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Master of Science (Research)

Recording and Tracking Design Decisions in interactive System Development

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Abstract

Experience economy is prompting the innovation of traditional product design. The design concept - "user-centered design" has received wide recognition. In the face of many professional or non-professional users, the priority of interaction design is to ensure the usability of the interactive product, and then a good user experience of the product. The user interface is an intermediary between human and computer. Users exchange information with the computer via the user interface. The user interface is an important part of a computer system. It is a big part of the software development. The quality of the user interface directly affects the performance of the software. For most users, the user interface is all they know from a product. So for these users, a program with a good interior design but a bad user interface design is a bad program.

In this project we investigate different ways of recording design decisions in interactive system development which may allow us to think of the different variants and alternatives that are possible (within a design space) in some formal notation, which then allows us to either reason about their suitability or record the decisions made to understand the impact of decisions and how well they support the given criteria. The goal of this project will involve finding out what the influences are which help drive the design process; considering the effects of individual vs. team design; deciding how and when decisions occur; thinking about useful ways to record decisions and their influences; and investigating the usefulness of the approach through the working examples identified as case studies

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Chapter 1: Introduction

Recording and tracking design decisions during interactive system development is the topic of this research. An interactive system is defined as the class of computational systems where the interoperations are seen to involve much user interaction (Johnson et al, 2000). There could be interconnected media and technology for interaction in this system, ranging anywhere from common media such as the keyboard, display, touch screen, mouse and more. There are many benefits to using this system, but in the design stages there are many issues of interactivity design that have to be considered in order to make them a success.

Most of the benefits in using the system are only achieved when different teams come together in a much more coordinated way in decision-making during the development (Shneiderman, 2010). A recording and tracking system for design decision-making could be developed based on some existing heuristics, as in the case of Laseau's funnel (Bowen & Dittmar, 2016) in decision making or it could be developed based on the research studies in the workplace on what form of productivity and efficiency statistics need to be met. This is necessary, as more user design teams might have different opinions during the design process as such and their collective opinions could be very helpful.

Now, interactive design is a user-oriented study topic where the focus is on how to understand collaborative and interactive process between the people as actors and technology as the medium. Interaction design theory and decision making are built on the basis of understanding the users. The user centricity is what necessitates that user interaction, and feedback is more considered in decision-making. The real purpose of interaction design is to let the machines communicate better with people, and for this the design usually handles a complex array of inputs from the designers on how this can be achieved. Hence complexity increases.

1.1. Problem Domain

At its most basic level, the interactive software system is usually defined as a user interface with user classes. It models the user interface requirements. The user classes are varied, based on the potentially conflicting requirements and expectations (Shneiderman, 2010). In addition, there are other systems in the working environment that the interactive system would have to interface with which furthermore adds to the complexity (Shneiderman, 2010). In the case of multi-disciplinary development in interactive projects, 'User Centred Design' UCD process is considered to be helpful in addressing the issues of changes in a much more just in time fashion (Duke & Harrison, 1994). Understanding interactive system design can also be done with user behavioural models and more and these discussions are presented in the literature review section of this thesis which presents the background on the decision support and interactive systems.

The use of formal methods has also been shown to be helpful in the design of interactive systems where formal methods is not part of the traditional UCD process, they can be incorporated in a way that be beneficial (Duke & Harrison, 1994). Software engineering methodology is usually based on a recommended development process proceeding through several phases, which are that of Analysis, Specification, Design, Coding, Unit Testing, Integration and System Testing, Maintenance (Dabbs et al, 2009). Formal methods can be a foundation for describing complex systems and also a foundation for reasoning about systems (Duke & Harrison, 1994). It helps in providing support for program development and also is a complimentary approach to methodology. Chapter 2 will present detailed evidence on existing research on the topic.

The problem that this research work focusses on, is that of understanding how real time decision making includes user interactive decision spaces, with subspaces and overlapping phenomenon of the subspaces. Any product needs to go through a complicated process including early-stage study, overall design, specific design and implementation, regardless of the respective particularity of the design and development process of each product. Strategy and user analysis is the first level here. At the strategy analysis and user analysis stage, it is to emphatically solve the direction and expected goal of product design. The "user-centred" design concept thinks that the success or failure of a product is finally determined by users' satisfaction. To reach users' satisfactory goal, it is required to deeply and precisely know who our target users are. This stage is exactly the description on users' features. Meanwhile, the product designer should definitely understand the target users' expectations of the product designed, including functions desired by users, the target ratio's to be reached etc. Thus, collection and analysis are required in this process. With the existence of a variety of restrictions, a product usually fails to meet all user demands, so the designer and developer should limit the application scope of a project based on its own conditions after comprehensive analysis on user and demand, and meanwhile should normalize the project goal. This is the definition of goal.

A product aims to help users to complete the tasks they expect to complete. After the project goal is determined, the users' tasks supported by the product are also relatively determined accordingly. Then, the developer's work focus is to analyse users' specific behavioural pattern to complete tasks. Besides, the represented model needs to maximally match with the target user model; namely, the logic of product design should be identical with users' habit and natural understanding, so that users can use the product in the most fast and easiest way and can obtain joyful user experience.

Secondly, the design and assessment stage is considered. The materials for early-stage strategy and user analysis can be effectively used only after they are analysed in a systematic way and expressed in a refined way. Object modelling, which is one of the methods, means classifying the results of strategy and user analysis according to the object determined before and vividly describing its attribute, behaviour and relation in the form of graph. The abstract object model can be gradually transformed into user interface views in different specific extents, i.e. low fidelity model and high fidelity model (Bowen & Reeves, 2008). After the design model is built, some means and methods are needed to verify whether the represented model matches with the ideal user model. The user availability test and expert assessment are two of such methods. The user test method is to show the design model to the target users and obtain the users' feedback data through users' simulated use or discussion etc. The expert assessment method is to invite experts in human-computer interface design and system function to examine the design model according to their experience and then point out the availability issues. The final stage is implementation and assessment and task analysis. This stage, which is the final high fidelity model after several times of iterative designs, is to conduct the interface visual design based on the enterprise's own design style and specification. After interface design, a comprehensive technical test and user test on the project are required to guarantee the maximal perfectness of product before it comes into the market. After the product is put into the market, the designer usually needs to collect all sorts of user feedback. Such information collection and processing not only can help the sales and market operation of current product but also can help the improvement, optimization and future updating of product. Therefore, in this stage, user tests should be carried out for several times in different stages or other ways should be used to track the users' use condition and satisfaction degree.

In narrow sense, the interaction design consists of the task analysis, object modelling and analysis, abstract design of view, rough design of view, associated design of view, comprehensive design of view and other steps and in a in broad sense, the description of user's features, demand collection and analysis as well as goal definition before task analysis can all be included in the scope of interaction design. It is also observed that the intermediaries for knowledge acquisition and modelling are the product, service marketing and users' reports. Based on the acquisition approaches, knowledge can be divided into the "explicit knowledge" and "implicit knowledge". The explicit knowledge refers to the skills and objective facts which can resort to writing, images, sound etc. and can be imparted to others; the implicit knowledge refers to human's skills, judgment and intuition, which cannot be easily described, such as insight, inspiration, visual perception and experience. As this knowledge is subjective, random and fuzzy, it is the difficult and key point of knowledge modelling to express it in a conceptualized way. Thus, it is required to study the user's complicated mental activities and behavioural pattern during the design process. Since users are complicated and changeable, it is required to carry out the "multidisciplinary" and "multi-angle" user research and establish a user model. The original point of user interface design can be found out only after users' goals, lifestyles and demand points are determined. A much more complex understanding of the decision space is hence necessary and this research will attempt to bring into context, how a complex decision space can be presented conceptually and how it compares against a real time space.

Donald Norman proposed that a designer should guarantee that users can distinguish the following relations according to the natural match between the design knowledge and user's knowledge; the relations include: relation between operation intention and possible operation behaviour; relation between operation behaviour and operation effect; relation between the system's actual condition and the system condition perceived by the user through visual and auditory sense etc.; relation between the system condition perceived and user's demand, intention and expectation (Norman, 2013). The "user-centred" design flow can be divided into two stages: "user-centred" analysis (UCA, namely strategy and user analysis stage) and "user-centred" design (UCD, namely the stage integrating the design and assessment stage and the implementation and assessment stage). It can be seen that the task analysis is a key step exactly in connection part between UCA and UCD. UCA is mainly based on the target user's demand, motivation, goal and behaviour. The demand analysis is the starting point; motivation analysis and goal definition are the middle key steps and the internal impetuses which finally trigger users' some behaviours. As the user's behaviour is abstract and scattered, the designer must abstract user's behaviour into task models through the task analysis process (task decomposition and reconstruction); finally, in the specific design stage, the design model can be generated gradually. The process of task analysis is not isolated and is a link in the tight flow chain of "user-centred" analysis and design. The collection and analysis of user demand, motivation exploration, goal definition and analysis on user behaviour are the foundation of task analysis. Thus, it can be seen from this point that the task analysis in interaction design is carried out under the guidance of user goal. This could give a rigidity in decision making in the process space and might ensure that decision making is point to point, instead of involving multiple points. The analysis of interactive design spaces forms the background context of this research paper.

1.2. Research Outline

This research investigates real-world design processes to identify decision-making and other important factors. It then looks at the ways of recording these during interactive system development in some formal notation framework. This allows us to either reason about their suitability or record the decisions made to understand the impact of decisions and how well they support the given requirements. The goal of this project involves finding out what the influences are which help drive the design process, considering the effects of individual vs. team design, deciding how and when decisions occur, thinking about useful ways to record decisions and their influences, and investigating the usefulness of the approach.

This research attempts to understand how existing research might incorporate multiple points of interaction too and how they would vary when compared to an interactive framework developed conceptually by Bowen & Dittmar (2016). In comparison with the conceptual framework of Bowen & Dittmar (2016) it would be possible to define how processes in the real world also work in multi-disciplinary setting with consistent design outcomes based on requirements.

1.3. Research Aim

The aim of this research is to critically present the conceptual framework of Bowen & Dittmar (2016) and compare it with two case studies where interactive design spaces are identified.

1.4. Thesis Structure

The second chapter presents the background and related work section. The section will present existing literature evidences on the topic of UCD, decision making and design processes, formal methods, supporting decision modelling, recording of design decisions, the significance of understanding design and decision spaces etc. Chapter 3 presents the case studies that are used in this research work. A company based case study and a university based case study is presented here. Chapter 4 analyses the case studies based on the conceptual framework on interactive decision spaces along with a reflection on the framework. In chapter 5 we present our conclusions.

Chapter 2: Background and Related Work

2.1. Users, UCD and the decision making process

The basic idea of user-centred design is to always think about the users from the starting point to the end point. In the initial stage of software development, the aim of the software should be to meet the needs of the users. The design and development process should be based on the study of the users. Basically, the users refer to the user who will use the product. Figure 1 shows the definition of "the users". When a person and a product have an interaction (the person use the product), the person is a user of the product. From this explanation, we can find that the users include two meanings:

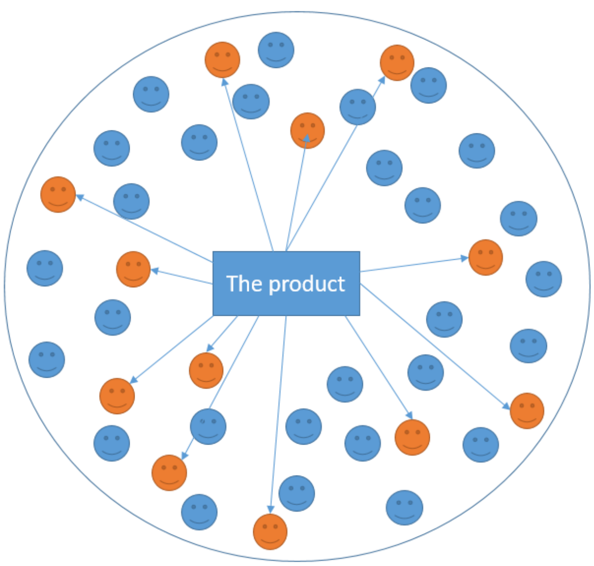

Figure 1: Who are the users?

- The users are the people who use the product.

In user-centred design, the users could be the current users of the product. They also could be the potential users. Their behaviours in the use of the product relate closely to the features of the product. In user interaction design, the user is always the most important factor. Researching the users can help people to understand the requirement and goal of the product. It also help us to make the product more useful and easy to use. The features of the product must be expressed through tasks. Tasks are the ways to get the user goals. In user interactive design, user goals can be classified into three categories: life goals, experience goals and usability goals.

- The users will have Life goals:

Life goals express the user's personal expectation. It is often beyond the context of the product design. These goals are the deep driving force and motivations. They are useful to understand the relationship between the users and others in a broader context and understand the user expectations from the perspective of brand. For example: to design an online dating platform, developers collect the following life goals:

- To share parts of their life with friends
- To make their life richer and colourful
- To know more strangers and have the opportunity to become friends
- To see the world and become a better person

These listed points above may have little influence to the user interface of the final product. But they are worth to be kept in mind. How to provide a product which can reach the users' life goals should be considered and satisfied.

- The users have Experience goals:

Experience goals are simple, ordinary but also personal. Experience goals express the quality when interacting with the products. Bernd Schmitt have classified the user experience into five major systems: sense, feel, think, act, and relate (Schmitt, 1999)

- Sensory experience: related to sight, hearing, touch and taste.
- Feeling experience: related to users' inner feeling and emotion.
- Thinking experience: related to understanding and solving the problem.
- Action experience: related to users' lifestyle and behaviours.
- Relative experience: related to the relative emotion, personality and the culture.

The five types of experience can generate many experience goals: satisfactory, pleasant, interesting, compelling, useful and enlightening. There is a progressive hierarchy relationship among these five types of experience. Sensory experience is the most direct and basic user experience. Next level is feeling experience then thinking and action experience. The highest level is relative experience. (See Figure 2)

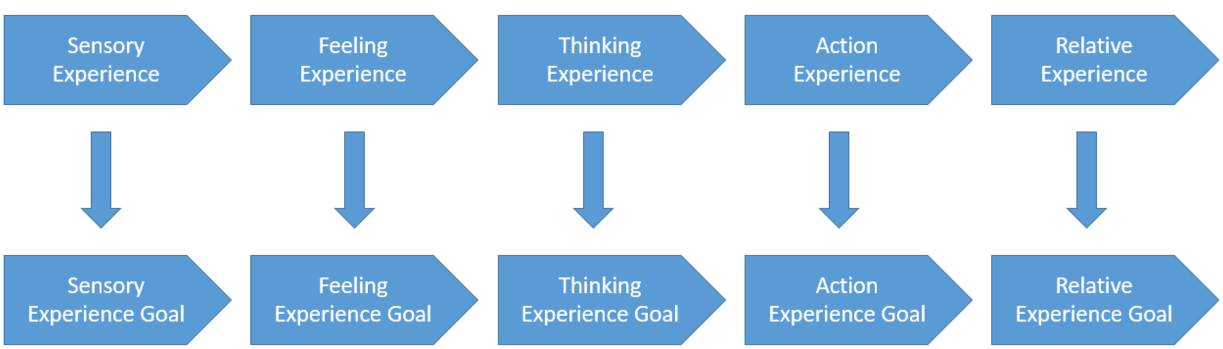

Figure 2: Five types of user experience and experience goals

Source: Schmitt, 1999. Reprinted with permission.

Usability goals:

Usability goals represent the users' expectations of result to use a product. For the users, usability goals can be specified to some tasks. For example, when you search certain information on Google, you have a clear objective. Usability goals must be satisfied. So the users are willing to pay time and money for the product. Therefore, developers need to pay most attention to the usability goals. Usability goals are the core of the user interactive design. Usability goals can be divided into the following goals: feasibility, efficiency, safety, versatility, learnability, etc. The following are the usability goals for a website for movie fans.

- To provide movie trailers
- To search movies according to the movie name, actor, director, etc.
- To list the film songs/music (if any)
- To provide reviews of the movies

Usability goal is the ultimate goal of user and the real feedback of user's expectations. Thus, it is the core of interaction design, while experience goal draws more and more attention from users in the experience economy era and also decides whether the developer's business goal can be realized or not. If the practical availability of a real product is ignored but it serves user's experience goal, however, then only a toy rather than a commercial application will be designed. Life goal is the deepest goal of users. Only their life goal is comprehended, the deepest demands of users can be figured out. Life goal is also fundamental driving force of a successful product which stimulates consumers' desire for consumption.

2.2. Need to understand decision modelling

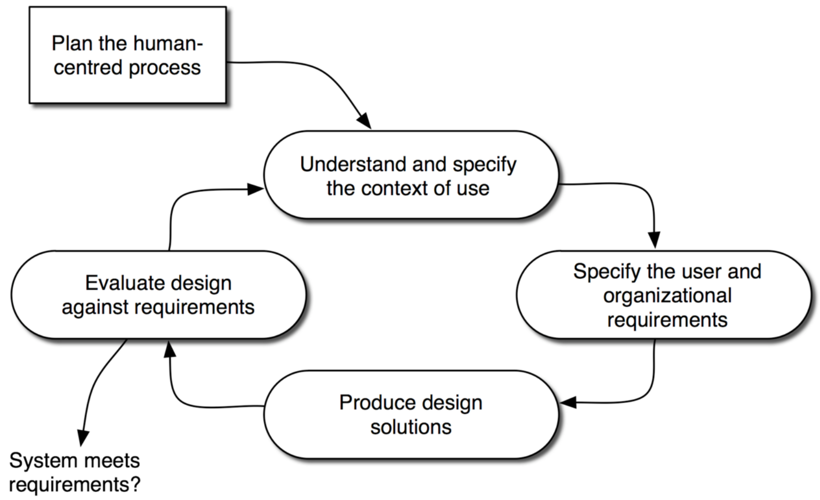

Figure 3: Human Centred Design Process for Interactive System

Source: ISO (1999). ISO 13407: Human–centred design processes for interactive systems. Geneva: International Standards Organisation. Also available from the British Standards Institute, London. Reprinted with permission.

This aims to make further interpretation from the perspective of knowledge. Knowledge includes illustrative (declarative) knowledge and procedural knowledge. Illustrative knowledge emphasizes static aspects of knowledge—object, event and the correlations there between, namely questions like "what". Procedural knowledge emphasizes utilization of knowledge—the process of problem solving, namely questions like "how". Therefore, a user model is essentially a knowledge set for solving "what" and "how" questions in the process of product design. The essence of matching represented model with user model is to require designer to fully understand user model, obtain and build rational user model based on user research, and realize natural match between designer's knowledge with user's knowledge via target product, the common carrier of designer and user.

Donald A. Norman first proposed the three concepts and correlations there between in The Design of Everyday Things, and Alan Cooper also stated his opinions on the three concepts in the About Face 3.0 the Essence of Interaction Design (Norman, 2013; Cooper et al, 2007).

User model is also referred to as user's mental model. It is knowledge about the due concept and behaviours of a product stored in user's brain. This knowledge may come from user's experience of using similar products before, or user's expectation on the concept and behaviours of the product based on the goal to be achieved by using the product. As for a tool of complex structure, it is unnecessary to explain particulars of the internal working principle to users, while users need to know something about the tool in using procedure to master it. Therefore, users tend to understand the product in their own way (Schmitt, 1999). It is possible that user's understanding completely deviates from the working principle of the product, but users can predict the using effect of the product based on their own understanding. This process refers to building user's mental model in interaction design. An example will be given to explain this concept, as below. The turn signal switch of most cars is set as a driving lever connecting to steering wheel shaft, which is at the back on the left of steering wheel. Pull it upward, and the turn signal lamp on the right lights; pull it downward, and the one on the left lights. A driving school student who touches car for the first time absolutely doesn't know this operation. Usually, coaches will not teach students to remember this operation. After hours of practice, most students can master the operation. Students build their own mental models, which are nearly identical: in order to turn right, the steering wheel should rotate rightward, and the left hand should move from down up; thus, the driving lever of turn signal lamp should be pulled upward; and vice versa. Actually, automobile steering device is controlled via electric circuit, and pulling up or down just gives electrical signals. Drivers unnecessarily need to learn the working principle, which is expected by designer of driving lever of turn signal lamp. A good design will help users to build a correct simple mental model easily. If driving lever of turn signal lamp was designed to be a device like “handbrake”, it is hard to master the operation, whether pulling up lights the left or the right lamp.

User’s mental model tends to be simple. Mental model acts to bridge tool and user operation, by which users can understand and use tool easily. The more complex a mental model is, the less its value is. If a mental model is too complex to take much time of user for thinking it, he/she will tend to figure out a proper application method via practical operation. In practice process, new mental model simpler and easier than the old one will be built. The purpose of building user model is to help users to learn to use tool. As users get increasingly skilful, they spend less and less time on thinking, and then their operation becomes a natural response.

Implementation model is also referred to as realization model. It relates to internal structure and working principle of product, and exists in the brain of technicians engaged in product development. Implementation model falls into the field of technical solution. In the field of human-computer interaction, implementation model refers to a mode of realizing interaction details via program code. In the field of industrial design, implementation model relates to internal structure and working principle of product, and product manufacturing and processing technology, etc. (Parasuraman et al, 2000). For example, the dynamic state of pictures is realized by sequencing pictures in a complex way by film projector, letting bright light penetrate a semi-transparent micro image in a flash, blocking the light at the moment the light moves to another micro image, and projecting light again in the next moment. A film projector shows 24 images a second, and continuously repeats it. Software-based products are not subject to such mechanism.

Instead, algorithm and intercommunication code module are adopted. The expression about how a machine or a program works is hence argued as a realization model (Baecker, 2014)

If engineers, who know well about how software works, undertake interaction design of software, then the product interface they design will be highly similar to the realization model. As far as engineers are concerned, such model is rational, real and correct. But, unfortunately, such model is not helpful or of any significance to users. Most users don't care about how a program is realized and the represented model is also referred to as presentation model. It relates to users' knowledge about how the product is used and works formed after the final appearance of product and the product itself are presented to users and users use it. Broadly speaking, it refers to human model about themselves, others, surroundings and things they access to formed via experience training and learning (Baecker, 2014)

Match relates to correlation between two things, and refers to the corresponding relationship between user's operation and feedback of system or product. Natural match means designing easy-to-use products based on physical environment analogy and cultural standard ideas. In an example above, the steering wheel should be rotated rightward when you want to turn right, which is a simple match between operation and outcome. By such match, it is easy for users to do correct operation. In such case, operation is in a closely visible link with outcome, and information feedback is given rapidly. This kind of match is easy to remember, and will never be forgotten (Cooper et al, 2007). Obviously, the definitions above show that the concepts and behaviours in user model fall into the problem domain or task domain of users, while implementation model into the field of technical solution. Generally speaking, the two models are largely different. The more the products are, the larger the difference is. Since user model falls into the problem domain or task domain, it cannot be easily changed by product designer.

Implementation model depends on the technological level at the moment, and hardly change in a certain period. Only represented model is of great plasticity, which can be changed by product designer through efforts. According to Figure 4, the represented model is always distributed at a point between user model and implementation model. The closer the represented model is to the user model, the fewer users have to learn and bear in mind about how to use products. This is because the actual products are close to users' expectations, and such products are easy to use in this case (Cooper et al, 2007). On the contrary, if the represented model is close to the realization model, users have to map some concepts and behaviours as they expect to some interface elements and operations showed in the represented model.

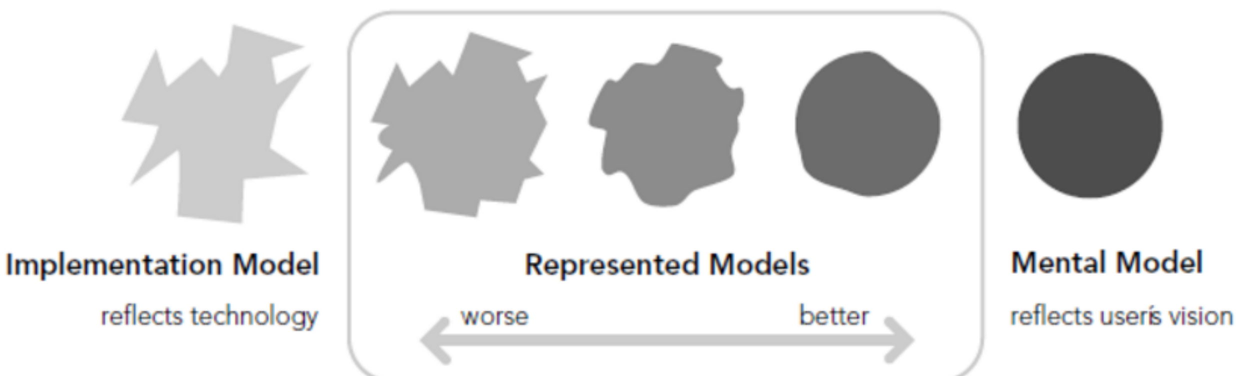

Figure 4: Differences between the Implementation Model, Mental Model and Represented Model

Source: Cooper, A., Reimann, R., & Cronin, D. (2007). About face 3: The essentials of interaction design. Indianapolis, IN: Wiley Pub. Reprinted with permission.

2.3. Recording Design Decisions and Decision Analysis methods

A macroscopic description on a system is to describe each member in the system and their respective tasks to be achieved. The diagram of use behaviour analysis, i.e. use case diagram, is the diagram constituted by the leading roles, cases and their relation. It is the first step of a software product from demand analysis to final realization and describes how to use a system. The use case diagram shows the relevant users, services desired for by users from the system and services users need to provide for the system. In this way, the system user can easily understand the usages of such elements and the product developer can finally realize such elements. The use case diagram is widely used in all sorts of development activities, but it is used to describe the relation between a system and its subsystems most frequently. Besides, a use case diagram generally includes 3 elements which are respectively the actor, use case and association. Actors mean persons or things which use your system, namely persons or things which do some operations. For instance, when you withdraw cash from an ATM, you and ATM are actors in the use case diagram. The use case means an action, operation or a triggered event, namely use case. For instance, "enter password" is a use case. Association, which means the relation between an actor and a use case or between actors, consists of inclusion, extension and generalization, which are not described in detail here. As a diagram of UML, the diagram of use behaviour analysis can explicitly show system members and system function and how they would make decisions.

A sequence analysis diagram is generally used to confirm and enrich the logic of a use scenario, which refers to the description on the potential use pattern of the system. The logic of a use scenario may be a part of a use case, an alternative task line, or a complete flow throughout a single use case, such as the logic description of the basic process of an action, a part of basic process of an action or logic description of one or more alternative scenarios, or the flow contained in several use cases. The advantage of sequence diagram is that it can intuitively describe the time sequence of steps needed by a certain user behaviour. However, the sequence analysis diagram fails to intuitively express the relation among all system elements. The cooperative relation diagram is a way to solve this problem. Thus, the cooperative relation diagram will be discussed below.

The cooperative relation diagram and sequence analysis diagram describe identical information in varied ways. The cooperative relation diagram emphatically shows the relation among all system elements in a user behaviour instead of the time relation among all steps. The cooperative relation diagram and sequence analysis diagram can be transformed into each other. Besides, the two methods are usually synthesized in practical applications (Fischer, 2001). The use of a task pyramid describes the relation between tasks at different levels. Any task may include some subtasks to form the pyramid structure, which can intuitively describe the task decomposition process of product. The sequence analysis diagram describes the typical steps of a certain use behaviour, which may represent most users' ways and characteristics of system use. However, different users may have different specific ways to complete a task and a user may adjust his steps and strategies to complete a task under different internal and external conditions. The procedure and decision analysis method comprehensively expresses the different steps possibly adopted by different users or under different conditions to complete a certain task by using the flow diagram. The story scenario analysis here is mainly focused on user experience design research field. Since it is very difficult to quantify user experience with statistical methods, user experience is usually described by the mode of user scenario construction. Through scenario simulation, the designer can gain the same or similar experience with the user. This contributes to designer's design. In user scenario construction, there are a series of effective tools, where the most typical tool is scenario storyboard (Schummer, and Lukosch, 2013). In task analysis, scenario storyboard is used to construct the scenario where the user uses the product through story telling method to simulate real task flow of user. Availability indexes and user experience indexes sought by the designer from specific scenario are the best task flow. It can be seen that the scenario makes scattered task a clear task flow. Compared with other task analysis methods, scenario storyboard method is most vivid and visual, because it narrates the typical overall situation where a user uses the system. It is shown by a visual story. The designer can acquire the interactive process of target users with products and environment more effectively. The story or scenario applied in task analysis may be true or imaginary. It may be general situation of current system use or imaginary ideal situation. It may come from the user or written by the designer. The key to this method is to make the story and scenario representative so as to serve as design reference.

2.4. Human Computer Interaction and the need to understand design and decision Spaces

The domain of human-computer interaction forms the key research background for understanding our problem space. Much research has occurred in this field and it encompasses those schools of thought such as that of interactive system design, user centred design UCD and more. The design process as understood from the user-centred background is one where the user involvement drives the decision-making process (Dabbs et al, 2009). The user interactions are iterative and other stakeholder involvement is considered here. External design representations such as scenarios and prototypes are also being incorporated into the decision-making process as different users would bring different set of concerns and understandings to the process. Also there is a shared understanding among the different users on why alternative viewpoints are to be entertained.

If in traditional work projects, some form of delegation is given, then integration would only occur at the project module functional level. Here on the other hand the integration would occur at every key decision making stage (Dabbs et al, 2009). Designer roles in interaction design is often exploratory of their decision-making in the design space (Dittmar, & Piehler, 2013). In the engineering approach, it is noticed that the technical emphasis is necessary to reconnect the user understanding of the interactive artefact. Formal models such as the task or the UI model might be made use of here and the desired system properties could be attained by design user interaction. However, in most theoretical underpinnings, it can be seen that there are specific goals, assumptions, activities, resources, and outcomes. For example, Dix et al. (2008) point out that "the ideal model of iterative design, in which a rapid prototype is designed, evaluated and modified until the best possible design is achieved... is appealing", but it is also important to use "more principled approaches" or formal techniques to overcome the bad initial design decisions and understand the reasons behind usability problems, not just detect the symptoms.

Another way of looking at this is to understand the heterogeneous design practices that are present in interaction design in order to understand. In the research work of Anke Dittmar (Dittmar, & Piehler, 2013). A better understanding of the interplay of such heterogeneous design practices will be helpful in the implementation of successful interaction design. Some of the assumptions made here are that the intangible design processes would more often begin from a least set of requirements and then would move from such a set to a more collaborative and iterative set which obviously is higher in magnitude. Different design practices acknowledged at this point leads to the understanding of different formal models as well (Johnson et al, 2000). The models range anywhere from the new constraints requirements to that of the reference tracking or backtracking, leading to modifications in the initial system. In the project management, programming or system development, a baseline set of objectives to be met are usually established and then with time and different decisions-making alternatives, this baseline is then modified. The same concern for modification is hence also applicable at this point. Therefore, when the design and user interactive space is created, it then becomes necessary to ensure that the changes are consistent with the existing decisions, and/or is consistent with that of the existing requirements or the newer constraints, etc. The reasons given by the multidisciplinary teams must also be considered at this point, and must be understood based on whether they are overlapping with one another, and or are related, etc. In the case of an evolving decision making scenario, it is necessary to understand the points of changes as well, because one point of change could also lead to a trajectory of changes.

Interaction design model needs to consider two aspects: users who use the software and developers who develop the software. Given this sense of complexity, the research focuses on how a recording and tracking system in interactive design development would help improve the decision space in development. Recording and tracking design decision systems are in existence for architects and system designers who need to know their design model well (Johnson et al, 2000). It helps them to keep track of decision, and also the transformation of customer requirements over time, which demands changes to be made in design decision making accordingly. The recording and tracking design systems also function as an efficient documentation element in those cases where a project staff member might have to leave and newer project members have to immediately enter the design space (Dittmar, & Piehler, 2013). In addition, it is often required that requirements analysts model a design solution already in the analysis phase. Such hasty design decisions may cause solution-specific restrictions which are not appropriate (Johnson et al, 2000).

Stakeholders not involved in the design decisions, such as that of customers, project managers and developers would have a hard time to understand the significance of relationship between customer requirements and services. This often leads to misinterpretations among them. There could be also ad-hoc changes to design that might end up being unmindful of the existing dependencies to other design aspects. The use of a recording and tracking design decisions model will reduce the distance between the users and developers and will increase the space and innovation attributes in design.

2.5. Integrating Multidisciplinary Teams

Engineering poses a different set of problems when it comes to understanding multidisciplinary teams. One concern is that engineers are usually trained to solve problems that have been given to them and are evaluated on the technical validity of their solution, not the relevance of the problem. This introduces constraints in decision making. Designing a software system by strictly following a set of design requirements does not guarantee a successful product and human users add complexity and unpredictability to the situation and solutions that appear correct on paper may not be valid in practice. In considering the role of multi-disciplinary design teams, it is established that the design of interactive software would require much differentiated knowledge on the application. Software engineering as such is just one of the aspects of knowledge derived, and in fact, different areas such as that of psychology and behavioural analysis are also required (Dabbs et al, 2009). Now in this context, it is necessary to notice the role of multidisciplinary design teams as well. The form of decisive and interactive software applications for which this research is done will be considered from many aspects, such as software engineering, non-technology related aspects and more. So naturally diverse viewpoints are necessary as well here. Diversity as presented here is not that of a clash of cultures but is more of an understanding of how different phenomenon is brought together. In seeking rational explanations, the designers have to understand what form of a concept space exists in the multi-discipline structure. Different people might be familiar with different concept ontologies. To understand how to make a decision that requires some knowledge from each of the ontologies, it would be necessary to have the experts in each of the ontology to come together in a collaborative space (Arango et al, 1991).

Bellotti (2014) argues that for an effective collaboration, a revision of each other's assumptions can be necessary. Here the researchers present the more conventional use of software engineering methods and that of the formal methods. They place the argument that formal methods are only useful if used within a structured development context from the beginning of a project through refinement to implementation (Bellotti, 2014). However, in the design representations, the conventional methods need to be dropped in order to increase complimentary models as well. Task models, UI models and more are usually the solution here. They meet the formal modelling and prototyping requirements and also capture heterogeneous design representations. A goal directed activity hence becomes sufficiently abstract enough to model intangible processes or previously not that identifiable processes. Client programmer relationships and decision-making and hoc nature are captured better here (Bellotti, 2014).

2.6. Complex Challenges

In addition, to the above said issues of multidisciplinary teams, there are issues introduced in the form of indirect system concerns and quality of service as well. The indirect system concerns are issues of system design and implementation and the influence of the system on the organization and the system's influence on the environment (Arango et al, 1991). There are issues of quality of service as well where the closeness of the system to the end-user lends special significance to quality of the service delivered. Quality concerns include those of availability, performance, usability and forms of delivery. The design of interactive software systems is hence a challenge by itself (Buckingham et al, 1997).

User-centred design strategies could be applied. Human-computer interface research generally relates to interactive mode between human and computer, and the layout of computer's information display. It is the medium helping user and computer exchanging information. The subjects of human-computer interaction include computer and computer user. Human-computer interaction research relates to how to design a computer interface that enables users to achieve the highest efficiency and satisfaction when using the system. The most important principle to be conformed to in human-computer interface design is to learn about product user, so that a usable, easy-to-use and favourite product can be provided to users to serve the availability goal, experience goal and life goal of users (Shneiderman, 2010). User model refers to information on users contained in the system, and collection of required user information and hypothesis in the process of the system adapting to users. User model is an important research direction of human-computer interface presently and in the next several years an important theoretical basis of task analysis is in interaction design. User centred design strategy development UCD as discussed by Bannon (1991) states that "What the term user-centred system design means or how it can be achieved is far from clear."

UCD is both a product and a process oriented design. In the context of the product,, the focus is mainly on creation and as such the product design requirements and more becomes the subjective focus. Design requirements in this product oriented UCD is understand based on established design requirements. Unlike the process oriented approach where designers have to consider the entire process of development, the product oriented approach is much simplified.

Human learning, work and communication are some of the core aspects that would be considered in terms of process oriented communication (Bellotti, 2014). The development of product is happening in a time scenario when user needs are changing and this would impose constraints. Change is hence considered as a basic aspect of the process. Plans are considered as the beginning of the process to end product design and not as the end product design static step.

2.7. Formal Methods

The formal methods and specifications are necessary because systems are increasingly dependent on software components and the complexity of systems with embedded software have increased rapidly. Interactive system designs are complex and are software intensive. The challenge of multidiscipline usage and different teams pitching in their ideas at the same time also necessitated that some form of formal method or UCD would be required for sure (Duke, & Harrison, 1994). It will help in maintaining the reliability for the software intensive process of interactive system design, and aids by means of the non-mathematical translation that is possible in the form of diagrams, tables, English text. These are converted into formal specification language. Multidisciplinary teams with different viewpoints are hence incorporated better using these systems and formal methods. Therefore, even if some of the sub teams are focused on creative focuses, others are focused on generic ones. These different focuses are brought together here. Creative aspects and the required functionality are both brought into context here for working towards a similar goal. The requirements of stakeholders are met and in addition the design process is also innovative in order to be futuristic.

In a more formal model driven model, there would have been less flexibility and less direction and support would have been given to the coordination of teams. On the other hand, in the case of the interactive decision support systems, sub-teams, design teams and more are given coordinated support. They are given better interaction design support and this enables them to work on multiple alternatives as such. There are variants in ideas and these variants have to be guided in order for them to become viable implementations. The workplace for interactive space and design has to support this and this becomes possible here. Therefore, formal refinement can be done. Idea generation, convergence and different design spaces are merged in order to enhance the understanding of how and why human decisions are made in the interactive paradigm (Dittmar, & Piehler, 2013). More than ever, user design support is extended to the design makers here.

2.8. Significance and Summary of Background Research

Interaction design focusses on learning the user's psychology and behaviour, and to determine the requirement of product and the expectations of the target user group. By analysing the user behaviour when using product, it builds a bridge of communication between users and systems to make the product easy to use, efficient, and enjoyable. From a developer's perspective, user interaction design is for developers to express the functions of the product quickly and accurately through the design of the interface. User interaction design is a part of software engineering. When it comes to engineering, the concept of agile and iterative update is very important, because it can not only guarantee the validity of the software interaction design, and meet the rapid development requirement. In the current thesis work, the focus is on understanding interactive design spaces and the literature review supports the need to explore interactive design spaces. Where the process of development has to be dynamic as discussions on UCD suggest, it is critical to understand decisions making in that dynamic interactive space.

Chapter 3: Case Studies

The purpose of conducting the case studies was to check for whether the design process decision making was being done in a traditional linear path or if decision making was being done in a more interactive design space and to identify if there are other newer factors other than the ones in the identified design space that could be used in Bowen & Dittmar (2016). Interactive design spaces are not always used and more literature evidence focuses on a focal point of decision making. Traditional problem solving and decision spaces are usually unchangeable, they are fixed structures and might not take into consideration the cognitive aspects of a decision maker to make improvements as development happen. The psychological stage of the decision maker and other dynamics would not be considered. This can be considered as opposite to what is proposed by Larbani & Lu (2014) as the optimizable decision space OCS. OCS is the design space in which there are optimizable components; optimizable components are those that are part of the decision framework that could be tweaked or adjusted for parameters. Competent, innovative or creative decision making is needed for solving some challenging problems and researchers claim that it is impossible to solve using traditional decision making spaces (Larbani & Lu, 2014).

Two different case studies were conducted to identify if there were common variables across the two different design processes and check if the interactive design space situation is applicable across both. The data gathered from each and a comparison between the two could help identify more data for future studies.

The case studies that were conducted focused on tracking of the design process by direct observation of the design teamwork and by collection of design artefacts. The motivation for the study was to understand first-hand what sort of decision making and tracking methods are used in projects. The first case study was conducted with a project in a commercial web development company (Digital Stream) with experienced manager, designers and developers. The case study in Digital Stream was a project which involved updating the old website for Auckland Eye Ltd. The time limit for the project was 6 months. A project manager, a data analyser, a designer, two developers, a content manager and clients were involved in this project. The project manager and clients worked in Auckland while other people worked in Hamilton. The main method for them to communicate with each other was by means of email and online meetings. Except for project managers, the people who worked in the Hamilton office would also have face to face meetings in the conference room.

The second case study was conducted as an experiment at the University of Waikato. It was conducted with several students who were all above third year, majoring in computer science or graphic design. The study was supported by note taking during in the design process and decision making stages. The participant/observer model was used for the study methodology.

Ethical consent for both studies was granted by the university of Waikato ethics committee in March 2016. (See Appendix A)

Methodology of the Study

A qualitative research methodology and analysis was used for the study. The study was conducted as a direct observation of different meetings in both case studies. There are different forms of qualitative data collection methods and this research made use of the observation method as it helped collect data on the actual happenings in the decision space.

Observation was conducted by working closely with the two teams. The meetings were identified as the core points as these were when the final decisions were taken. Decision artefacts were collected which were the final output points of these meetings. The minutes of the meeting were then collected, and also data was collected by audio transcripts.

The study was conducted over two weeks. Each of the meetings were observed for approximately a time period of two weeks and there were at the least a total of four participants for each individual meet.

3.1. Details of the studies

3.1.1. Case Study 1: Company

The design process included:

- Investigation of the industry
- Building of the site map
- The creation of the wireframe and prototype

The Industry investigation was conducted by the data analyser. There was a pre-designed investigating report template in Digital Stream stored on line. The data analyser filled out the report template and it was then presented to the project manager for review. They use email and on line meeting method for discussions and feedback. The design artefacts of this process were:

- A report prepared on the recommendations to be included in the next phase of the project.
- Google analytics review which was conducted and a report prepared on the same.

The project manager then arranged a meeting with the client who was in charge of Auckland Eye Ltd projects. A meeting was conducted in the Digital Stream Auckland office. During the meeting, the project manager showed the client the investigation report and discussed what they could carry out as improvements on the old site. Based on the client's feedback, the project manager then created a new site map with online mind map tool which allowed for tracking of changes to the site map. Then the project manager exported the sitemap into pdf and this was sent to the client by email. Final sitemap was approved. The design artefacts in this process were:

- Old sitemap and content was reviewed, planning for new content.
- New sitemap was created and approved.

After the new sitemap was approved, the project manager then emailed the web designer about the new sitemap along with a brief of the design. The brief related elements are that of the main colour, standout functions, related websites, the main layout of the homepage, etc. Each of the details was discussed in online meetings. With the online meeting tool, sketches were drawn in order to enable better understanding and the sketches also form part of the design artefact set. The meeting ended after the designer had no more questions. The designer was given the option to call the project manager or email the project manager in case he had further questions. Designer designed the wireframe with Photoshop as the next step and this was sent to project manager for approval. Only after the project manager approval, the wire frame was sent to the client. Client feedback was critical here. The client approved the wireframe and the designer created the prototype. Photoshop was used for the creation of the prototype. For the prototype, 2 or 3 options for each page were created based on project manager's idea. Similar to wireframe process, after the project manager reviewed the prototype, it was shown to the client who chose from the different options. The design artefacts comprised of the following,

- Design meeting was conducted.
- Wireframe was created and approved.

- Prototype was created and approved.

Constraints found in the project:

The constraints on the project are those elements that have an impact on the overall decision making. These are different factors such as time, cost, the human resources involved, their skills etc.

- Constraints of Time and Budget

Time constraints were observed here. In Digital Stream, the project manager had hoped that the projects could be closed as soon as possible. Therefore, no suggestions were made towards adding some functions that are good for the project because they could have been time consuming. Also budget constraints existed.

- Technological Constraints

Technological constraints are the constraints that the company faces with respect to possessing the required technology for completing a project. Companies must not accept projects that their technologies are not able to support. When their technology falls short in terms of some function, they can't achieve the function. For this project, some main constraints that existed were that of the interoperability and interpretability of existing systems, targeted deployment platforms, lack of supplier relationship and communication management software and internal intellectual properties. Interpretabilities of the existing systems limited the protocols and technologies that could be used for the project. Targeted deployment platform also limited efficiency of completion. There were some internal intellectual properties issues since Digital Stream wished to use their own developed system.

- Organizational Constraints

Sometimes, organizational politics may prevent an organization from achieving efficient project completion. In digital stream, the data analyser, developer and designer always agreed with the project manager in major decision making because of organization culture they were used to. Similarly, project managers also did not negotiate with the client properly. These were some issues observed, that could be categorized as organizational constraints. These constraints limited the time taken towards concluding on a decision in a meet.

3.1.2. Case Study 2: University

The case study at the university was an artificial design project created for a group of students. They were asked to design a mobile application to save battery life on mobile devices. The time was quite limited for this project since there were only 4 meetings of an hour's length each. The participants in this project were all students with no commercial experience. Two of them had computer science experience and the other two had a graphic design background. However, they didn't know each other before and their roles for the observed project were not as clear as the first case study.

They brainstormed their ideas and noted them down on written papers. Every participant had several papers for the design process and they also made use of their mobile phones to search for online resources and help. The location for those meetings was in the lab room of the Waikato University. The design process for this project included:

- Investigation of the related project
- Identification of the features and functions
- Sketches of the homepage were drawn
- Prototypes were drawn

Associated projects were first investigated. It was observed that even after reading the project brief, the participants were still confused on what had to be done. They searched some battery saving apps on their own mobiles and looked at the most popular apps that were created by other companies. Useful features from these apps were then noted down. Different comments were made on the features and a brainstorming session was conducted in order to identify three personas and three scenarios. The output artefacts identified were:

- Related project review report written up like a literature review but with more specific details
- 3 personas and 3 scenarios were created.

In the second meeting, they primarily reviewed the personas and scenarios they had created in the first meeting and then brainstormed the features. These are features for all people and they are ordered by priority for the user groups. The lists were discussed and then priority was reordered at the end of discussion. High level features and low level features were prepared and list was finally approved with some changes by all members of the team. The artefacts in this meeting were:

- Project session records of session 1 after the review.
- Priorities of the different features that were analysed.
- A list based on features and their agreed upon priorities which were drawn.

The third meeting was held in the second week. By now the members had ideated on the design process. They brought individual sketches to the meeting that they had prepared over the weekend. It was observed that the students who have graphic design background drew much faster and better than the ones who did not. Team members drew the sketches and presented at the same time. The sketches were then analysed and based on analysis; a list of the desired elements from each of the sketch was identified. One of the sketches was used as a base sketch. Secondly, a list of redundant elements in the system design was identified and these were eliminated. The artefacts that were generated in this meeting were:

- Individual sketches drawn and reviewed.
- A list of the desired elements from each of the sketches was identified and a report was generated
- A list of redundant elements in the system design were identified and these were eliminated in the final sketch

In the last meeting, the aim was to come up with a final design. The desired elements were reviewed and then the layout was created. It was observed that one of the students was designated for drawing the design and the others gave suggestions and comments. Ideally, the students wanted all the desired elements to show up on the homepage but this would have resulted in a cluttered look. At this point, the team mates also reviewed related apps and websites and based on different designs, managed to create their final design. The artefacts of the final meeting were:

- A review list of the desired elements
- The final design creation with related projects and desired elements.

3.2 Constraints found in the project

- Constraints of Time

For this project, time was extremely limited. They only had 4 hours in total to finish the design. In this case, the design process was compromised. In the end, they had to use related projects as reference to finish their design.

- Personnel Constraints

The team in the project is all students without commercial experience. They did not have all the skills needed for the project. Besides, there are only 4 students participating. Therefore, they couldn't take everything into consideration for this project.

Chapter 4: Analysis of Results

4.1. Case Study 1: Company

Artefacts

Key artefacts collected in the data analysis process were the report that was prepared in the investigation in order to present the recommendations for the next build, and the Google analytics review report. Key artefacts that were collected in the meeting between client and project manager were the review report created by comparing old site map and content with the plans for the new content. A newer sitemap was later created and then approved. Key artefacts created in the design meeting were the wireframes with photo shop and the prototype design.

Discussions and Stakeholders

Three main discussion meetings were conducted as part of the first phase of the project. The first was an investigation of the industry; the second was the building of the site map and finally a wireframe and prototype was created. In the first discussion, the project manager, the clients and the people who worked at the Hamilton office were involved. In the second discussion, the project manager and the clients were involved, and in the third discussion meet, the project manager, the web designer and the clients were involved

		Wireframe
	Review Report, New Site Map	
Google Analytics Review Report		
Old Site Map	New Site Map	New Site Map
Meeting 1	**Meeting 2**	**Meeting 3**
Project Manager, Clients, Analyst	*Project Manager, Clients*	*Project Manager, Web Designer, Client*

Figure 5: Timeline for Case Study 1

Decisions

Based on the review report, the main decision to go ahead with the site map change was at first approved. Based on the comparison of the old site map content and the new requirements as understood from site investigation, the decisions to authorize a new site map were taken and a new site map was created. Finally, the wireframe and the prototype was created and approved.

4.2. Case Study 2: University

Artefacts

Key artefacts in the investigation of the existing projects resulted in the creation of the personas report and scenarios report. The artefacts in the second meeting were reports created based on feature analysis. List of features and the agreed upon priorities were then drawn. In the third meeting, the key artefacts are the primary sketches, and then the final sketch in which redundant elements were identified and eliminated. Key artefacts in the final meeting are the final design report, along with a detailed listing of the project and the desired elements.

Discussions

Primarily, discussion proceeded in four stages of meetings. In the first meeting, an investigation into related projects was conducted. The second meeting was feature and function analysis. Discussions revolved around sketches, redundant elements and more. In the third meeting, a final sketch of homepage and in the final meeting a prototype was drawn.

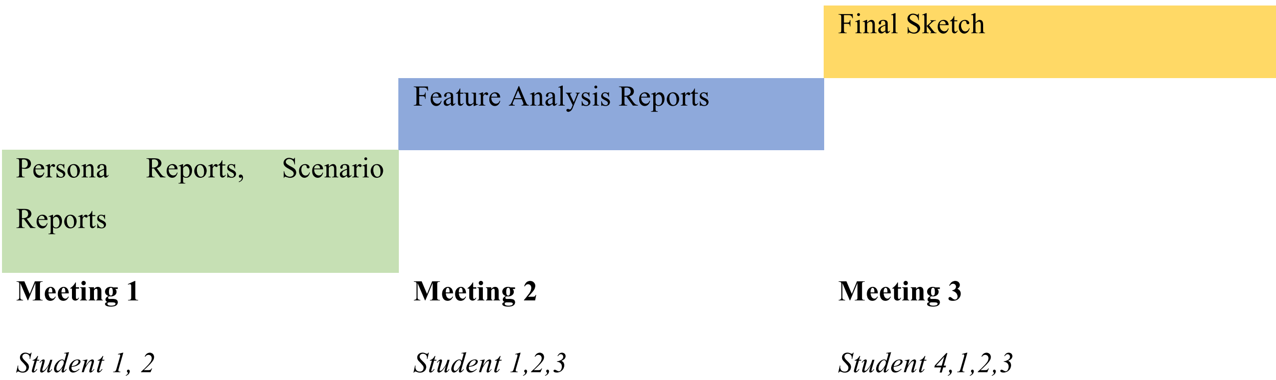

Figure 6: Timeline for Case Study 2

Decisions

Of the many different personas and scenarios, the most relevant ones as applicable for the context is chosen. Based on sketches, a priority list is chosen. A final design was then decided upon.

4.3. Discussion

In 'A Semi-Formal Framework for Describing Interaction Design Spaces' a conceptual level framework for defining how interactive design spaces work is presented (Bowen & Dittmar, 2016). The argument made in this research work is that such a process could also be supported formally. Now in the case of both case studies, an iterative process is being followed, in fact in both case studies it is noticed there are meetings concluded at every level of design decision process. All stakeholder involvement is present, and this is technically a software iterative design space. Only when a newer decision is being taken, then there is a process movement towards holding of a meeting.

So for every key process, in either of the case studies, we would search for whether a process has been done multiple times. However, this is not the situation in the case studies. An alternative definition of iteration is the one where the definition of iteration is understood as a form of planning and development process where iteration delivers unique models or end products which are used for determining the next step of development. This is the situation used in the given case studies. In both the case studies, the iterative process is planned heuristically. The solution is planned in small sections, and each and every section is reviewed. Artefacts such as data reports and design documents are developed for both university and the company case scenario. All forms of decisions are jotted down along with the priority listings and more. As Dabbs et al. (2009) argues the user interactions centre on these different iterations and a definitive iterative process and an interactive space is created. Where traditional work projects missed out on these interactive spaces, it is seen that both the projects considered have made use of them in a functional way. Integration has happened at every key phase.

In case study 1, the key iterative points as identified for three different phases are that of the investigation of the industry, the building of the site map and the creation of the wireframe and the prototype. In case study 2, at the end of outcomes and artefacts for the next iteration or next development of the project was decided, the design process phases are the preliminary literature review where similar related projects were analysed, the identification of features and functions, the drawing of home page sketches, and the prototype development. In iterative development, usually there is a check done every time to ensure all the iterations are backward compatible. However, this is missing. Backwards compatibility is necessary to ensure that every new development is compatible.

In the case of (Bowen & Dittmar, 2016), the interactive design space presented is different from the funnel model of Laseau.

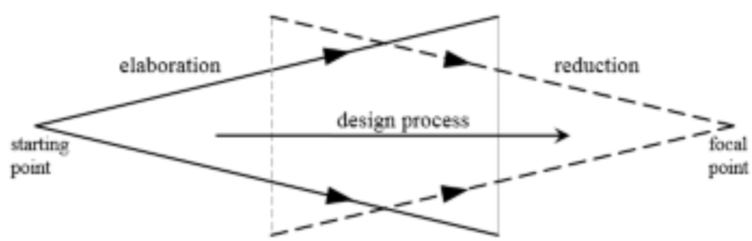

Figure 7: Laseau's Overlapping Funnels

from B.Buxton 2007, Sketching User Experiences, Morgan Kaufmann. Reprinted with permission.

Laseau's overlapping funnels moves from concept generation to concept convergence. As the concept is being built, there is less level of granularity in the design which means that although there is a design space to start out with, the design space converges and one final solution is what one would be focused on. Now consider the funnel aspect in both the case studies. In case study 1, the starting point is the investigation of industry and from herein, the process moves towards the building of the site map and then the wireframe. In the preliminary decision making in the first phase/iteration, they have reviewed associated projects and created analysing result sheet.

The user goal motivations and the form of interaction were considered here. On the other hand, personas are considered as an inventive person that is used to understand how effective a choice on use scenario is. In the case of the personas and scenarios they are once again brought into the interactive design space for discussion. It is not accepted as a given, but instead time between meetings has been used to understand if the designers have come up with something new and slowly the design process moves on to a focal point. Similarly, in case study 1, the beginning is the research review and then a slow progress towards the prototype creation which is the final end point.

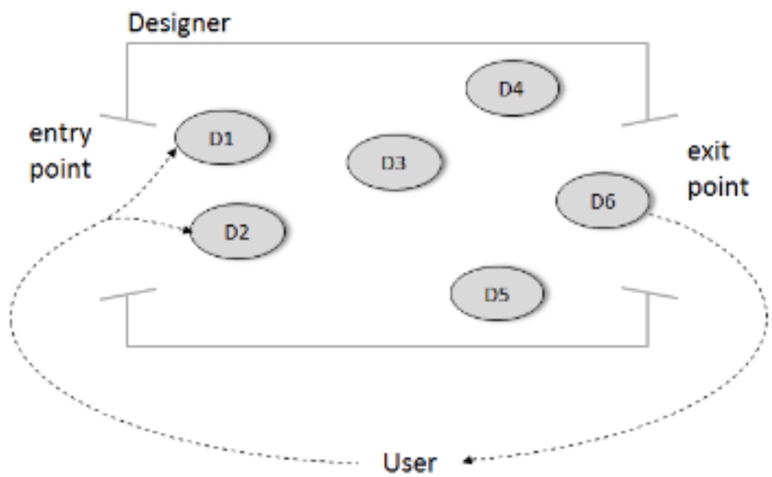

Figure 8: Decision Making Points

Source: Bowen, J. & Dittmar, A. (2016). A Semi-Formal Framework for Describing Interaction Design Spaces, EICS '16, Brussels, Belgium. Reprinted with permission.

Here in the above diagram, D1, D2, etc. are the decision making points in the interactive decision space and as such can be considered as those points where the actors of the space come together for formulating a decision or path for the project to follow. There are two ways to understand how decision making navigation happens through this diagram. 1) The constraints influence the decision making process and based on the constraints the decisions can be understood. 2) Based on the required result the best choices are backtracked through the model system. Now consider the first part where D1, D2 and D3 are understood as constraints. Now in the first case study, design meetings, wireframe meetings and prototype meetings were conducted. In the case of the design meeting, D1 could be the time constraint that a design has to be approved by end of the meeting. D2 could be the constraint that such a design can be implemented with existing software. D3 could be a constraint of behaviour where the manager decision is never critiqued or discussed. The design space hence becomes a complex design space.

Some of the elements of decision making are explicit, such as voting for or against a design. However some elements of the design spaces are not explicit, such as whether the developers in the meeting had the confidence to speak against a manager's decision or recommendation. The form of influences on decisions can hence be categorized into many forms. In our case study we presented the constraints of technology, constraints of organization and the traditional cost and time constraints. In the second case study, during the project session records of session 1 after the review, the determination of priorities of the different features was analysed. When creating the list based on features and their agreed upon priorities, constraints might be introduced. For instance, when deciding upon priorities, some might have to be high priority because a resource is available only for a short span of time. Therefore, the resource becomes a constraint. The resource could be software or could be a developer hired based on number of hours.

In the second context, decision making would be based on the end result or artefact required which could be fixed. This is also a form of constraint. Now in the case of the first case study, D1 could be assumed to be the decision points involved in the investigation of the industry and to produce the relevant artefact on the design process so as to move to D2. D2 is the process of building site map and D3 is the decisions involved in fulfilling the processes of creation of wireframe or prototype. In the second case study, with respect to the decision processes, D1 could be considered as the decisions involved in the investigation of the related project. D2 is the identification of the features and functions. D3 is the decisions involved in the sketches of the homepage being drawn and D4 is the decisions involved in the making of the prototypes.

Now the design space framework that has been presented in (Bowen & Dittmar, 2016) work is one where there is an entry point on the left and there is an exit point on the right in the decision making process. There are multiple decisions points in the decision space. Similar to the Funnel aspect, there is an entry and an exit point, but the design space movement can be from left to right or from right to left or any other movement. It need not be a linear line drawn from entry to exit. As observed in the case studies, at every point of discussion there is a divergence from the straight line path as the stakeholders would also discuss what they have done prior to the meeting. The designed in the case study looked like they had a final objective in mind. There was some amount of flexibility present in how they went back to redo lists, such as the priority feature lists in case study 2 for the University.

Summary: The case studies were used to investigate how interactive design space is being used in decision making for projects both actual real-world projects and in a constructed experiment which was the objective. The team in both case studies seemed to know the solution they were looking for, and were not throwing multiple design decisions into the space, but were quite flexible. However, there is room for improvement. Now although they allowed for multidisciplinary team interaction with different team members, and their different viewpoints, some of the more creative aspects and their influence would be degraded here. They worked on the same goal and yet as presented in design literature, their design space is not black and white. They don't work with a funnel aspect, but they are not completely interactive spaces either. It could be possible that in real world the design spaces are merged, as in end to end decision making as in the case of the funnel, and the completely interactive space could overlap. So based on real world practice observation, the framework might need to consider overlapping concept spaces or subspaces.

4.4. Reflection on the framework

In any interactive state design, it is possible to understand discrete elements properly only if these elements are considered within the context of a formalized framework. In the case of the decision elements, it is necessary to conceptualize them as a framework and understand their working better. The design space with respect to interactions is a very complex framework as such and hence understanding it by breaking them down into structured entities with a defined entry point and an exit point enabled us to learn more on what could be improved.

Existing research studies on the formalizing aspects of the design space are considered. Most of the existing studies with respect to the formalizing aspects drawn from the Laseau's model and some of them were variants of the model. In this research as well, a slight variation of the model was considered for whether it would be helpful in the overall decision making improvement process. The variation that was considered was checking for whether the model has to indeed work from concept generation to concept convergence only. Laseau's model is one that works on the process of formalization and in its formal space it considers the interactive decision making process as walking from the generation end to convergence end in such a way that multiple decision processes combine to deliver the end idea or decision choice. If the decision space was to be considered as a non-convergent one, meaning that at all points of decision making multiple processes and aspects are still considered, then it would be possible to account for all impacting factors in the real world. The real world decision space needs not be a convergent one; there are many aspects that are different, from people to ideas, departments, resources available etc. Therefore, there would be many factors of influence at all points with even little convergence when a decision is made and it is only fair to give all these factors some representation in formalisation. The alternative design space is hence a variant of the existing one, but refines in terms of considering the decision space as an expansive one.

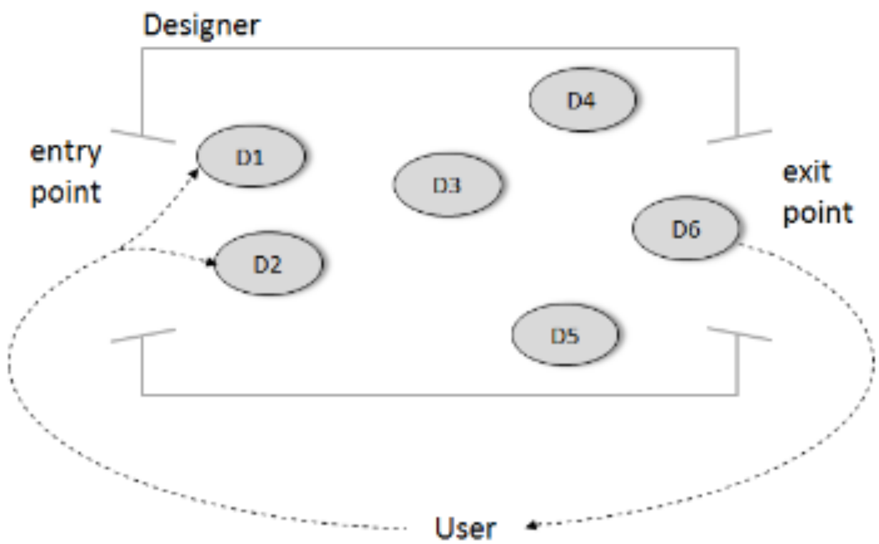

Figure 9: Constraints and Decision in Concept Space

from Bowen, J. & Dittmar, A. (2016). A Semi-Formal Framework for Describing Interaction Design Spaces, EICS '16, Brussels, Belgium. Reprinted with permission.

Constraints and decisions identified by means of case study could be understood in the decision space presented above. For example, consider the following

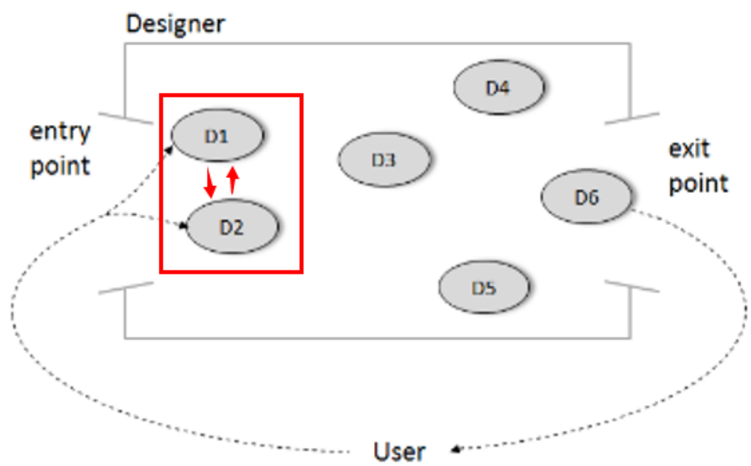

Figure 10: Constraints and Decisions

D1, D2 which are decision points could be understood as being sub-decision points within a larger decision framework. They could also be described by a decision making process such as QOC (Question, Option, Criteria) (Allan, Richard, Victoria, Thomas, 1991). The arrows could reflect their dependency. This is an alternative view of the framework. QOC notations have Questions identifying key design issues, Options providing possible answers to the Questions, and Criteria for assessing and comparing the Options. In the alternative way to envision this, D1 through D6, from entry point to the exit point is understood as a series of question, option and criteria influencing option selection clusters. For instance, in case study 1, the first design process was the investigation of the industry. Thus any series of decisions that take place when investigating the industry could fall as points D1 through D6 in the interactive design space. Here D1 could be a question, D2 could be the set of criteria and D4, 5, 6, could be options. It could also be possible to understand D1 as by itself being a set containing 1 question, multiple options and criteria and only when D1 is solved, D 2 or D3 could be reached. However, this second form of design once again imposes direction to decision making and hence the former is better to use for improving existing framework.

In envisioning constraints in the decision space, if D1 is the question, then D2, and D3 could be considered as explicit constraints which are constraints that are defined and accepted in the environment. However, there could also be some implicit constraints that are not defined verbally but are understood to be part of the decision making space. Some examples of this could be that decision making as an activity might not go on for more than 8 hours-average working time of the human resource involved in the space, etc.

In the first case study, the design process included the 1) investigation of the industry, 2) the building of the site map, 3) the creation of wireframe and prototype. Now if the point D1 is the decision point for creation of wireframe, D2 are the implicit constraints as was identified in the investigation of industry, D3 was client feedback, D4 was designer level constraints, etc., and then it could be said that smaller subspaces can be identified in the larger decision space. Smaller subspaces within the design space, such as D1 and D2 are more closely linked. D1 and D2 are linked because they are they are the design and concept limitations, D3 and D4 might be grouped with D1 and D2 in a second level subspace because they involve the human level design constraints. Similarly, several more subsequent levels or subspaces in the interactive design space that either overlap or are “contained by” can be identified. Each of the subspace includes smaller subspaces and are themselves a part of a larger subspace. The below is more of a hierarchical gradation, subspaces however need not have a hierarchical gradation, they could also overlap.

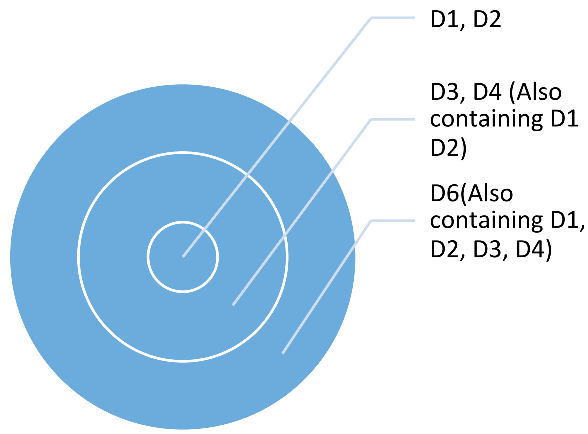

Figure 11: Overlapping Subspaces

D6 contains all sub design constraints D1 – D5

From the above, D1 and D2 are of the same category meaning they are concept level constraints, of the same genre. Similarly, D3 and D4 can be linked as being human resource level constraints. D3 and D4 can be said to contain concept level constraints because human resources would also be impacted by D1 and D2, so now a bigger subspace grows, from only D1 and D2, the subspace enlarges to include D1, D2, D3 and D4.

In the semi-formal description of the design space framework, in the definition list, user designer relationships are discussed, alternatives and variants are discussed as well. In relating designs and more, sub spaces are identified as well.

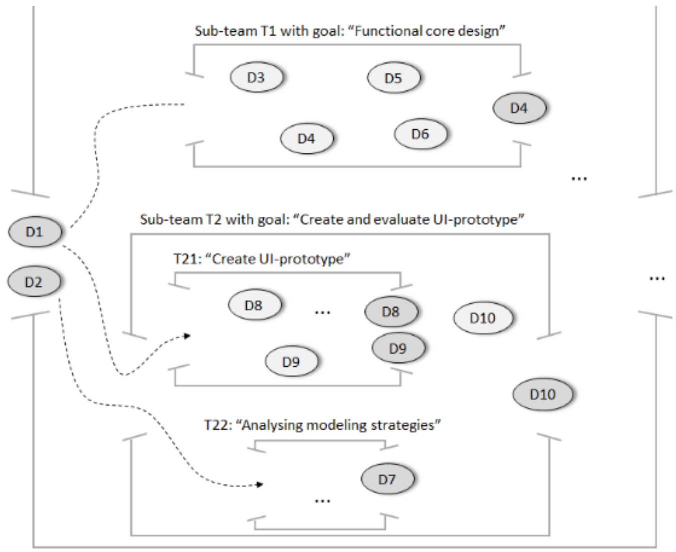

Figure 12: Design and Subspaces in the design space Framework

Source: Bowen, J. & Dittmar, A. (2016). A Semi-Formal Framework for Describing Interaction Design Spaces, EICS '16, Brussels, Belgium. Reprinted with permission.

However, in these diagrams, the design subspaces are identified with proper exit and entry points, similar to the hierarchical gradation as presented above. An analysis of case studies points out that the gradations (entry and exit) need not be hierarchical. For instance, we have assumed D1, D2 links as concept level links, and D3 and D4 as human constraints and imitations. Now based on ownership, D1 and D3 can be linked, because it is the client who owns the design of wireframe D1. So having a rigid entry and exit point might challenge the very nature of interactive design spaces and their real time representations. However, not having a final exit point or stopping point might also not be requirement. In final design artefacts, if a decision making towards better improvement goes and on, there must be some way to identify a stopping point. Now in the case of the two design teams, the meetings in which the decisions on design took place were time constrained, so naturally end of meeting a stopping point was acknowledged. Stopping point hence cannot be generally defined, it has to be defined based on the context.

The Framework with the new elements helps the design decision teams, 1) Identify sub spaces for the design teams. The concept of sub spaces, and relationships, and gradations introduces a level of complexity in decision-making which would make the teams more aware of how small level choices could have an impact on the larger decision making. 2) The framework helps the design teams envision design decision making as a more solid process rather than viewing it as an abstract or ad-hoc process.

Chapter 5: Conclusion

Recording and tracking design decisions does play an important role in system development. Design has to be interactive given that the number of stakeholders involved in the system design are high based on complexity. Different stakeholders have brought different forms of perspectives to the decision making and it is recommended to incorporate their viewpoints and perspectives as well. A recording and decision tracking system that is more than the formal framework in decision making would be of much support. Given the above context, this project has analysed the form of design decision making that is present in the design space. Design spaces with formal notations are understood in context here. The project aim was to study two case studies in which project design decision making occurs. Based on observation of the two projects, an understanding of interactive decision space is arrived at. In specific the project considered the effects of individual versus team design, the way decisions are made and recorded, the form of subspaces involved in decision making and the usefulness of these forms in current work projects.

The design process as presented in literature reviews was first discussed. Literature evidence highlights the significance of understanding human computer interactions in design and decision spaces. Human computer interactions in decision spaces have a long history. The static and dynamic nature of interactive designs are argued as a necessity given that user requirements change as the design process progresses. The need to understand multidisciplinary teams is also one of the core concerns here for researchers. Design processes, such as UCD, formal design notations and more serve to give a detailed background for interactive decisions understanding. In literature, the design process is presented through models and frameworks such as that of the User Centred design UCD, the formal methods, behavioural models etc. The use of these models and frameworks present ways for critical reasoning about the interactive decision making. For instance, consider the UCD style of decision making presented in the literature review. The definition of users, their life goals, their experience goals and their usability goals are brought into context. In decision modelling, each of these goals will lead to a comprehensive evaluation of the next step possible as a design solution step. User metal model, the implementation model and the represented model are some of the other models that are human centric in decision making. The need to understand decision spaces in the Human Computer Interactive HCI space is a main point specified across all discussions on interactive decision making.

To understand and analyse the use of design in the real world, two different case studies were conducted. They served to identify if there were common variables across the two different design processes and check if the interactive design space situation is applicable across both. The data gathered from each and a comparison between the two could help identify more data for future studies. The case studies were selected here that focused on design process and decision tracking understanding of two real time projects. The first study was the decision space of a real web development company and the second was a University style project. Both cases studies followed the norms of ethical research with observational methods being used. For both the case studies, the decision points were identified which were formal meetings.

Design artefacts are finalized here in these meetings and these are considered as different phases in the formation of the final system. Constraints within the project such as constraints based on cost, time and man power were identified and discussed. Each of them have a unique influence in the decision space. Qualitative research methodology was conducted here. At the end of each of the meetings, decisions were taken and some specific artefact was concluded on either as design reports or moments of meeting and this was considered as the end in data collection. Observational analysis is both a strength and limitation in this research. These limitations however are not the constraints identified within the case studies, they pertain to the methodology used and not the interactive decision space analysis.

The use of the decision framework combined with collecting direct observations presents itself into different ways that theory can be applied in practice. Understanding the working of the funnel framework and then observing the actual mechanics of such an action is interesting. There was some key learning that were possible from the work such as the formalizing aspects of the design space and these are discussed in analysis and reflection sections. The conceptual design framework and its subspaces can be developed in more intricate details as in hierarchies and gradations based on the discussions.

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THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

12 May 2016

Cassie Yang
C/- Department of Computer Science
THE UNIVERSITY OF WAIKATO

Dear Cassie

Application for approval under the Ethical Conduct in Human Research and Related Activities Regulations

I have considered your application to conduct a research project involving human participants entitled "Recording and Tracking Design Decisions in Interative System Development" to be conducted at the University with students/guests/visitors or lecturers. The purpose is to understand the impact of decisions and how well they support the given criteria.

The procedure described in your request is acceptable. I note that you state participants involved in the study will not be identified in any resulting publications. At the conclusion of the project the recordings will be submitted to the FCMS Data Archive repository for five years.

The Participant Information Sheet, Consent Form and Design Worksheet comply with the requirements of the University's Human Research Ethics policies and procedures.

I therefore approve your application to perform the research project.

Yours sincerely

Mark Apperley
Human Research Ethics Committee
Faculty of Computing and Mathematical Sciences