was 4.60 and iReach 1.0 3.31 (-1.286 difference).

7.5.11.4.4 Perception of effort (manual)

The uniform agreement by the users was that the tool was simple and easy to use. No feeling of stress was caused. As seen in the Figure 55, 90% of the users pegged the solution as effortless to use and found it to cause Low (15%) or No Effort (75%) or manual stress.

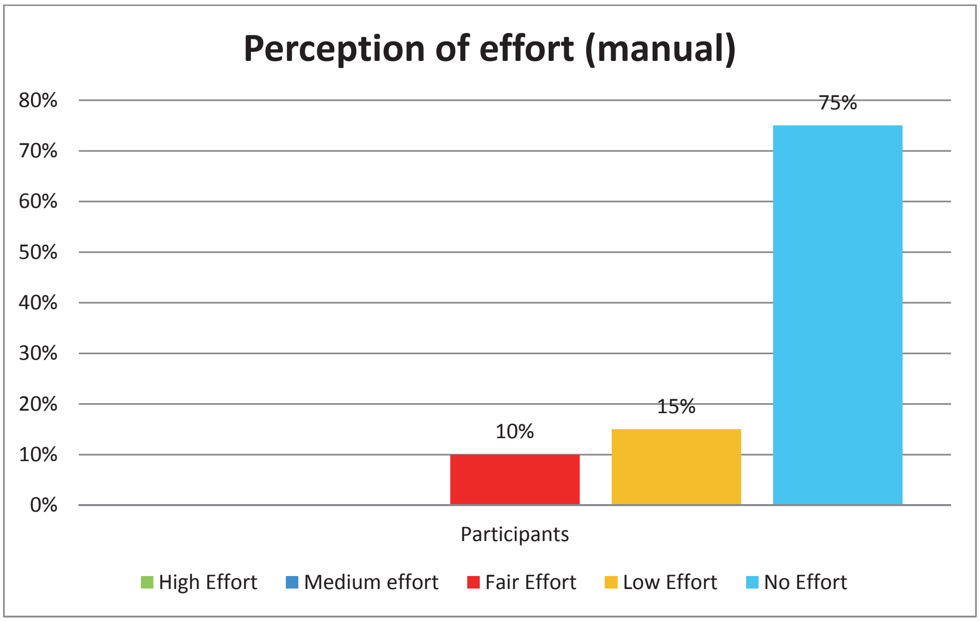


Figure 55: Improved perception of lowered manual effort

The lack of linear workflow with strict entry and exit points were attributed to this perception. The participants mentioned that this did not feel like work. Even though presentation of large and complex data, results into user interaction becoming an effort according to Huang et al. (2009), the interface from iReach 2.0 was perceived by the user as effortless to work with even with large amount of data.

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Perception of Manual Effort score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -13.973$, $p < .001$ (two-tailed). The mean of Perception of Manual Effort score for iReach 2.0 was 4.65 and iReach 1.0 3.00 (-1.649 difference)

7.5.11.4.5 Sales orientation vs. decision support orientation

The users appreciated the nonlinear workflow arrangement of the tool. This gave the impression of being a Decision Support System and not a sales oriented system where they were expected to make a decision at the end of the workflow. The flexibility of addressing the information and the ability to drill down deeper whenever necessary was a big plus. With 90% participants feeling that the tool was Decision Support Oriented this was the most useful improvement over iReach 1.0 and other tools that the participants have used or experienced as seen in Figure 56.

None of the participants thought that the solution was forcing them to make a decision and hence the feeling of selling was totally absent and appreciated. The participants commented that the tool was able to create emotional influences that they welcomed and at the same time, the workflows did not force them to make any decision.

Their need to understand the data and satisfy their need to justify pre made decision or to create options mentally, for making decisions in form of research, was satisfied in a balanced way. The interface was not sales oriented, which can be frightening to users according to Greer, MacKenzie and Koehn (1996) and thus appreciated by the users.

As seen in Table 4 and Table 5 (Anexure-1), iReach 2.0 received generally better Sales Orientation vs. Decision Support Orientation score than iReach 1.0, as confirmed by a paired samples t-test, $t(76) = -16.150$, $p < .001$ (two-tailed). The mean of Sales Orientation vs. Decision Support Orientation score for iReach 2.0 was 4.87 and iReach 1.0 2.68 (-2.195 difference).

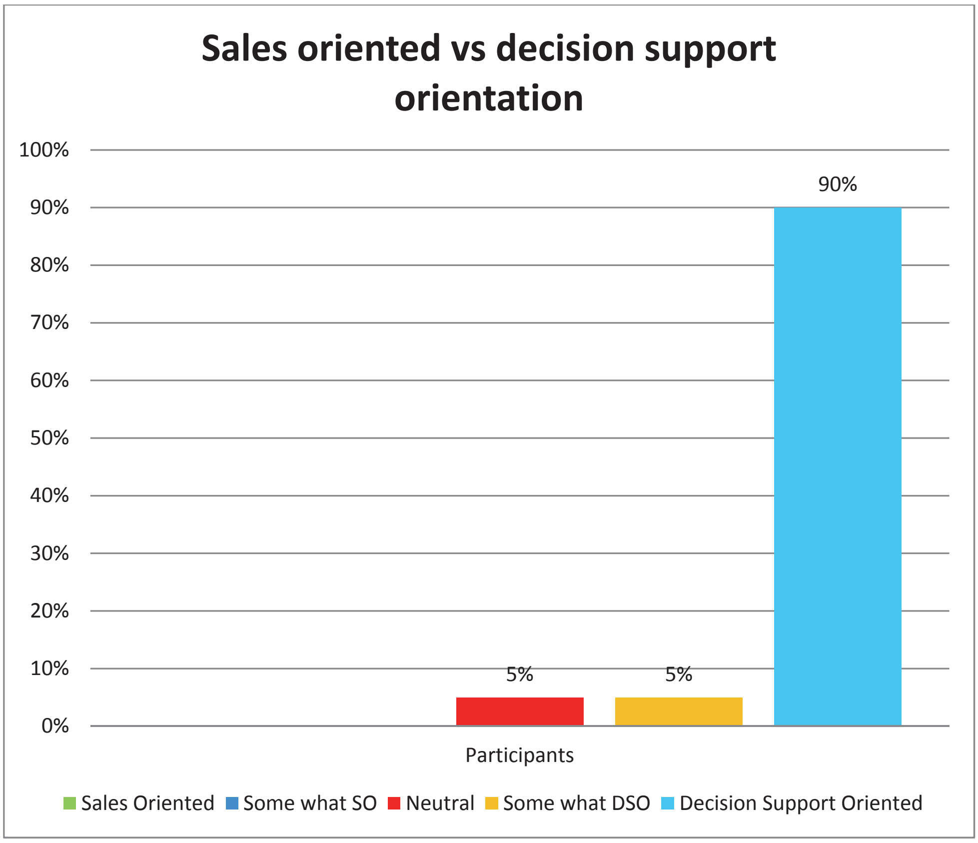


Figure 56: High perception of Decision Orientation

7.5.11.4.6 Fun to use

This was the main missing factor from iReach 1.0. Again, the perception of the users was that this tool felt like play and not works. However, at the same time, the tool had the ability to throw up business related information whenever the users wanted it. It gave the feeling of empowerment too. Overall feedback of the users was it is a fun tool and they wanted to keep using it. Participants pegged the Fun to Use parameter at Very good (85%) or Good (15%) as seen in Figure 57.

They felt that the smooth transition of the options on the canvas added to the wow factor. The fact that the workflows were not linear and working with the tool did not feel like work, contributed to the fun/pleasure feeling. Even though Fun is antonym of Serious (Blythe & Hassenzal, 2004), the iReach 2.0 allows users to break the monotony of work, encourage learning and make the experience pleasurable.

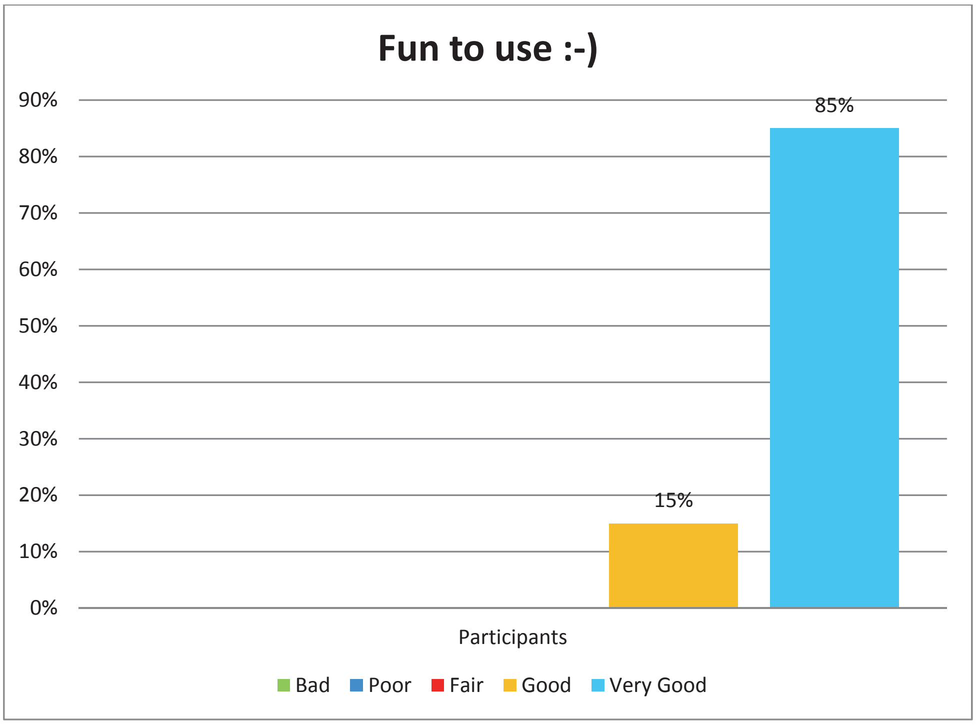


Figure 57: Improved fun to use perception

7.5.11.5 Findings from iReach 2.0

The trials of iReach 2.0 were dramatically better than iReach 1.0. The performance, perception, learnability and the enthusiasm of the users was evident when they kept playing with the tool even when the tests and the focus groups were over, is a good indicator of the match of the tool to the form-of-life the participants represented. The TSA were successfully met with the functionality presented with the technical solution that iReach 2.0 presented. The challenge of the FoL is addressed and a solution created for the same. The traditional usability engineering attributes support the performance, perception and efficiency of the users thus creating a solution that can successfully support the stakeholders in the Social Work world, in their decision making process.

I would again like to highlight that the presentation of the findings is not an empirical evidence that can be generalised. All findings and observations are heuristic in nature. Statistical comparison of results with iReach 1.0 is available in Annexure 1.

8 CONCLUSIONS

Based on the recommendation of my guides, it was decided to have an hourglass approach to the process. In the beginning, a broad based approach of exploring the methodologies and frameworks of traditional engineering Design Thinking was undertaken. This was followed, by the narrowing down to the actual design and development process, leveraging Leikas's (2009) Life-based Design conceptual framework. Finally, I have stepped back again to recommend in the following chapters, a framework of software design methodology that is an amalgamation of traditional approaches like waterfall model (Royce, 1970), prototyping (Brooks, 1975) and agile methodologies (Beck et al., 2001). The decision to address the development process based on life-based design conceptual framework (Leikas, 2009), where form-of-life is the fulcrum, the driving force and guiding principle for development, was implemented for the first time in a technical solution development project. The iterative approach of the HCD combined with the life-based design approach helped to get a deep insight in to the lives of the people participating in their form-of-life. The resultant RSAs and TSAs facilitated in the development of the actions and facts and value mapping, which in turn were the artefacts used for follow-up of the development process and the results through the concept design and development phase of the actual solution.

When we are working on theoretical frameworks and concepts and then trying to implement them in practice as working models that can be implemented in real life, it is necessary to keep in mind the industry perspective where it will be used as a reference for further development. My work, models and recommendations are directed towards the software industry. Other technical streams may need to look at Leikas's conceptual framework (Leikas, 2009) in details with insights from the existing implementation models in those particular industries. Software engineering has been defined and presented in the IEEE standard as,

> "The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software." (IEEE Standard, 1990, p. 30)

Diverse applications and solutions, based on equally diverse methodologies are produced by this industry, which can be run on a variety of hardware systems. In my thesis, I have focused on the software part of the solution with hardware consideration limited to standard PCs and laptops. The fast nature of the industry drives innovation on one hand and on the other hand creates many artefacts that can be junked. The fast paced change in the industry and ideas, lead to a generation of new fads all the time. They can be compared to fad diets where some of them work while others do not. It is very dependent of the willingness of the people involved in execution (Vijaysarathy & Turk, 2008). Practitioners need to look rationally at multiple possibilities and ideas and then adopt those that address the needs to the changing times. The Life-based design steps away from the pure engineering and empirical approach towards solution development and takes a humane approach towards solution designing.

> "Life-Based Design (LBD) is a multi-dimensional and holistic approach, which integrates HTI design issues with the concepts in human life sciences and calls attention to a careful analysis of people's forms of life." (Leikas, Saariluoma, Heinilä, & Ylikauppila, 2012)

8.1 Early Design phase

The TSAs shortlisted during the early design phase were visibility, sorting and filtering, visual and emotional cues, verification and tracking. To translate the TSAs to functional requirements, standard-out-of-the-box controls were first explored. User Interface (UI) components can be distinguished as elementary and composite interfaces based on orthogonal distinction (Paulheim, 2011). In the modern technology development, boundaries like these are difficult to draw. All the components used in the design in all phases of the development can be termed as composite or hybrid interfaces.

The wizard approach and design (MSDN Library, 2012h) towards presenting, filtering and populating information was chosen as a way to handhold the users in the process. The wizard format was chosen as a control to be used in order to meet the TSA requirement of making the experience more visual driven. The wizard control also helps the users to follow a predetermined path and helps them to understand their location in the workflow. For example, in a wizard, it is communicated how many total steps or screens does the users need to complete in order to complete the workflow. Breadcrumbs (MSDN Library, 2012f) were used to give a spatial location of the user in the workflow. In other words, the breadcrumb paradigm was used to display the status of the completion of the workflow and let the users know where exactly they were in the overall workflow. Keeping in tune with the breadcrumb control in a wizard format, a descriptive left-hand side panel was added as a permanent feature. The current step in the workflow of the wizard was highlighted and updated with the users actions.

Radio buttons (MSDN Library, 2012g) are used in the interface wherever there is a need for the users to choose between two or more elements (Nielsen & Pernice, 2010). The drop-down combo-boxes (MSDN Library, 2012c) were chosen to help the users drill down and choose from all the choices available. The combo-box control was chosen with multi select possibility in order to meet the requirement of the TSAs to support visual display of all the options available and then select and sort based on selecting and de selecting between linked combo-boxes.

With the first step in the wizard, the users use radio buttons to choose their role as givers or receivers of the aid. By making this choice, the users could determine how they wanted the following information to be assembled. It set the reference for the starting point from which workflow they wanted to start the activity for- as NGOs or Sponsors. The NGOs looking for aid could choose iNeed and the sponsors could choose iGive. Once the users chose the starting point or the entry point to the task, they could further make selection of the criteria on how they would like the information to be organised, based on choices related to geography and type of the support offered or needed. This too was filtered and populated in combo-boxes.

After the selection and sorting of the information as required by the TSAs, the result was collected in list view or list control (MSDN Library, 2012b). The list control populated all the results from precious selection in a sortable format. On clicking the heading of the column, the users could sort the information in the result data group. The result data set was compiled under the headings of-cause, country, type, agency, programme details (start date, end date, status, current support, overview/description) and contact details (organisation name, contact name, phone, mobile, email, IM, responsibility and identity). The list was a multi column scrollable grid (MSDN Library, 2012d) with scrolling enabled (both horizontally and vertically) to meet the TSAs of maximizing visibility and enabling sorting and filtering. The users chose one of the rows and the selection further resulted in the population of a group box with details in an easily viewable, readable and printable format. The detailed layout also contained the information of the organisation and the cause selected. The users could change their choices on their current screen of the wizard or then going back directly to the step they want to refine from the left-hand side panel.

The performance and the perception of the design was tested with the participant users. I received a mixed feedback about the design. The users did not find the design friendly. Too many steps were required to complete the workflow. Data was not visible upfront. The wizard workflow forces users to take very small steps, while the users believed that bigger steps are possible. The wizard format also makes users think that they are doing something wrong when they need to change something from the previous selection generating a negative feeling.

8.1.1 Components and Features, Feedback and Affected TSAs in the Early Design Phase

In the Table 1 below, I have listed the components and features that appear in the Early Design phase. The feedback from the participants and the affected TSAs are listed in front of the components and the features. The participants found the Design overview oversimplified and expect to be presented with more information upfront. This can be looked in combination with the next feedback from the users, where they found the workflow to have too many steps making sorting and filtering a challenging process. The combo-box feature was perceived to be difficult to use and the multi-select possibility is tough to understand and follow affecting the visibility of information. However, I had decided to continue this component in iReach 1.0 design, hoping that the users will see the merit and benefit of having a powerful control like that to make multiple choices. Collection grids with their scroll bars are perceived as difficult to use and affect the visibility, sorting and filtering TSA.

Table 1: Early Design- Feedback and affected TSAs

Component and Feature	Feedback	Affected TSAs
Design (Overall)	Too simplified	No single TSA is affected
Workflow	Too many steps	Sorting and filtering is not easy
Design	Visibility of the data is not as good as expected. The information is presented in very small bites.	Visibility
Drop-down combo-box	Too cumbersome to use. Multiple selection possibility is not obvious even with checkbox facility.	Basic usability
Collection Grid	Though the information is visible, it is limited by the size of the column and it is extra efforts to go through every single cell. Horizontal and vertical scrollbars make it difficult to navigate to the right cell to view relevant data.	Visibility Sorting and Filtering
Collection Panel	Good Visibility of the complete information. However, this takes too many steps to get too.	Visibility
Collection Panel (Logo and website link)	Logos of the organisation and website link is nice. It allows users to go directly to the website of the organisation and find out the latest information.	Visual and Emotional cue (minor impact) Verification and Tracking
Bread-crumbs	Nice way of knowing where we are on the workflow. Very clear visibility of how many steps are remaining.	Visibility

Nevertheless, the users appreciated the compilation of information, presented together in the collection grids. This was supported further as a concept where the collection panel was used. The users found the presentation simple and upfront and there was a semblance of emotional cue associated with this component since it displayed the logo and links to the websites of organizations, however, they mentioned that the compiled information appeared too late in the workflow. The bread-crumbs was perceived as a good feature to see where the users are in the work flow and how many steps are remaining, thus creating a feeling of good overall visibility of the completion of tasks.

Based on the initial findings of design demo, iReach 1.0 was created. Challenges of gaps between the TSAs and functionalities identified during the early design phase were sought to be addressed in iReach 1.0 design.

8.2 iReach 1.0

In the iReach 1.0 design, the wizard workflow was discarded in favour of creating one single page or form to address the concern from the early design phase of too many baby steps. Since the users were able to work with most of the components used in the early design phase easily, the base components were not changed with a few exceptions. The multi-select combo box was discarded in favour of the multi-select list (MSDN Library, 2012e). The link table approach was used to get rid of the multiple clicks needed to drill down into the data. With a single click on the link table row, the data in the corresponding table either populated or de-populated. Thus, the generation of the result set became visible on a single selection or then multiple selection if the user so desired.

The users were able to see much more data upfront with both the elements in the iNeed and iGive sections visible in a grid format in either of the lists. The collection panel consisting of collapsible sections was kept expanded as a default feature to ensure that maximum visibility of the result information.

8.2.1 Components and Features, Feedback and Affected TSAs in iReach 1.0

In the Table 2 below, I have listed the components and features that appear in iReach 1.0 design. The user's fond the overall visibility of the design much better than the Early Design phase. The sorting and filtering was also easier in the new workflow. The complete visibility of the workflow information allowed the users to complete the task/s better than Early Design with sorting and filtering TSA getting better. The upfront presentation of the data was perceived as easy to understand and follow. The hybrid search component that allowed users to do a free-text search was perceived as very useful, even though the response time was not thought to be good enough. In iReach 1.0 too, the collection panels and grids were perceived as components that generates some sort of emotional cues with the presence of organisation logos and website links.

Table 2: iReach 1.0- Feedback and affected TSAs

Component and Feature	Feedback	Affected TSAs
Design (Overall)	Better than the early design. Better visibility of information. Upfront visibility of the workflow.	Visibility Visual and Emotional cue (Minor impact)
Workflow	It is easy to sort and filter the information. It is easy to visually see many options. Dynamic scaling of the data between the link tables makes it easy to understand the dependencies in the data.	Sorting and filtering is easier
Design	Data is much more visible and easy to comprehend. It is easy to learn and complete the workflow.	Visibility Sorting
Search box	Easy to use and change the words typed based on the dynamically generated result set in the list.	Visibility Sorting and Filtering
Collection Panel	Good visibility of the complete information. All the relevant information is nicely compiled and visible	Visibility
Collection Panel (Logo and website link)	Logos of the organisation and website link is nice. It allows users to go directly to the website of the organisation and find out the latest information.	Visual and Emotional cue (minor impact) Verification and Tracking

iReach 1.0 addressed most of the TSAs in form of functionality and the users were able to successfully complete the workflows. They also showed a marked improvement in performance of the tasks from a usability perspective. In the follow-up discussion in the focus groups, the participants mentioned that the tool was easy to learn and use. At the same time participants commented that even though the tool did work well in displaying, sorting, filtering and sifting through the data, the workflow made them feel that the result expected was a decision on their part to shortlist one of the iNeeds or iGives. This is not what they did in their real life. This was a surprise for me since the core reason for developing the tool was to help the users make a decision and hence a decision support system was being built. The solutions purpose was to help the users come to a conclusion and make a decision, but the users were unwilling to make a decision. It was evident that even though the users were able to work with the solution effortlessly, a fundamental and key-insight had to be learnt. From the focus group discussion the following facts were realised and agreed with the participants:

"Stakeholders do not use technology solutions (like websites and portals) to make a decision. They expect support from the tools to make a decision. The stakeholders cannot make and are not expected to make a decision on their own, but are dependent on other factors and players in their environment for a decision to be made. For example, a CSR manager is responsible for making the investment decision, but in real life, she either finds the right match to invest in or gets inputs from the company's management or board where the investment should be made. In either case, she needs to build a case of rationalisation for making the decision of investment and hence seeks tools or solutions. On the other hand, a NGO representative does not want to apply for new support from donors on her own, but wants to create a list of possibilities that can be discussed and agreed on with various stakeholders of the NGO which may include the management team, the Trustees and at times even existing funders or sponsors."

The result of any research that the stakeholders do cannot be conclusive and restrictive since the topic that they are addressing is not binary or black-and-white. The expected result is a multiple of options based on which a decision can be reach or supported. Stakeholders are uncomfortable to see visualization of a data in a single linear format. They would like to see the big picture from multiple perspectives and drill down to details of multiple options in a comparable way. Most of the time, the decision is more emotional and not purely rational. Though the presence of the logos is a nice way to give cues of emotional empathy or association, they are not comparable because in the workflow, they appear last and after the Decision Support System has reached the end of the workflow.

Based on these inputs and learning from the focus groups, it was necessary to re-calibrate the TSAs and relook in to the fundamental form-of-life. There was a need to go back to the drawing board and rework the design. The focus would be to address the emotional cues, which played a bigger role in the decision supporting process. At the same time, look at a way to present the data in a multidimensional comparable format, rather than as a workflow with a finite end-result of one shortlisted component of iGive or iNeed.

8.3 iReach 2.0

iReach 2.0 was the second iteration of the solution, design and concept. A non-traditional approach towards visualising the data was sought. The PivotControl running on Silverlight plugin for web browsers from Microsoft was used to develop iReach 2.0. Linear workflow was discarded in favour of data presentation in a visual format. All the organisations were made visible upfront in form of their visual and brand identities. The logos of all the organisations were a starting point of the workflow if the users so desired. The users could compare the data on two axis. On one hand, it is possible to sort the database from the combo-box on the top and compare it by selecting one of the parameters in the left hand panel. The user could also select the presentation as a graphical view or a grid view by simply clicking the button on the top. The left hand panel has a free-text search field on top, where users can search the complete database on the topic they want to see highlighted.

The result set is again possible to be visualised in a graphical or a grid format. On the main canvas as the dataset is displayed, in the Left-hand panel, the values from the dataset are also visible in a numerical format corresponding to parameters displayed. To drill down to details, the user can simply click on any of the logos on the man canvas at any time. This action highlights the selection, and at the same time, in the right hand panel, the details pertaining to the selected choice are displayed. Microsoft's Bing search engine is integrated in this panel and the latest contextual news from the web is fetched in real-time and displayed at the bottom of the panel.

8.3.1 Components and Features, Feedback and Affected TSAs in iReach 2.0

In the Table 3, I have listed the components and features that appear in iReach 2.0 design. The main canvas with all the logos of the organizations presented upfront was unanimously approved as a strong emotional influencer. The simplicity of working with the canvas was also perceived as a good way to sort and filter large amount of data. With no specific entry or exit point of the workflows, the users thought that they were in control since they could choose how to being and finish their workflows. The participants felt that the multiple parameters on which the data can be selected made sorting and filtering very easy. The association of brands and visual identity of organisations creates empathy towards the ones that are relevant and hence influencing the participants as they expected. The left hand panel was perceived as a simple and easy to use navigation, sorting and filtering aid with possibility of clicking and getting results immediately. On the other hand the Right hand Panel, with all the details presented together related to an organization was perceived as an effective way to get compilation of data in a single click. The verification and validation TSAs were supported with the integration of the search engine results in the panel, allowing the users to have unbiased and updated news from the Internet available just in time. The drop-down menu on top, the gird view button and the landscape view buttons were perceived as simple and easy to use features that generated immediate results on the main canvas. The zooming feature and the bread-crumbs were perceived to be supporting visibility and aiding tracking.

Table 3: iReach 1.0- Feedback and affected TSAs

Component and Feature	Feedback	Affected TSAs
Main Canvas Design (Overall)	Simple, Wow, Smooth. The visibility of branding upfront immediately creates an emotional connect. Feels like sorting cards. The solution has less elements but does more things. It is immediately clear that there are	Visual and Emotional Cue Sorting and filtering

	multiple ways to sort and filter the data. *Looking and feeling* instead of *Reading and understanding* to makes selections.	
Workflow	User is in control. No specific workflow. No specific place to start or to finish. There is no mistake, it is just looking at the data from a different perspectives.	Sorting and filtering is flexible and easy
Design	Details visible just in time. Multiple parameters on which the data can be selected makes sorting and filtering very easy. The association of brands and visual identity of organisations creates empathy towards the ones that are relevant.	Visibility Sorting and Filtering Visual and Emotional cues
Left hand Panel (Search Box)	Saves time and allows the sorting and filtering of information instantly based on anything that the users thinks is relevant. No need to sort or filter the data manually.	Basic usability
Left hand Panel (Sort Parameters)	Provided very easy sorting and filtering mechanism. The result of the sort data changing dynamically with filtering makes it easy to understand the popularity of a particular criteria.	Visibility Sorting and Filtering Visual and Emotional Cue
Right hand panel	Good visibility of the complete information. Just in time and when needed. The search integrated helps to understand what is the status in an updated and timely manner. Information is always fresh.	Verification and tracking
Top- drop-down box	Easy way to choose how to sort the information. Result is immediately visible on the main canvas	Sorting and Filtering
Grid and Graph buttons	Allows to look at the same data in different ways. Caters to both the needs of looking at the big picture and at the same time structured information presentation.	Visibility Sorting and Filtering Visual and Emotional Cues
Zoom Control	Simple and effective way to support visibility when the data becomes very large.	Visibility
Bread-crumbs	Nice way of knowing- what are the filters used. Especially useful since there is no single way to navigate through the information. Helps identify the location of the user in the process.	Tracking

iReach 2.0 addressed the traditional needs of usability engineering based on the research. At the same time in the focus groups, the participants agreed that the solution catered to and supported their form-of-life (FoL).

People who work in the Social Sector as sponsors need to find avenues to invest resources in the causes that benefit the society. The NGOs on the other hand need resources to execute their agenda in the cause that they focus on. In order to meet these requirements, both parties struggle to find the right partners and the right resources. With the ever-expanding choices that technology and telecommunication are able to bring to them, they find decision making tough. However, at the same time multiple choices also mean greater opportunities. Since technology has created the visibility and access to multiple choices, it is only logical that technology also helps in making the choices.

In the early stage of this research, the take-away from the participants was that they need an intelligent system that supports them to make a decision. iReach 1.0 was developed based on this FoL. This was also the accepted conclusion with the participants in the user group. Nevertheless, during the focus group discussion after iReach 1.0, I realised that the people do not want to make the decision. Or rather, the solution is not expected to make the decision on the user's behalf. The expectation from the solution is to make the various choices available in a visually palatable format. At the same time, the expectation is that the solution will primarily give emotional and visual cues that will influence the users supported by facts and latest information.

In real life, the stakeholders, be they from the NGO sector or the corporate sector, use multiple sources and tools to gather, visualise, sort and filter information. Their primary purpose is to get an overview of all the possibilities that are out there. Secondly, they want to see what are the other players doing and how are they performing. Decision of what they will do is not part of these tasks at all. The decision making process happens in multiple different ways and though they are responsible for the decision, they are not (almost never) the decision makers alone. In case of the NGOs the stakeholders who decide where to apply for resource commitments comes from the trust board, the management team, operational team, existing sponsors etc. It is not a straightforward decision that can be taken by a single person. Similarly, corporate sponsors are dependent on the communications department that wants to see the influence of the association on the brand of the sponsor. The management team, the board members and interested employees also have a direct or indirect influence on the decision making process, which in turn varies from organisation to organisation.

The responsible actors from the NGOs or the sponsors in the decision-making process need help in two cases:

- To create a long or short list of possible collaborations if the decision is not made. This helps them guide and influence the decision makers, keeping in mind the various angles that need to be addressed during the decision making process OR
- To create a justification of the rationale behind a decision, that has already been taken. In this situation, the actors would like to verify and validate the decision by identifying supporting factors. In case, there is a mismatch or an obvious glitch in the decision making, that the actor identifies, they would like to go back to the body of people, who have participated in the decision making process, to highlight the challenges.

These insights were used as inputs to redesign the solution. The emotional and visual cue TSAs became more important than following a predefined workflow. The users did not want to follow a particular workflow since there is no expectation of a specific result, which can be achieved, by a determined entry point or exit point of a workflow. iReach 2.0 allows the users to determine and select their own entry points, create their own workflow on the fly, based on where they want to start. The outcome of whatever actions that the users do in the interface is that of displaying data based on their selection. There is no right or wrong step that the users take in this situation, because, with every click a different façade of the data is presented. This in turn can create new visual, emotional or logical triggers for the users.

The reflection of the functionality presented with iReach 2.0 catered to the FoL that the users followed, was perceived as a good support or solution to addressing their challenges. The design also triggered responses from the users, where they were able to draw a parallel between the design and the functionality of iReach 2.0 to other forms-of-life that they were used to. One of the participants compared the tool to flashcards (as seen in Figure 58), that she had used in childhood or even as grown-up, to learn new things or enhance existing knowledge.

Figure 58: Flashcards

Flashcards are used as a learning aid from early childhood. This tool is consistent across cultures and geographies, and all the participants could immediately associate with this comparison. They mentioned that the added benefit is that they are able to remember the information better. Flashcards are the cards with information on one or both sides. A common use is to have a question on one side and the answer on the other side. It is one of the most commonly used learning aid to improve vocabulary, improve memory etc. (Wikipedia, 2012a).

The second example that one of the users compared to iReach 2.0 was a Tapas Bar (Wikipedia, 2012c) as seen in Figure 59. The participant and her husband live in Germany. She works as a communications manager for a large engineering company responsible for CSR. Her husband works in the same company in their engineering department. They very often walk across to a Tapas bar (as seen in Figure 59) close to their office, for lunch in the afternoon.

Figure 59: Tapas Bar

Both of them like to frequent the Tapas bar because of the variety of food on offers. The display of the food is very pleasing and appetizing. They also like the fact that this presentation invites patrons to try different things without feeling the pressure of choosing something that they do not like so much. Her husband likes to sample things based on some logic, like left to right, top to bottom, top row first, red colours first etc. On the other hand, she likes to choose her tapas randomly and likes to be enticed by the display. This way the Tapas bar satisfies both their needs- an engineer who like to follow a pattern and a creative professional, who want to experiment and make random decisions. One more insight that the participant mentioned was that even though they like to have the variety offered, they seldom tried different things. They already had their favourites and ended up choosing the same ones in different combination. However, the fact that they were free to choose was a motivator for them to frequent the tapas bar.

The Focus group participants found interaction with iReach 2.0 designs very enticing. The interaction and the results from the interactions were perceived to be insightful. The result datasets and the ability to relook at the dataset by drilling deeper, moving the perspective and even changing the perspective, allowed the participants to play with the data. They believed that the solution was fun to use, because of its toy-like-behaviour. It could be this quality, that made the users believe that the solution has an ability to create an emotional connect. The visual presentation with logos is easy to connect to and make an association.

9 SOFTWARE DEVELOPMENT LIFECYCLE MODEL WITH LIFE-BASED DESIGN APPROACH

In the project, I have used a hybrid of traditional software development models with the Design Thinking built on the fundamentals of Life-based Design conceptual framework proposed by Leikas (2009). I have used the elements and combination of the waterfall model (Royce, 1970), prototyping model (Brooks, 1975) and the agile model (Beck et al., 2001) and evolved a new model that overcomes the limitations of these models. The early design phase, and iReach 1.0 iterations were built using rapid prototyping approach. Since I was using readymade data, I could already, in iReach 1.0 iteration use OOPS model (Gamma, 1995) to build the basic library of components. The same database could be quickly configured for developing iReach 2.0, giving me the new design and concept to test with the users in short time. It is good to remember, that to use the Life-based design conceptual framework, it is necessary to make sure that the definition of form-of-life is correctly interpreted and articulated. Agile methodology during the development process is possible because of availability of object oriented programing tools (Panikkar & Sanjeev, 2004).

Using the LBD, we start by identifying and defining the form-of-life and the problem it contains. Unlike mathematical challenges, design challenges are ill structured and open-ended (Dym & Brown, 2012). This idea is further explained as,

> "Design problems are open-ended because they usually have many acceptable solutions. The Quality of uniqueness, so important in many mathematics and analysis problems. simply doesn't exist. Design problems are said to be ill-structured because their solutions cannot normally be found by routinely applying a mathematical formula in a structured way". (Dym & Brown, 2012, p. 13)

There are stages in the development lifecycle that need to be linear in nature. The first step of identifying and describing the FoL (Form-of-life) needs to be done before going to the concept design phase as seen in Figure 60. This linear progression is similar to the waterfall model's (Royce, 1970) linear progression. However, the development of the FoL definition, by identifying the real life problem and developing the RFAs (Rule-Following Actions) and DRAs (Design Relevant Attributes) are an iterative process and agile methodologies (Barnum, 2010) need to be leveraged.

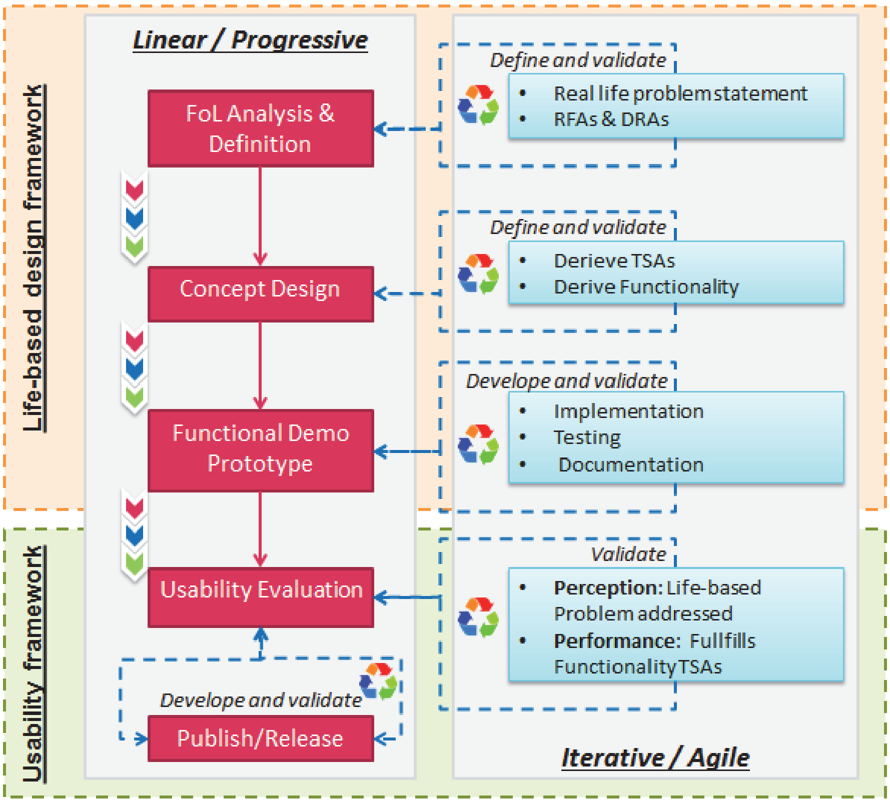


Figure 60: Life-based technical design framework

The following phase is that of concept design. This stage takes inputs from the FoL analysis phase. TSAs (Technology Supported Actions) are formulated and actual functionalities are derived in this phase (Leikas, 2009). Inside the concept design phase, designers and developers need to work in an agile way to bring quick iterations to the users for validation (Ratcliffe & McNeill, 2011).

The concept design output, in form of functionality insights and design inputs, are used in the following phase of developing functional prototype (Kamrani & Nasr, 2010). Functional prototypes need to be developed using agile methodologies. The OOPS paradigm, allows the functional prototypes to become release candidate material if they are usable (Hartson & Pyla, 2012). Traditional agile methodologies can be directly implemented in developing the functional prototypes (Beck et al., 2001).

Once the functional prototypes are ready, the traditional usability testing process starts. Usability testing needs to satisfy two fundamental user needs-they need to perform at an acceptable level and they need to have a positive perception of the solution (Lidwell, Holden & Butler, 2010). Care must be taken, that the functionalities that address the TSAs are following the actions and the users are able to complete their tasks. It is also mission-critical that the users perceive that the original problem-of-life identified through the FoL phase has been addressed.

The final stage is of the release of the solution to common use. This stage can be handled iteratively. Minor issues, that are identified in the usability tests, can be handled in an agile manner. Moreover, there will be some challenges that are identified when a larger audience starts using the solution in real-life too (Hartson & Pyla, 2012).

If object oriented development tools and methodologies are not used to develop the software solutions, this methodology is not recommended. In that case it may be wiser to use throw-away demos instead of functional prototypes or the prototyping method runs the danger of becoming very expensive (Selby, 2007).

Thus, the model includes a linear flow supported by agile and iterative development and prototyping in its lifecycle as seen in Figure 60. I have highlighted the linear parts of the process by shadowing out the iterative parts in Figure 61.

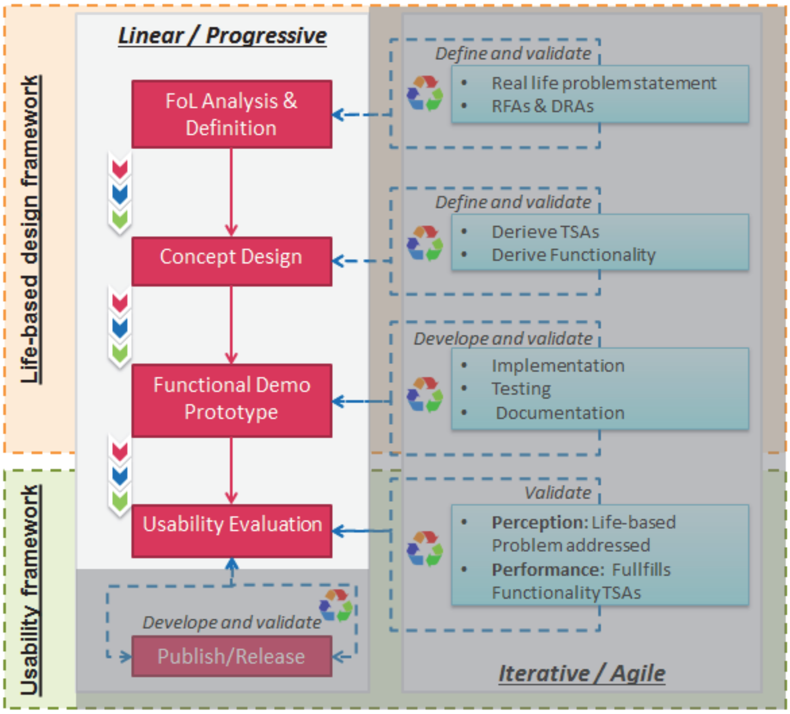


Figure 61: Linear/waterfall sub phases of the process

The Figure 61 above highlights the phases in the process that follow a linear hierarchy. In the Figure 62 below, I have highlighted the iterative and agile sub phases of the development process and shadowed-out the linear parts. The functional prototype in this picture is not a methodology but an output.

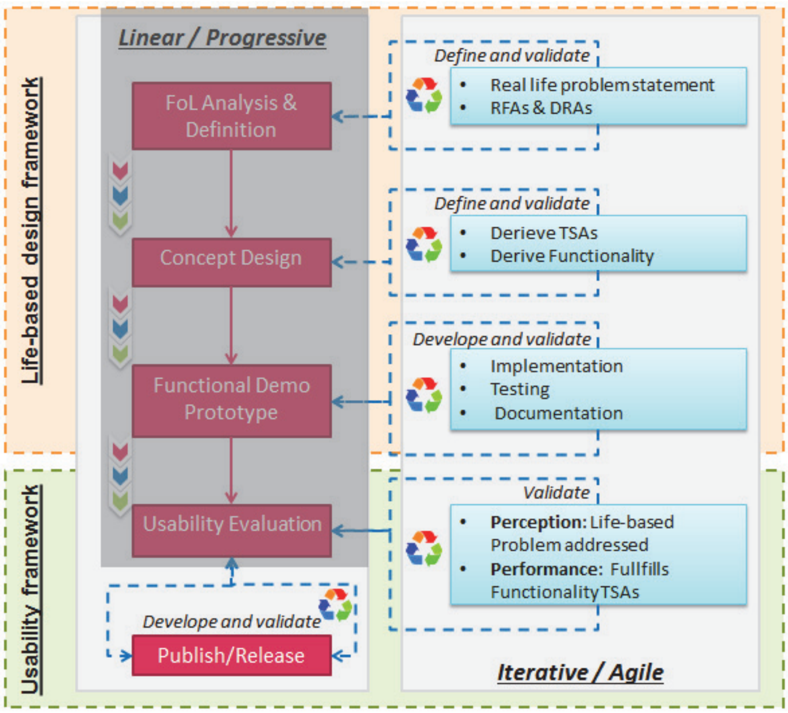


Figure 62: Iterative and Agile sub phases of the development process

In my quest to develop a solution for the Social Work sector, I have gone through the literature review of the Design Thinking thought process, in the beginning, when it was still limited to arts and crafts and tracing it through the traditional engineering phase, the Human-Computer interaction phase and concluding with the Life-based design idea and conceptual framework. I think that the evolution of the Design Thinking process into the Life-based Design Thinking is a natural progression based on changing needs of the society. With technology surrounding us and assimilating in every aspect of our life, and its increasing influence (Hongladarom & Ess, 2007), it is necessary for designers and solution creators to defocus from the technology based thinking. Move beyond the focus of optimizing the human-computer system. Relook on the aspects of human life itself. Look at the challenges that exist and are created with the way our lives change with technology. Instead of dumping technology solutions and waiting for adaptation of the human life around them, it is necessary to investigate the very reason for the presence of technology tools. As designers, we need to be ready to look beyond ICT technology and look at human sciences to understand the challenges various forms-of-life throw up.

> "It emphasizes that the technology design is not only about techniques and artefacts; it is essentially about designing for human life to improve its quality. One may even say that the core idea of Life-Based Design is to design the life itself and not just devices, systems, artefacts, products or other techniques. This is why we need the concepts of human life sciences in the design." (Leikas et al., 2012, p. 24)

Life-based design framework, as proposed by Leikas (2009) works as a good and simple starting point for practical implementation of the idea in technology development. The framework does not seek to replace the traditional usability engineering approach, but supplements it with a broader thought process by bringing forth the concept of Form-of-Life, as the core concept, that needs to be investigated, to design a solution. This allows designers to use the traditional usability engineering framework for validation and confirmation of usability solutions. Designers need to remain alert of the trap that, tradition engineering results may not solve the life based problem, even though the users may perform their tasks on a tool very efficiently and show excellent learning curves. This was the trap that I got into with iReach 1.0 when the traditional usability engineering test results showed a good learning curve, improved performance and good perception of the solution itself.

The form-of-life itself had to be relooked at, before going back to the drawing board to design iReach 2.0. The key insight provided by the participants was that though they wanted a decision support system, they did not want the system to make the decision. Research indicates that ill-structured problems lead to people not taking decision with a decision support system (Bansal, 2002). They did not want to make a commitment. The solution was only expected to provide insights. Furthermore, they were expecting the solution to provide emotional and visual cues. They desired a bias to be created, which a traditional decision support system would try to avoid. In the early discussion and focus groups, though this underlying meaning was already visible, I had failed to recognise it. Only when iReach 1.0, built on standard and easy to use components, was not perceived to be solving the purpose, that more attention was paid to this underlying signal and the significance of it was recognised.

iReach 1.0 was built with standard components or hybrid/composite components that are commonly seen and used in digital solutions. Their recognition and easy of use coming from habit was banked upon to deliver a seamless experience (Klaus, 2010). This worked in principal by increasing the efficiency of the users, driving up the learnability curve and at the same time creating a positive perception of the solution. iReach 2.0, uses the Silverlight PivotViewer (MSDN Library, 2011a) which is not a standard control, nor does its behaviour have any obvious paradigm with other standard components.

> "Successful products are easy to learn and to use, and memorable so that users do not have to invest heavily in relearning operations each time they use them" (Peerce, 2002, p. 523)

The users were able to learn the usage and successfully work with it in no time. This breaks the misconception that standard components are safer or more efficient to use while developing digital solution. With the on-going innovation in the hardware as well as software, there are new devices and new digital components created all the time (Avgerou & La Rovère, 2003). On one hand, this provides a huge opportunity for designers to pick-and-choose the components that they think fit the best for their solution to convert the TSAs to functionalities, but on the other hand, we need to be careful in using thing by testing their usability. Users are constantly exposed to new ways of interacting with devices and solutions and are quickly able to adopt new paradigms (Goldin & Smolka, 2006). However, the usage of these paradigms need to reflect in real-life solutions if we want the users to adapt and use these creations.

9.1 Future Study

New research is necessary to improve the Life-based technical design framework. As more designers and developers use the framework, they will generate fresh data and face new challenges. Different forms-of-life will generate different solutions. Technology solutions created, based on Life-based technical design framework also need to stand the trial of time. In this case, it will be interesting to see the impact of innovations in technology, data storage, data visualization, devices and others in future development. It will also be interesting to see the impact on the form-of-life itself, with the changes in technology. It is inevitable that the social fabric may itself undergo change and the roles stakeholders play may undergo a change with it. As we generate more data and more reference cases of developing solutions based on the life-based technical design approach, it will also become imperative to develop a system that identifies and validates the form-of-life. This will help avoid the challenges I faced to identify the correct form-of-life in the very beginning. If I had been successful in identifying the correct form-of-life in the first place, it would have been possible to look beyond standard components even at the early design phase. It is mission critical to get the right definition of form-of-life as early as possible. Late realisation will create a lot of repeat work and increase costs for developing solutions.

Thus, my recommendation for further researchers is to device a methodology or toolset to correctly identify and validate the form-of-life definition. This toolset with the life-based design technical framework will provide developers and designers, a complete package to implement the idea. On the other hand, it will also save time and resources by avoiding fundamental flaws at the beginning of the development process. Fundamental researchers, developers and practitioners of design need to develop this toolset together in order to learn from, and leverage each other’s experience and expertise. As Leikas (2009) has proposed, it is a multidisciplinary endeavour. Design process is not a purely empirical pursuit that can be implemented and validated using engineering approach. It is equally an art and science. Human beings, need a logical solution, and at the same time expect sensory gratification. I have created a solution that the stakeholders, in the defined form-of-life, were able to use efficiently and solve their problem and they loved it. Based on the learning from this process, the life based technical design framework was developed. In order to garner some sort of empirical validation, it is necessary to develop more solutions using the technical framework, in order to better understand the challenges to identify the form-of-life and define it. This experience will not only give insights in this topic but also identify other needs that I may not have encountered or have missed in this project. This research can be deemed as a laboratory study and its learning can be taken as heuristic inputs rather than hard-facts, that come from empirical validation and evidence.

9.2 Relevance to Industry

It is probably undermining to call the development of technology in the past few decades as evolutionary. Especially after the advent of the internet, it has been nothing short of a revolution. Information and knowledge is now accessible as never before, leading to quantum jumps in application and innovation based on the same. Even if this age is to be called evolution, it has certainly revolutionized the human life. This superhighway of information technology, combined with communication and media convergence is one of the most fascinating times to be living in. The development in technology is not limited to scientific development, but has direct reflection on business and industry leading to in inclusive and connected global society. Baldauf and Stair (2010) hold that the ability of technology to optimise resources and deliver more, is radically changing our lives, which in turn has negative as well as positive connotation.

> "The social impact of these technologies seems to occur with little or no forethought by those responsible for developing and applying the technology. Government are scrambling to establish laws to minimize negative impacts, while ethicists struggle to apply traditional ethical standards to brand-new modes of human interaction." (Baldauf & Stair, 2010, p. 621)

Technology has certainly raised our standard of living by automation, which increases human productivity. On the other hand, it is also a dangerous situation that we are very dependent on technology; its failure might lead to our inability to cope with basic functions in life. It is difficult to imagine a situation at home where the oven stops functioning, the communication grid is offline or even if a thermostat is dysfunctional. Similarly, in working environment, it is not possible to imagine life without computers and especially digital computation and communication devices. To put the revolution in perspective, the small mobile devices we carry around in or pockets today have the same power that a computer in the 90s had. Furthermore, the information access on these devices is equivalent to all the libraries in the world put together. We human beings possess amazing ability to observe, learn and adapt to changes around us. It is certainly easier, with the changes that are driven by us, granting us the time to cope with it because of prior insights and knowledge to manage expectations and learn new skills. However, in a revolutionary environment this is not the luxury the human society has and furthermore, it is not equally accessible across the globe, thus creating a 'digital divide'.

> "The "Digital Divide" is the growing gap that exists between those who have access to the resources of the global information revolution and those who are deprived of such access due to gaps in their education, personal handicap, poor digital infrastructure, or lack of advanced computer equipment. Bridging the Digital Divide is the effort to provide increased access to information and communication to those who have little or none at all. "Communication bridges" involve social dynamics as well as the technological tools that support social interaction."(Tucker, 2004, p. 1039)

In the previous chapters, I have gone through the literature review of the evolution of Design Thinking and mapped it from the time it was still 'art and craft' through the engineering times and finally to the state here we are today. Design Thinking, in my opinion has come a full circle, where we start addressing the question of, what role does design play in human life. Admittedly, it is no longer limited to art and craft. On the other hand, it is no longer enough to look at it from a pure engineering approach. Today's technology revolution is forcing us to relook at technology and its role and application in human life as much as it is forcing us to re-evaluate the role of design. Industry capitalises on new technology to drive better business and better profits. At the same time, it is necessary for the industry to develop products and solutions that solve real life problems for the consumers of technology. In order the solve these problems, it is necessary for the industry to also understand the form-of-life in which human beings find themselves in, the challenges they face in that form-of-life and then develop the solutions-technical or otherwise- with the focus on solving them. Industry needs to exist to support and enhance human life. Without human life, industry is meaningless. Consequently, the focus on life itself, forces Design Thinking to dwell in depth and address the issues of what worth and value creation is done from human life perspective and the ethical alignment of the same. Leikas (2009), concept proposal of Life-based Design offers developers of technology to move away from an engineering and industrial approach towards design, to a human/social approach towards design. My research and application of the Life-based Design concept in development of a technology solution and the subsequent proposal of a model of future software development, gives a practical tool set to designers and developers to leverage the Life-based Design concept in actual solution development. Thus, in my opinion, it is not a real option, but imperative for the industry to refocus on human-life in practice, to develop meaningful solutions.

> "Given the notion of consumer involvement in product design, development and marketing, the practitioner can benefit from a fresh perspective on technology adoption. Many of today's consumers want to be influential in many aspects of products and services, and companies can provide these opportunities through social computing tools."(Vannoy & Palvia, 2010, p. 152)

With social computing and social network phenomenon becoming a way of life, industry has better possibility of getting insights in human life form, for which they are developing solutions. For that matter, the inspiration for new solutions can come from the insights that the social computing and social network phenomenon offer.

9.3 Relevance to Life

Life-Based Design thinking should not be restricted to technical solutions alone. It can be leveraged to create solutions to address real-life problems in forms-of-life that lead to designing solutions around logistics, transportation and education to name a few. To give an example, traditional engineering will focus on creating a tool for transportation of children to school while HCI will provide the expertise and insights needed to make the technology solution (in this case a bus) efficient, safe, easy to use and ergonomic. However, in context of a real life situation, one needs to find out why is there a need to create the transportation solution in the first place. There are anywhere between 400,000 to 500,000 street children in India (Chatterjee, 1992). Many of these children are runaways, orphans and have given up on the society. They perceive the school as an institution and do not see any benefit in education. They also live and sleep off the streets. The government of India wants to make sure that all children receive primary education including the street children (Department of School Education & Literacy, 2007). Free school buses, to get these children to school failed because of three primary reasons- 1. The bus drivers did not know where to pick up the children from since they keep changing their locations. 2. The children did not want to go to school and did not proactively get into the bus and 3. The schools and the teaching staff were not equipped to handle these children.

A human approach to address this life-based-problem was creating of a Mobile Learning Centre (MLC) that went wherever the children were, instead of children coming to the school (Identity Foundation, 2007). The MLC is a bus equipped with audio-visual learning aids as well as interesting games, colouring books, activity books etc. Staffed by sensitized teachers who focus on making the learning experience fun, the MLC is a hugely successful project funded by Tieto Corporation (Sponsor) and run by Identity Foundation (NGO) in Pune, India (Tieto Corporation, 2012). The technical solution of transportation of children to school using a school bus fails completely in this scenario even if utmost care to adhere to usability, ergonomics and HCI best practices is implemented. Identifying the real-life challenge, understanding the form-of-life of street children and then designing a solution where by the school came to the children, instead of the children going to school was an approach that worked.

According to Leikas, et al. (2012), usage situations are still the main area of concentration when it comes to HTI design while developing technology, while ignoring the real needs that arise out of people's needs. Solution for the sake of creating technical solutions is not enough. Successful solution creation process needs to look at technology as one of the possible enablers and not the default tool. In the field of software engineering too, it is necessary to understand what is the relevance of technology to begin with. Leikas, et al., (2012) recommend that there is a need for change in focus from usage of technology and users like or dislike for it, to what people use or wish to use the technology for. Challenges in human life are not necessarily solved by ICT technology. The humans participating in various forms-of-life do not demand or expect a technical solution. Technology is one of the many tools available to create a solution. In my opinion, the Life-based Design framework has a more universal application and is not limited to technology alone, although it certainly has elements that inspect in depth the possibility of leveraging technology in solution creation. The model for solution development I have proposed is more relevant for creating software solutions. As future study, it will be interesting to develop a model that works independent of solution development tools.

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ANEXURE 1

Table 4: Paired Samples Statistics of the scales for iReach 1.0 and iReach 2.0

	Mean	N	Std. Dev.	Std. Error Mean
iReach 1.0: Visibility Overview	3.74	77	1.105	.126
iReach 2.0: Visibility Overview	4.35	77	.739	.084
iReach 1.0: Ease of Sorting & Comparing	3.84	77	1.077	.123
iReach 2.0: Ease of Sorting & Comparing	4.36	77	.647	.074
iReach 1.0: Visual & Emotional Cues	2.96	77	1.292	.147
iReach 2.0: Visual & Emotional Cues	4.35	77	.739	.084
iReach 1.0: Ease of Verification	3.84	77	1.125	.128
iReach 2.0: Ease of Verification	4.44	77	.678	.077
iReach 1.0: Ease of Tracking	3.48	77	1.221	.139
iReach 2.0: Ease of Tracking	4.70	77	.563	.064
iReach 1.0: Learning Challenges	2.01	77	.910	.104
iReach 2.0: Learning Challenges	1.30	77	.563	.064
iReach 1.0: Perception of Simplicity	3.77	77	1.134	.129
iReach 2.0: Perception of Simplicity	4.70	77	.563	.064
iReach 1.0: Perception of Guided Help	2.68	77	1.292	.147
iReach 2.0: Perception of Guided Help	4.69	77	.730	.083
iReach 1.0: Ability to Move Between Hierarchies	3.31	77	1.206	.137
iReach 2.0: Ability to Move Between Hierarchies	4.60	77	.748	.085
iReach 1.0: Manual Effort	3.00	77	1.246	.142
iReach 2.0: Manual Effort	4.65	77	.664	.076
iReach 1.0: Sales Orientation	2.68	77	1.251	.143
iReach 2.0: Sales Orientation	4.87	77	.440	.050

Table 5: Paired Samples Test of the scales for iReach 1.0 and iReach 2.0

	Mean difference	t	df	p
Visibility Overview	-.610	-4.616	76	.000
Ease of Sorting & Comparing	-.519	-6.190	76	.000
Visual & Emotional Cues	-1.390	-13.688	76	.000
Ease of Verification	-.597	-5.780	76	.000
Ease of Tracking	-1.221	-11.743	76	.000
Learning Challenges	.714	10.024	76	.000
Perception of Simplicity	-.935	-8.509	76	.000
Perception of Guided Help	-2.013	-12.532	76	.000
Ability to Move Between Hierarchies	-1.286	-11.780	76	.000
Manual Effort	-1.649	-13.973	76	.000
Sales Orientation	-2.195	-16.150	76	.000