DACADE: A systematic data collection and analysis tool for design students

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Abstract

Creating a successful product is a goal of every designer. To do so, it is important for a designer to understand consumers’ perceptions of a product early in the design process. One way to do this is by collecting data systematically from consumers representing the target audience and then to analyze those data statistically. Norman has claimed that design students lack the skills and knowledge of data collection, user testing and data analysis to support design solutions in the product design and development process. Consequently, their products might not be acceptable to the intended consumers and thus result in a failure in the marketplace. Norman, however, cites no empirical evidence in support of his claim. This study therefore took up the challenge of producing such evidence. Via a comprehensive archival search, it first scrutinized university design curricula to establish if design students are actually taught data collection and analysis methods. This was followed by a survey and a series of interviews with design students and lecturers. The results supported Norman’s claim, suggesting that there is a need to overcome this deficit. Further investigations were then carried out into existing tools supporting the running of user tests. These revealed that no suitable tool existed. It was therefore decided to develop a simple software tool, DACADE, to help design students gather consumer opinions and run simple data analyses. Paper prototypes of DACADE were prepared and evaluated in two formative usability tests to ensure that DACADE would not contain any usability flaws. Based on the results in the first usability test, a tutorial was added and tested in the second usability test to aid design students’ DACADE usage. Upon implementation, a User Acceptance Test was conducted to determine the level of user satisfaction, perceived usability and aesthetic appeal of DACADE among design students. Given design students’ sensitivity to aesthetics, that measure was considered especially important. Results indicated that, despite the presence of the tutorial, the design students tested were still unable to grasp the necessary understanding and acquire the essential skill of collecting and analyzing data systematically. The general discussion addresses several theoretical implications concerning the transfer of learning, the appropriateness of graphics used in a software tool, and user motivation in a learning environment. It also proposed future studies. It provides strong empirical support for Norman’s provocative claim.
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Publications associated with this research


Declaration by Candidate

This thesis contains no material which has been accepted for award of any other degree or diploma, except where due reference is made in the text of the thesis.

To the best of the candidate’s knowledge, this thesis contains no material previous published or written by another person, except where due reference is made in the text of the thesis.

Signed:

Date:
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Phase I – Exploration

**Chapter 1:** Introduction

**Chapter 2:** Theoretical Frameworks
Chapter 1: Introduction

Designing a successful product has always been a dream of every designer. In order to be successful, as well as focusing on the objective requirements of a product, a designer should also consider consumers’ subjective requirements (Poirson, Petiot, & Richard, 2010). It is also important for a designer to understand consumers’ perception of a product early in the design process. This has increasingly been recognised as a serious concern for design students and novice designers who need to compete in the 21st Century and become successful designers. One way for designers to ensure that consumers’ perceptions and ideas are taken into account is to gather data from the target audiences of their proposed products and then to analyse those data statistically. It has been claimed that designers lack knowledge of the importance of data collection and user testing to support design decision-making as well as the skills to collect data and conduct user tests (Norman, 2010). He said:

“Design needs to develop its own experimental methods. They should be simple and quick, looking for large phenomena and conditions that are 'good enough'. But they must still be sensitive to statistical variability and experimental biases. These methods do not exist: we need some sympathetic statisticians to work with designers to develop these new, appropriate methods” (p. 4).

In that opinion column, Norman emphasized the importance of empirical methods specifically for a design student to support his or her product design decision-making for successful product development (Norman, 2010). His major criticism was that design curricula are not balanced between the hard sciences and the social sciences. In particular, he believed that design students need mathematical and statistical knowledge to judge if the products they design will be successful. This requires students to understand how to gather empirical data from potential users, how to analyze these data statistically and how to interpret the analysis outcomes. By the same token, Norman also highlighted the fact that designers with engineering backgrounds acquire knowledge of the mathematical sciences but leave the soft sciences untouched. As a result, such designers spend considerable time developing products but disregard
important social and behavioural factors. Consequently, their products might not
always be acceptable to their intended users, which will lead to a failure in the market
place.

Experienced designers do sketching and drawing while interacting with clients
in order to reach to the best product design solution (Cross, 2001). Although this may be
ture for expert designers, there are limits to how far the idea of sketching and drawing
can be used to gather data, especially for novices who may lack the skills and
experience to communicate effectively with consumers. Further, the process of
sketching and drawing is insufficient as a basis for sound decisions with no input from
consumers.

Hasdoğan (1996) claimed that most designers tend to rely on their idiosyncratic
understanding of user needs and preferences based on everyday activities and
exchanging ideas among themselves due, in part, to the lack of reliable tools and
sources. This was supported by Frascara (2003) who found that product designs were
based on designers’ perceptions, intuition and experience with no involvement of users.
He argued that one possible reason of this situation is that since the Bauhaus emerged as
one of the oldest design schools in Germany, design curricula have tended to disregard
courses that incorporate user preferences, views and needs that enable a design student
to involve consumers in the product design process. Design students are taught to
believe in their own intuition and creativity (Taffe, 2012). Consequently, designers often
rely heavily on personal preferences, tending to understand the term ‘research’ as
simply being the gathering of archival information from the library or from the Internet
instead of running user tests with consumers to inform design decision (Dickinson,
Marsden, & Read, 2007; Frascara, 2007; Dickinson, Anthony, & Marsden, 2009).
However, to date, no reliable evidence has been produced about the relevant knowledge
among design students. This is the main aim of this thesis.

This research provides an exciting opportunity to investigate design students’
understanding of empirical methods and user testing in product design and to contribute
to improving such knowledge. Thus, this thesis provides empirical evidence of the state
of design students’ relevant knowledge, as well as intending to encourage them to
embrace the power of empirical research for supporting design decision-making.
In the light of this discussion, the degree to which the claims hold among designers pertaining to a lack of knowledge about data collection and analysis in Australia was unknown, as there was no empirical evidence to support or refute it in the literature. The purpose of this research was therefore firstly to investigate the degree to which this claim remains valid, concerning design students’ knowledge of systematic data collection, statistical analysis methods, and user testing. The second objective was to find a remedy to help design students acquire the knowledge necessary to test their evolving designs in a systematic manner.

The data presented in this thesis were drawn from several sources. First, the design curricula offered in Australian universities were scrutinized, followed by a series of interviews with design students and lecturers. The existence of support tools developed specifically for design students was then investigated. It led to the design, development, and implementation of a new tool.

This thesis is composed of three phases, of which Chapters 1 and 2 form Phase 1 (Exploration). The next chapter presents a review of the literature on theoretical frameworks necessary to guide this research. Phase 2 (Modelling) begins with Chapter 3, in which courses offered in Australian universities’ design curricula are scrutinized to learn if these include courses on systematic data collection methods, user testing and statistical analyses. The necessary data collection process is presented in three stages: a comprehensive archival search, a survey, and a series of interviews with design students and lecturers.

Chapter 4 completes Phase 2, presenting a review of existing visual software tools that might support teaching and assisting design students to understand the concepts of user testing and analysis of consumer data. Each tool is reviewed with a focus on visual techniques for user input and system output as well as outlining its advantages and disadvantages.

Phase 3 (Design and Evaluation) begins with Chapter 5, which reviews possible data-collection and analysis techniques appropriate for design students. It specifically covers techniques that might be appropriate for assisting design students to design and run user-based tests and interpret data. As this research showed that no such tool exists, it was decided to produce a new tool providing those capabilities.
Chapter 6 covers a critical review of relevant theoretical models related to human memory to guide the development of the new software tool. This required an additional review of theoretical models to guide the design and development of a new software tool. Chapter 7 reviews a range of design and development methods with a view to identifying the most suitable method for the new software tool.

Methodologies such as Usage-Centered Design, the Usability Engineering Lifecycle, and the User-Centered Design method are reviewed. Chapter 8 discusses the initial design and the first formative usability test of the new tool that relied on paper prototypes. Chapter 9 presents enhancements performed to the paper prototypes based on the data collected in the initial usability test as well as feedback from a new group of test participants. It discusses the reasons for designing a tutorial to accompany the use of the proposed tool. The second iteration of usability testing is conducted; the results are presented and discussed. Chapter 10 describes additional enhancements to the prototypes based on the feedback gathered from the second formative usability test presented in Chapter 9. It then outlines the User Acceptance Test performed on the implemented tool. This test focused on the level of user satisfaction and aesthetic appraisal as well as ensuring that no new usability problems had crept into the tool during implementation.

Chapter 11 completes Phase 3 with a general discussion, presenting a summary of the main findings and highlighting the theoretical implications of the study. Other contributions of the study and suggestions for future work that arise from the study are also presented. A conclusion is finally presented. Figure 1 summarizes the entire research process graphically.
Figure 1: The research process presented in this thesis
Chapter 2: Theoretical Frameworks

This chapter presents a critical review of a sample of candidate theoretical frameworks for guiding Phase 1 of this research. According to Norman, designers lack knowledge of the importance of data collection and user testing to support design decision-making as well as the skills to collect data and conduct user tests. In order to derive an understanding of what design students might know about data collection, analysis, and interpretation, and to find possible gaps in their understanding, it is necessary to investigate theoretical frameworks that could potentially guide this research. Accordingly, the purpose of this chapter is to identify suitable theoretical frameworks. A brief outline of Schema Theory is presented, followed by a discussion of Scripts. The concept of Mental Models and Conceptual Change Theory that share several elements of relevance to this research are then presented. These four theories selected are the major theories in the field.

Schema Theory

British gestalt psychologist, Sir Frederick Bartlett (1932) introduced the notion of “schema” into the field of cognitive psychology. Schemata refer to the internal models of the world learned through experience and stored in the brain; they are primarily applied to predict future events but also to interpret situations as they occur. Schema Theory holds that knowledge is stored as retrievable “look-up tables” in the brain. Bartlett demonstrated some of the characteristics of recognition and recall in memory studies. For example, when individuals are attempting to recall a story, they tend to manipulate it in such a way that it relates to their unique experiences and thus appears familiar to their own sets of schemata. Piaget (1952) argued that schemata are the “basic building blocks of knowledge and development”. He held that memory develops according to how individuals perceive objects or phenomena through “assimilation” and “accommodation”. Assimilation refers to the ability of individuals to make sense of a new idea or new knowledge and to adjust these to their existing knowledge stored in those schemata. By contrast, accommodation is the ability of individuals to accept new knowledge as being novel and to create a new mental schema.
For example, one may assume that a design student would understand the concept of data sampling and statistical data analysis if he or she already has some relevant research-related knowledge. That would enable them to assimilate new information, which thereby expands their existing knowledge of data sampling. However, without any knowledge of data or research principles, they would need to “accommodate” the new topic of data sampling and statistical analysis as a new schema or set of schemata.

Anderson (1977) and Rumelhart (1984) explained the concept of schemata with several characteristics also described by Plant & Stanton (2012). According to all these authors, schemata are organized meaningfully; they are embedded with other schemata and contain sub-schemata. They change from moment-to-moment as information is received; they are reorganized when incoming data suggests a need to restructure existing schemata. Zhao & Zhu (2012) further stated, “schemata affect attention and the absorption of new information. People use schemata to organize prior knowledge and provide a framework for future understanding.” (p.112) It can be anticipated that our individual networks of schemata are structured by topic and connected to other relevant sub-topics; that they can be improved over time and work as the basis for understanding and interpreting future behaviors. However, it is unclear if one or more existing schemata in the network can be deleted or removed if they are no longer meaningful or useful. Nor is it clear what might happen to these schemata if they are no longer used.

Any new concept, idea or information can become meaningful when they can be related to existing knowledge that someone already possesses (Jiang, Xu, & Zhou, 2008). This is understandable: if the information is new, and none of the existing schemata can be linked to it, then it is difficult to appreciate and comprehend it. This argument would appear to support Piaget’s theory in the sense that accommodation is likely to take place if the person is able to understand and appreciate the new information and establish a new schema. However, the way in which new information is accommodated in a schema remains unclear.

Schemata are exclusive to each individual (Nash, 2012). There will be no two people storing exactly the same information in precisely the same fashion. This is evidenced by one of Bartlett’s experiments in which he found that individuals manipulated and retold a story they heard by applying their own unique interpretation
and culture. It is also important to note that the more schemata one has, the better one can predict future behaviors (Zhao & Zhu, 2012). Experienced drivers, for example, can drive any car, be it automatic or manual, better than novice drivers, because experienced drivers possess much more refined networks of schemata associated with driving. Schema theory would thus appear to be a convenient vehicle for explaining designers’ existing internal models for designing products. In relation to design students, whenever they are given the task of creating a new product, their existing knowledge, or schemata, related to product creation will be activated to guide the new product design. Designers may select only relevant information or schemata related to the product as they may deem appropriate from their own perspective, understanding, interpretation and culture. Similar to the example of drivers, it can also be inferred that young designers or design students are likely to have fewer schemata than design experts or experienced designers, thus limiting their ability to design more successful products. Keeping this in mind, Schema Theory will be considered further in this thesis.

**Scripts**

Another type of cognitive representation described in cognitive psychology is a “Script”. Schank and Abelson (1977) defined a script as a “predetermined, stereotyped sequence of actions that define a well-known situation.” (Schank & Abelson, 1977, p.210) Some authors regard scripts as a specific form of event-related schemata (Erasmus, Bishoff, & Rousseau, 2002). Abelson (1981) described a script as “an expectation bundle that might direct cognitive processing toward the appropriate inference.” (p. 717) The classic example of scripts is dining at a restaurant. It typically triggers scripts that involve a series of steps starting from entering the restaurant, looking for a suitable table, reading the menu, selecting food, eating, through to paying at the cashier and leaving the restaurant. Basically, it is procedural knowledge about how to behave appropriately in a particular situation (Abelson, 1981).

Scripts are somewhat individual (Erasmus et al., 2002), based on interactions with one’s environment (Nottenburg & Shoben, 1980) although they share many similarities among individuals. Each individual may thus have similar scripts for buying
basic household appliances such as a fridge, stove, washer or television, but these may differ according to preferred shops, brands, specifications and prices based on each individual’s experience.

Like schemata, scripts are knowledge structures that are organized in common, sequential orders (Nottenburg & Shoben, 1980). Previous research has shown that when individuals are faced with a scrambled order of events, he or she will try to unscramble and organize them in the correct sequential order (Erasmus et al., 2002). An example of a scrambled order is that it is not possible to watch a movie at the cinema before buying a ticket. Individuals usually have a standard script for watching movies at a cinema, where they have to first buy a ticket, give it to the usher, go to the right hall, sit on the dedicated seat, watch the movie and leave the cinema. Each individual already knows that they must first buy a ticket (unscrambled an unorganized event) before entering the cinema. It is worth noting that information presented in an orderly fashion and in a step-by-step manner is especially important in a learning environment. This concept of script will be kept in mind when investigating existing tools.

**Mental Models**

The literature suggests that mental models are similar to the concept of schemata (Bartlett, 1932) and scripts (Schank & Abelson, 1977) in the sense that people use existing knowledge stored in the brain to interact or react with objects and events. Mental Models, according to Johnson-Laird (1983)

“play a central and unifying role in representing objects, states of affairs, sequences of events, the way the world is, and the social and psychological actions of daily life. They enable individuals to make inferences and predictions, to understand phenomena, and experience events by proxy; they allow language to be used to create representations comparable to those deriving from direct acquaintance with the world; and they relate words to the world by way of conception and perception” (p. 397)

Mental Models can be regarded as cognitive representations or individuals’ thoughts on how objects work, and therefore affect the way they interact with objects (Roth,
Schmutz, Pauwels, Bargas-Avila, & Opwis, 2010). While Johnson-Laird (1983) was generally credited for inventing the notion of Mental Models, the idea of internal models had already been discussed by Bartlett (1932) who found that people try to relate new information to existing knowledge to form new networks or expand existing ones (Brewer & Nakamura, 1984). Later, Craik (1943) in the field of psychology, proposed that people construct internal models of external events that were then used to predict events and form explanations of the outside world (Jones, Ross, Lynam, Perez, & Leitch, 2011). Decades later, Johnson-Laird introduced the notion of mental models in human reasoning in experimental psychology. He suggested that people use mental models to reason and make decisions. However, Craik had already introduced this concept of human reasoning in 1943 (Staggers & Norcio, 1993).

Mental models are not necessarily accurate; they are usually incomplete, (Norman, 1983; Staggers & Norcio, 1993). For instance, an individual with an accurate mental model of how an elevator works will understand that they only need to press the button once and wait, while people with an inaccurate or incorrect mental model might keep pressing the button until the lift doors open. This shows similarity with a Script, whereby an individual possesses a model of a sequence of actions before they get into the elevator. This also suggests that mental models are based on individuals’ personal experiences, beliefs and knowledge. Thus, everyone’s experiences differ from everyone else’s, another criterion similar to Schema Theory and Scripts. For instance, designers are likely to have some knowledge, or even to possess complete mental models, of sketching and drawing using an AUTOCAD drawing tool, whereas lawyers, who have little or no knowledge of sketching and drawing, would not. In contrast, a designer may have no knowledge of what legal proceedings in court are all about unless they have some experience of attending one. However, knowledge and experience really depend on the nature and task and the way individuals interact with their environment (Erasmus et al., 2002). Individuals’ experience of grocery shopping is another example of such interactions. People usually know where to find bread and milk on the shelves regardless of which shops they go to; they can also search the signage provided in a shop. This is because the mental model of shopping for bread and milk is already stored in their minds. By contrast, the process of buying or renting a house may differ
according to individuals’ experiences, such as when dealing with fussy landlords or agents. With respect to this research, design students coming from different cultural and educational backgrounds as well as varying personal experiences may have different mental models or no knowledge of data collection, analysis or even what data sampling should be applied when designing new products. Therefore, their understanding, perception and acceptance level of new information or knowledge will differ.

Mental models are intangible and difficult, but not impossible, to measure (Staggers & Norcio, 1993). For example, Gentner & Gentner (1983) carried out an experiment to help a group of graduate students understand the concept of electricity flow through batteries and resistors in a physics course. They used two metaphors where the behavior of batteries was explained by flowing water, and the behavior of resistors was represented as crowds of people moving through narrow gates. The students were given training on one of these and then asked to answer questions about both batteries and resistors. Students who had been taught about resistors were good at using those metaphors to describe the behavior of resistors, but the metaphor could not be used to explain the behavior of batteries. Likewise, students who had been taught the behavior of batteries managed to establish and describe a mental model of electricity by relying on the flow of metaphor. The study concluded that metaphors helped students to learn relevant concepts, but they could not be extended or transferred to the other concept. The research also suggests that training helped learners build mental models of the topics being studied. In relation to design students, the nature of mental models suggests that metaphors cannot readily be extended to unfamiliar phenomena; design students might therefore have problems understanding statistical calculations if they are not already familiar with sampling, or collecting data from participants.

In addition to Schema Theory and Scripts, Mental Models provides another valuable guideline to be considered in this research. Firstly, according to Mental Models, design students may have existing knowledge relevant to user testing, statistical analyses, and interpretation to help them in making decisions for designing products. Secondly, these existing mental models stored in their minds may not be accurate according to individuals, and can be modified. Thirdly, design students who are unfamiliar with these concepts of user testing and analyses might have problems in
understanding and thus applying the knowledge to make decisions. Fourthly, Mental Models is related to Schema Theory in the sense that Mental Models are sets of knowledge or information stored in schemata used to predict or explain phenomena or objects. For these reasons, Schema Theory, Scripts and Mental Models are discussed further throughout this thesis.

**Conceptual Change Theory**

Another theory related to human cognition which might be relevant to this research is Conceptual Change Theory that was introduced by Posner et al. (1982), inspired by Piaget and extended by Hewson (Hewson, 1981; Posner, Strike, Hewson, & Gertzog, 1982). The underlying concept of Conceptual Change Theory, as suggested by the second such study, is to create a cognitive conflict in an individual’s mind by introducing an alternative concept that meets the criteria of being intelligible, plausible, and fruitful. This is intended to make the person feel dissatisfied with the existing belief or concept, which is then discarded and replaced by the alternative concept (Lee & Yi, 2013). Hewson (1981) introduced the notion of C that refers to existing concept and C’ that refers to the new or alternative concept. For C’ to be accepted, one must be dissatisfied (a cognitive conflict occurs) with C, and at the same time C’ must be intelligible, plausible and fruitful (Hewson, 1981; Özdemir & Clark, 2007).

For a concept to be intelligible, it must be comprehensible and easy to grasp. The person will only be able to accept an alternative concept if they can make sense of it. A concept is plausible if it is deemed feasibly true and valid. For instance, many design students may have a clear idea of creating a new product that usually involves sketching and drawing. When the alternative concept of user testing early in the product creation process is introduced, the design student may find that it does not accord with their normal routine or experience. The concept of user testing must demonstrate that it can generate fast, accurate and reliable results as well as facilitate a design based on consumer feedback, and that it will help them to produce better products. For a concept to be fruitful, it should be able to lead to a future research program. This third criterion goes well beyond the scope of this research and will therefore not be discussed further.
The concept of user tests is important because design students must be able to gather design ideas or input from their target consumers to inform design decision-making and lead to creating successful products.

The theory suggests that one might reject any alternative concept (C’), if the individual’s existing concepts (C) are sufficient to solve problems within the current conceptual schema. For example, design students may have some knowledge of systematic statistical analysis methods using real data obtained from the target consumers. They might therefore think it is unnecessary to learn a new statistical analysis method. In such cases, no assimilation or accommodation would occur. However, if a new statistical analysis method can be incorporated into (or reconciled with) the student’s existing data analysis methods and yield more accurate results faster, thereby constituting an improvement to existing methods in their schemata network, the new method might be assimilated. Reconciliation is “the process whereby a person makes sense of a new conception and gives it meaning by seeing it in the context of their present knowledge and understanding” (Hewson, 1981). Accommodation, on the other hand, could occur if the statistical analysis method is totally new to the student and they can understand and appreciate its merits. This can lead to accommodation by modifying (replace and reconcile) their product design schemata and fit a new element of statistical analysis into their schemata. The characteristics of Conceptual Change Theory that allows accommodation to take place, share strong similarities with the concept of Mental Models that can be modified and added to, provided the person is able to understand the new information. This explanation suggests that the principle of Conceptual Change Theory is comparable to Mental Models discussed earlier.

Nevertheless, Conceptual Change Theory adds a new guideline to this research, particularly in a situation where design students may have no knowledge of user testing, analyses and interpretations. These new concepts must demonstrate more strength to the design students, such as the ability to collect data faster and generation of accurate results, encouraging them to accept the new knowledge. Keeping this in mind, this theory is considered further in this thesis.
Summary

The aim of this chapter was to critically review the relevant theoretical frameworks underpinning this present research. The investigation suggests that Schema Theory and Scripts are suitable as general guidelines in understanding design students’ prior knowledge related to user testing, statistical analyses and interpretation relevant to this research. Mental Models are highly relevant to the concept of this research that add more explanations in the learning environment. However, a small part of Conceptual Change Theory was deemed relevant to this thesis by making information intelligible and plausible to the design students to foster learning. These four frameworks underpin this research and will be used further in investigating design students’ understanding of the notions of data sampling, statistical analysis, and conducting systematic research at large. The examination of the courses offered in design curricula to learn if any of those courses teach design students systematic data collection methods, user testing and statistical analysis, will be discussed in the next chapter.
Phase II – Modeling

Chapter 3: The examinations of the design curricula

Chapter 4: Investigation of existing software tools for design students
Chapter 3: The Examinations of Design Curricula

The purpose of this chapter is to examine the courses offered in design curricula to learn if any of them teach design students systematic data collection methods, user testing and statistical analysis. The investigation was carried out in three stages. The outcome of an archival search of design curricula is presented first, followed by a survey carried out to confirm the accuracy of the curricula, and finally, a set of interviews was conducted to investigate the extent to which Australian design students might acquire sufficient skills and knowledge to conduct the systematic research that leads to well-informed design decisions.

Archival Research

The archival research explored if any courses or course components existed that specifically related to systematic data collection, user testing and statistical analysis methods. Archival research is the investigation of data or files that are made available, created or received by other companies, organizations or individuals (Geiger & Moore, 2011; Note, 2011). The archives searched can be from a building, a library or a website (Geiger & Moore, 2011). For this study, the design programs with courses offered by selected universities were examined through their universities’ official websites.

Materials, Procedure and Results

Design curricula offered by Australian and overseas universities were sampled. Of the 38 Australian universities investigated, 21 offered design courses. In addition, a sample of 30 overseas universities was selected from the United Kingdom (n = 8), Continental Europe (n = 6), the United States of America (n = 11), Canada (n = 1) and Asia (n = 4) via an online Design School Directory website (Core77, 2011). The sample covered both undergraduate and postgraduate programs and represented various areas of design such as Multimedia, Product Design, Industrial Design, Interior Design, Communication Design, and Fashion & Textiles. The full list of degrees and relevant
material for this chapter are shown in Appendix A, pp.207-216. Each university’s website was examined in detail. The results suggested that none of the design courses investigated incorporated any elements of systematic data collection and statistical analysis concepts. This was true for both Australian and overseas universities.

**Email Surveys**

Following analysis of the selected curricula, an email with an open-ended question (Appendix A, p.217) was sent to coordinators of design schools in Australian universities (n = 21) to verify the reliability and accuracy of the data gathered with emphasis on systematic data collection, user testing and statistical analysis components in the design curricula. An email survey was chosen to gain additional insight into the findings obtained in the archival research. A single open-ended question was administered because it provides responses faster than multiple closed-end questions arranged on Likert Scales (Hutchison, Fleischman, & Johnson, 2011).

**Results**

Of the 21 Design course coordinators contacted, eight (38%) responded, informing us that none of their schools integrated any element of systematic data collection, user testing and statistical analysis methods. Respondents from three universities mentioned that they did teach elements of qualitative data collection methods such as interviews. One respondent explained that they taught their design students Thematic Data Analysis methods in the following terms. “The major piece of assessment involves designing and running a small qualitative interview study; they then analyze the data thematically and write it up.” Thus, only three universities appeared to teach any aspect of data collection, user testing and analysis at the time of the survey.

These results indicate that design students are not taught how to collect data systematically or how to analyse data statistically and interpret the data before developing new products, enabling them to justify design decisions. However, some
design students apparently did learn to design interviews as well as to conduct, and analyse, interview data. In order to understand design students’ responses to the need for them to learn about systematic data collection, user testing and statistical analysis, a series of interviews were next conducted.

**Interviews**

The reliability and validity of the information gathered thus far with regard to the presence of quantitative elements in the design curricula were investigated further through interviews using a semi-structured interview protocol (Keats, 2000; Gillham, 2005; Fontes, 2008; Mears, 2009). That interview format was selected because it provides first-hand feedback from interviewees. This is likely to yield more insightful information than is typically possible in a survey. Another advantage of semi-structured interviews in particular is that they allow inclusion of both closed-end and open-ended questions; the latter provide further opportunities to probe deeper as required and to change the protocol as needed. All interviews were conducted at one university.

**Participants**

Design lecturers and design students at the Swinburne University of Technology, Melbourne, Australia, were interviewed. A total of 20 design students (12 male) from undergraduate and postgraduate levels, ranging from 18 to 60 years of age, took part in this study. They represented Industrial Design and Communication Design. Ten design lecturers (5 males, 5 females) were also interviewed. The majority held a Master’s Degree (\(n = 6\)), two had Ph.D Degrees, and two held a Bachelor’s Degree.

The interviews took place in a quiet room in one building of the Faculty of Design. In order to protect the anonymity of participants as required by the Ethics Committee, students were selected at random. Ten students were from the communication design program and the others were from the industrial design programs as indicated on class lists provided by the design lecturers. Random selection was carried out within each design program. The researcher approached the students
personally, explaining the purpose of the interviews and making it clear that their participation was voluntary. This procedure continued until the target number was achieved. For lecturers, participants were identified by the courses they teach in the Faculty. The participants’ pool was relatively small because as the interviews progressed it was apparent that there was uniformity in the responses. Extending the sample of participants was unnecessary.

Participants were interviewed in individual sessions, taking approximately eight minutes on average for design students and 15 minutes for lecturers. Participants were not paid and did not receive a course credit in return for their time.

**Materials**

To explore if any systematic research-method component was being taught, four open-ended questions with sub-questions were prepared for the design students. The first and second questions were related to systematic data collection and data analysis courses offered in their studies. If they had taken any of these, further questions concerned the nature of the course and if any assignments were given. The third question sought their opinions about the potential benefits of such courses for students. The last question was designed to find out if they had used any support tools to assist them collecting and analyzing data.

For the design lecturers, six open-ended questions with sub-questions were used, with the first question related to their working experience. The second question related specifically to the courses they taught, and especially if these contained any research components such as systematic data collection or statistical analyses. One question sought their opinion towards providing any of these courses to design students.

While the interviews were audio-recorded with participants’ consent and ethics approval, notes were also taken for future reference. The interview protocols and demographic forms for each group of respondents are attached in Appendix A, (pp.218-226).
**Design**

The interviews were audio-recorded for later transcription. Data were analysed manually using Excel spreadsheets. As indicated above, the uniformity of responses did not necessitate complex data analysis. Manual analysis was quite satisfactory.

To prevent identification of participants by other parties, participants’ names and other forms of ID were not used in the interviews. Upon completion of the transcription, all recorded materials were destroyed, and all transcripts were kept in a locked, secured place in the Faculty of Design. (Please refer Appendix A for the Ethics Clearance (p.218) and Information Consent Statement (p.225)).

**Procedure**

When participants arrived at the venue, they were welcomed by the researcher and were given a quick briefing about the interview. Participants were then asked to read and sign the informed consent form and fill in the demographic information form. After completing the forms, the interviews proceeded as per the interview protocol. Before being dismissed, participants were given an opportunity to ask any questions and/or make additional comments.

**Results**

The results are presented in two sections. The first shows the results of interviews with the design students followed by the results of interviews with the design lecturers.

*Design Student Interviews*

Questions 1 and 2 asked about any course(s) participants had taken that related to systematic or quantitative data collection and analysis as well as the name of the course(s) and the type of method(s) they had been taught. They also asked if any
assignment(s) were given that related to data collection and analysis. Table 1 shows a summary of the number of interviewees who reported having learned some data-collection methods. As can be seen, eight participants said they had learned In-context Interviews and used a Self-documentation Kit (n=8). The Self-documentation Kit is an investigative method used in design to gather feedback from participants in a natural setting (Pontis, 2009). Some examples are diaries, sketches, cameras, or cards that can be printed out or saved as electronic documents with open or structured questions. Users are asked to record their feelings or activities over a certain period, typically during a minimum of one week. Two participants mentioned that they used card sorting. Card sorting is a method where participants are asked to sort cards into groups that make sense to them using any criteria, and divide the groups into as many subgroups as they like (Goodman, Clarke, Langdon, & Clarkson, 2007). They are then asked to label the groups. For example, participants may be given a deck of cards with pictures of chairs and asked to sort these cards according to their own judgment. Most data collection methods that participants mentioned were characteristic of qualitative methods. Two participants mentioned that they collected data from the university’s library, from the Australian Bureau of Statistics (ABS) and through the Internet (Google Scholar). Evidently, their concept of data collection concerned searching secondary sources with no direct involvement by participants or user testing.

Table 1: The list of Data Collection Methods that they learned as highlighted by participants

<table>
<thead>
<tr>
<th>Data Collection Methods</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-context Interview</td>
<td>8 (40%)</td>
</tr>
<tr>
<td>Self-documentation Kit</td>
<td>8 (40%)</td>
</tr>
<tr>
<td>Card Sorting</td>
<td>2 (10%)</td>
</tr>
<tr>
<td>Research on the Internet only (Australian Bureau Statistics, Google Scholar, University Library)</td>
<td>2 (10%)</td>
</tr>
</tbody>
</table>
Three students claimed to have taken a systematic data analysis course, referring to the method learned as Sticky Note Manifesto. It is a method whereby designers write each unique comment or key point made from all data collected through, for example, interviews or a self-documentation kit on a post-it note. These are then categorised into groups and sub-groups and stuck on the wall (Methods of Investigation, 2013). The sticky notes may also be colour-coded and sorted into as many groups as the researcher likes without imposing any formal rules or procedures. Designers then interpret these groups according to their own judgment; there is no hierarchical notion involved. This sounds similar to Affinity Diagrams as applied in Contextual Design (Holtzblatt, Wendell, & Wood, 2004) whereby feedback typically concerning design ideas is recorded on cards or Post-it Notes. Similar ideas are identified and sorted into groups; each group is given a unique label until all ideas or cards have been allocated to a group. However, in Contextual Design, a maximum of four notes are allowed in any one group. When additional comments or design ideas appear to belong to a given group, a new group with another unique name must be created. Groups that deal with similar content, for example, language, menus, or navigation, are then arranged hierarchically. These grouping, organisation, and labeling processes are absent from the Sticky Note Manifesto in which frequency is not taken into consideration. This suggests that students may have a concept of data but that their concept is insufficient to encompass everything students need to know about data to accommodate statistical concepts as well.

The Australian Bureau of Statistics (ABS) releases many kinds of statistical data. Designers search the ABS website for relevant data and use these for designing new products. This involves no direct contact with consumers.

Participants mentioned that they learned these data collection and analysis methods in courses such as Research Methods for Design, User-Centred Design and Methods of Investigation. Six of the 20 participants had taken one research-related course, one student had taken more than one course and 13 participants had not taken any courses at all. Thus, while some students thought they had learned about data collection and processing, their feedback suggested that more than half of them had not taken any of these courses. In addition, all of the methods mentioned are qualitative, yet
the students believed they were quantitative, suggesting that they do not know the difference between qualitative and quantitative data. Question 2 also asked if they would like to learn more about systematic data collection and analysis methods, to which 14/20 agreed. This suggests that they were interested to learn the concepts involved in systematic data collection and analysis; however, they might not understand what this is all about, and this might influence their willingness to learn these concepts.

Question 3 asked whether design students thought they should learn systematic data collection and data analysis. It revealed that 13 participants were interested and thought it would be useful for all design students. Additionally, three of these participants mentioned that they are more visually literate and prefer visuals than numbers. One of them said, “I see the world spatially; I don’t think and see the world as numbers. Very visual, for example, I am not great in languages, abstract theories like a science person. But, very visual like colours, textures, sounds, so I will not know people's name but I will always remember them, it is stored in me somewhere” Another participant mentioned, “Because I think as a designer, part of the journey is being creative, having a talent to create”

Another participant said, “If statistics and design outcome were really linked properly into the method of teaching, that would be really useful, and cool… if just a lecture, talking about stats, people would be like, 'I’m not here to do maths.' If they [design lecturers] can show them [design students] the benefits of stats that are good. Not necessarily the students have to work out data, you might give them a couple of standard distribution curves, then show them how to get design directions, feed them in the design project. Understanding of how it can help you, pretty cool!”

At the same time, seven of those 13 participants were unsure about what to say.

Question 4 asked if they had ever used any software tools to help them collect or analyze data. Of the 20 participants, 17 had never used or had even heard of such tools. One or two participants mentioned they used online surveys such as Survey Monkey for
data collection and iPhones for capturing audio, video or image data. Two participants also mentioned that they had used Microsoft Excel to analyze data. Yet when asked how they analyzed their data, none was able to respond.

Taken together, it is established that design students prefer tools or methods that are visual and aesthetically pleasing to the eye to numbers or simply text. This is supported by another participant’s comment when asked if any existing software tools that they have used,

“No, and that something that I would be interested in knowing, if there is software that can make collecting data easier for designers, then I would be interested to know… Good to have software that can sometimes understand data better than you. Because designers sometimes are very lazy to find for answers and normally look at the obvious not deeper. It may result with a very quick design solution because your information has been analyzed more critically.”

**Design Lecturer Interviews**

Table 2 presents the design lecturers’ work experience. Nine participants had more than six years of experience working in academia and had taught both undergraduate and postgraduate design programs. Seven had also worked in industry for more than six years starting as junior designers and continuing as senior designers, project managers, and/or directors.
Table 2: Design Lecturers’ working experience

<table>
<thead>
<tr>
<th>Participants Background</th>
<th>Frequency, Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of design students they teach</td>
<td></td>
</tr>
<tr>
<td>Undergraduate only</td>
<td>5 (50%)</td>
</tr>
<tr>
<td>Postgraduate only</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Both</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>Have worked in academia</td>
<td></td>
</tr>
<tr>
<td>0 – 5 Years</td>
<td>1 (10%)</td>
</tr>
<tr>
<td>6 – 10 Years</td>
<td>6 (60%)</td>
</tr>
<tr>
<td>11 -15 Years</td>
<td>1 (10%)</td>
</tr>
<tr>
<td>More than 15 Years</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Worked at Swinburne University as their first university</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>No</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>Have worked in the industry</td>
<td></td>
</tr>
<tr>
<td>0 – 5 Years</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>6 – 10 Years</td>
<td>4 (40%)</td>
</tr>
<tr>
<td>11 -15 Years</td>
<td>-</td>
</tr>
<tr>
<td>More than 15 Years</td>
<td>3 (30%)</td>
</tr>
</tbody>
</table>

Question 3 asked if they had taught any courses related to systematic data collection and analysis methods. One participant responded that first-year students just search for information in the library.

“Not really asking them to collect data, they might collect data from designers, not quantify data, just search information from the Internet and library. Certainly not for undergraduates (first year), but for Honors and third year students, yes, they (conduct) interviews.”

Another participant’s courses involved no analysis; the lecturer seemed to believe that data analysis would be irrelevant to design students, saying “No, we’re probably not going to use that word (systematic data collection and analysis) but I have been teaching Methods of Investigation (that) cover some but too broad. Definitely not analyses”.
Only three participants mentioned that they had taught design students the basics of Interviews, Card Sorting, and Self-Documentation Kits for data collection.

Question 4 addressed the level the design students in their courses were at, while Question 5 requested the titles of these courses, shown in Table 3. To illustrate, three courses taught at various levels of study contained information about data collection (for example, Professional Practice, Methods of Investigation and Research Methods for Design) but only two courses (Methods of Investigation and Research Methods for Design) included data analysis techniques. Interviews appeared to be most popular among both design students and lecturers. However, when asked how interviews are conducted, the lecturers responded that it was very basic, “…Very informal, loosely called an interview, very minimal, like a survey. They just find people in their own social group. Just very basic. Not scientific or accurate.” Besides interviews, the design lecturers also mentioned Card Sorting, Observation and Self-Documentation Kits as representing the ‘best methods’ for data collection. For data analysis, two lecturers mentioned the Sticky Note Manifesto as the main method, while one mentioned Affinity Diagramming for further analysis. However, eight participants mentioned that there was no analysis component in their course and one lecturer informed that sometimes students just analyze manually.
Table 3: The list of courses comprises of data collection and analysis in the design programs as claimed by the design lecturers

<table>
<thead>
<tr>
<th>Course</th>
<th>Level of Study</th>
<th>Method of data collection taught to design students</th>
<th>Method of data analysis taught to design students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional Practice</td>
<td>3rd year</td>
<td>Interviews</td>
<td>Simple analysis – students manually analyze data</td>
</tr>
<tr>
<td></td>
<td>(Undergraduate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methods of Investigation</td>
<td>1st year</td>
<td>Interviews, Card Sorting, Observations</td>
<td>Sticky Note Manifesto, Affinity Diagram</td>
</tr>
<tr>
<td></td>
<td>(Undergraduate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Methods for Design</td>
<td>Master</td>
<td>Interviews, Observations, Self-documentation kit</td>
<td>Sticky Note Manifesto, Affinity Diagram</td>
</tr>
<tr>
<td></td>
<td>(Postgraduate)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Closer inspection of the data showed that two lecturers had taught the Sticky Note Manifesto. The next question asked if any of these approaches used any descriptive or inferential statistical analysis; none of them did.

In response to Question 6 relating to lecturers’ thinking of systematic data collection and data analysis methods, five thought it would be useful, indeed necessary, and that it should be integrated into the university’s design curriculum. They were also asked to share their thoughts on teaching such methods to design students. Four participants agreed that it would be useful; two said that statistical analysis “can do good analysis and draw out good figures to whatever subject”, and “useful and structured”.

Another participant said,

“I think some form of data collection and analysis for students to know how to do it and do it, and present that information to a client will help the client to relax and feel that they are making the right decision. Yes, it’s going to help the process and designers in the industry, to design work better without fail. I think 50% of designs fail, or don’t get made, or don’t happen and there is a lot of problem along the way, so finding out some real information is very useful”.

One participant was not sure but did agree that statistics can be useful for the design students. “I thought it is outside of how we normally think. Generally speaking, there is no great mathematician out there, but I think it would be useful”.

The other four participants disagreed with using statistics in the design field. Besides claiming that it is very hard, one participant said,

“I think data analysis or quantitative analysis is a specialized skill. Probably would only really be appropriate at the postgrad level, potentially… And maybe, more engineering side, or IT side if they were going to focus more on user testing. I would not even recommend for the qualitative; we do it very loosely. But as far as to make it rigorous as qualitative, we are not pretending to be anthropologists”.

One more participant suggests that it is an expensive technique, “…Seems expensive or maybe just look at the surface not the heart of the problem.” Another participant said, “I think it’s great and fine but I think it’s naïve in these days, to do it like traditional scientific way like hypothesis…I think if you ask experience, thoughts, they are abstract and difficult to that on its own”.

Another two participants, on the other hand, had no comments. Taken together, it is safe to conclude that while nearly half of the design lecturers appeared to disagree with the concept, most of the lecturers believe that systematic research methods can be useful for the design students.

In the last question, participants were asked for suggestions of relevant types of statistical analysis that should be incorporated if a new tool were to be developed. One participant responded, “I don’t know enough about it, but in my opinion, people don’t want to link to questionnaires, and I think, you know more than a page, not interested. People like it more informal, not too long, or it will become laborious. Concise, be relevant.”

Another participant said, “I guess in framing the right question, asking the right people, also how to analyze … I am really a beginner. Just started, in Masters, a long time ago, I used SPSS, but it was quite confronting, I needed to ask for help from
others, quite alien to me, a little bit tricky.” This showed his disappointment with the statistical software. The first two participants said they had no idea of what type of statistical analysis could be suitable for design students. One participant suggested the importance of interaction.

“My opinion about this is the interaction. They can be very boring if you’re not interested in it; I think the engagement part should be more interactive, stimulating. Students actually have mixed emotions of data collection and analysis. If you get interactive and visual, it should be good, although they don’t really understand”.

When designers want to develop a new product, it seems likely that they will use methods such as a self-documentation kit, or interviews for data collection and Sticky Note Manifesto for analysis. The results of the interviews indicate that design students do have some, albeit limited, knowledge of data collection related to qualitative method. This, however, is limited to basic grouping of information gathering with no further analysis carried out.

Discussion

The investigations conducted thus far show that both students and lecturers were superficially familiar with some qualitative data collection methods, but that they were unfamiliar with quantitative methods. For most participants, this lack of familiarity extended to the very notion of quantitative data. It is notable that neither the students nor the lecturers mentioned any inferential statistical methods such as ANOVA or Factor Analysis, even t-tests or nonparametric equivalent analysis methods in the design curriculum. This therefore suggests that design students lack a basic understanding of data and all its implications. As argued by Taffe (2012), design students are taught to believe in their own intuition and creativity, consequently, designers often rely heavily on personal preferences, tending to understand the term ‘research’ as simply being the gathering of archival information from the library or from the Internet instead of running user tests with consumers to inform design decision (Dickinson, Marsden, &
Design students have no knowledge of data, and there is a need to design a tool appropriate for the design students to deal with numerical data.

The findings also suggest that there is a need to design a visual and interactive tool for design students to understand the concept of data sampling and the value of data gathered through a direct contact with consumers. This interpretation was based on the responses given by the design lecturers during the interviews that design students might benefit from a visual and interactive method such as a software tool to assist them to collect and manipulate data. Design students also claimed that they are visually literate and prefer visuals to numbers. These findings appear similar to the work of Goodman et al. who proposed a design tool should possess the criteria of being visual, interactive, concise and relevant to a design context (2007). Without participants having an understanding of data and what value that data can add, it was futile to seek their views on precisely which data collection and analysis methods should be taught. To overcome this problem, existing tools suitable for the design students to collect and analyse data first need to be investigated. The criteria identified earlier will be kept in mind when investigating existing tools for the design students.

**Summary**

This chapter examined the courses offered in design curricula to discover if any of those who teach design students use systematic data collection methods, user testing and statistical analysis through archival search, email surveys, and interviews. The investigations show that design students lack a basic understanding of data and all of its implications, and there is a need to solve this problem. To overcome this, some important criteria for data collection and analysis suitable for design students were identified, including visual and interactive tools. The next chapter explores existing visual tools available for design students to learn about the value of data, and the power of statistics to help them carry out systematic research.
Chapter 4: Investigation of Existing Software Tools for Design Students

This chapter explores possible solutions to overcome the problem to which Norman alluded; namely that design students lack the skills and knowledge of user testing and data analysis to inform design decision-making that can help them to create successful products. This chapter completes Phase 2 of the present research. The purpose of the chapter is to investigate and report a review of the existing visual software tools based on the criteria mentioned by design students and lecturers; visual and interactive. Such tools might meet the requirements for teaching design students about selecting a sample of suitable people and products to test, collecting, analyzing, and interpreting data, as well as conveying the value of data, and showing how to draw valid conclusions from their data. A discussion of existing visual software tools is next presented, followed by a discussion of the merits and disadvantages of these and a summary at the end of the chapter.

Visual data collection and analysis tools for design students

This section identifies and discusses interactive tools that are potentially relevant to enable a design student to collect and analyze data. The focus is on visual techniques for user input and system output. These interactive tools were the only ones filling the criteria for suitable tools for design students; offering visual techniques for both user input and system output.

Visual Research Package

A Visual Research Package (Antikainen, Kälviäinen, & Miller, 2003; Kälviäinen & Miller, 2003) is an exploratory tool that allows users to sort product images into three different types of grouping activities; grouping freely, grouping by combining and grouping based on Semantic Differential (SD) scales (Osgood & Suci, 1955). While
grouping freely allows participants to sort products however they like, grouping by combining requires participants to sort products into two or more groups: for example, “I like this product,” versus “I don’t like this product.” In contrast, grouping based on SD scales enables participants to manoeuver stimuli or objects on a set of opposing adjectives; for example, Big - Small and Ugly – Pretty. This product is similar to the traditional card-sorting tasks that have been broadly applied in various fields such as psychology and design (Nurmuliani, Zowghi, & Williams, 2004). Card-sorting techniques usually consist of a set of cards with some descriptions or pictures prepared by a researcher. Participants then sort the cards into categories/groups, describe their sorting criteria as well as the names they use for each group/category (Nurmuliani et al., 2004). These three methods are further illustrated in Figure 2.

![Figure 2: Illustrations of the three methods available in Visual Research Package. Source: Redrawn from Antikainen (2003, p. 2).](image)

Some advantages of the Visual Research Package are that the tool enables the user to choose several visual techniques for data collection and to view the results visually in a flexible manner. Users can click on the items in the results screen to access
individual explanations for positioning a product in that particular location. However, this tool provides three different techniques for collecting data, which are grouping freely, grouping by combining, and semantic differential scales that could lead to confusion for design students who are unlikely to have had training in user testing. They might have problems deciding which technique to use.

This tool allows users to view the results on a 2D map, which is also known as a perceptual map. Perceptual maps can be defined as methods to analyze and understand consumers’ perceptions of products by visualizing the products in a 2-dimensional or multi-dimensional space according to its specific features or attributes such as price and quality (Hair Jr, Anderson, Tatham, & William, 1995; Rice, 2001). Gower, Groenen, Van de Velden, and Vines (2010) added that perceptual map refers to “plots obtained by a series of different techniques, such as principal component analysis, (multiple) correspondence analysis, and multidimensional scaling, each needing specific requirements for producing the map and interpreting it” (2010, p. 1). Any method that produces perceptual maps is called “perceptual mapping” (Gower et al., 2010).

To shed some light on the concept of perceptual maps, products plotted on the map include “consumer products (e.g. toothpaste, cars), industrial products (e.g. computers, tools), institutions (e.g. corporations, hospitals, universities), activities (e.g. vacation spots, movies) or people (e.g. entertainers, political candidates)” (Rice, 2001, p. 1). The perceptual map as a method of data visualization is, according to Gower et al. (2010) widely used in the domain of marketing to study relationships between visual product attributes, product design and positioning, brand switching, as well as customer value and satisfaction. Marketing professionals often want insight into how consumers perceive a particular product compared to other competing products (Bimler & Kirkland, 1998). There are two approaches to creating perceptual maps; one is based on certain attributes assigned to products or stimuli, and the other is based on similarity judgments (Chuang, Chen, & Chuang, 2008; Agarwal & Dey, 2010). For attribute-rating, Agarwal & Dey (2010) for example, studied and compared customer satisfaction with six Indian domestic airlines based on service quality. In that study, participants were asked to evaluate the service quality of all airlines involved by scoring from “Strongly Agree” to “Strongly Disagree” on a 5-point Likert Scale for each question.
For similarity judgments, consumers were usually asked to position a product based on its perceived similarities or dissimilarities with other products; the closer products are placed to each other, the more similar they are considered, and the further apart they are, the more different they are considered to be. In order to capture the overall perceptions, Multidimensional Scaling (MDS), a statistical analysis technique was used. MDS can be defined as “a set of data analysis methods, which allow one to infer the dimensions of the perceptual space of subjects” (Wickelmaier, 2003, p. 4). MDS is used to reduce large amounts of data into easy-to-visualize structures in a set of distance measurements, for example similarity or dissimilarity distances between objects (Anastasova & Jaworska, 2008). The input data for MDS usually involves similarity or dissimilarity of products or brands that is also known as “proximities data” (Wickelmaier, 2003).

This technique of perceptual maps is a graphical representation used to visualize complex information that can be useful for design students. However, perceptual maps in the marketing world generated by complex statistics such as MDS are usually neither colorful nor attractive. The map would consist merely of simple black dots on a white background, probably not suitable for a design student who prefers information that is aesthetically pleasing. (This was identified during the interviews.) It might also be too complex for them to understand and interpret the map.

Figure 3 shows an example of a perceptual map on SD scales of ‘Hard, unusual – Soft, typical’ and ‘Modern – Traditional’ generated by the Visual Research Package.
In Figure 3, products C, A, R, and D are somewhat harder and unusual but also more modern than H, I, F, G, B and J, so the product judged to be most modern, soft and typical is U as encircled in red. The disadvantage of this tool is that the results generated by this tool are limited to displaying perceptual maps; no further statistical analysis is provided. For these reasons, this tool is regarded as unsuitable for design students.

**Computer Aided Kansei Engineering**

Computer Aided Kansei Engineering (CAKE) developed by Chuang & Chen (2003) is an Extensible Markup Language (XML) technology survey tool based on attribute rating tasks of Semantic Differential scales. CAKE was inspired by the Japanese term, ‘Kansei’ that can be defined as an individual’s subjective impression from a certain artifact, environment or situation, using all five senses (sight, hearing, feeling, smell, taste) (Schütte, Eklund, Axelsson, & Nagamachi, 2004). This web-based online survey platform allows users to design survey questions by creating forms for
participants’ demographic information and by inserting stimuli and semantic terms involved in the study.

During the rating task, participants rate each stimulus on sets of adjectives; for example, on the Ugly – Pretty semantic scale. CAKE then automatically sorts the products according to the scales at the bottom of the screen as shown in Figure 4.

![Figure 4](image)

**Figure 4**: The screenshot of products rating based on SD scales in CAKE
Source: Redrawn from Chuang & Chen (2003, p. 3)

Participants can adjust the rated value interactively by sliding the object at the bottom of the screen (see Figure 4) until they are fully satisfied with the overall ratings. All data are collected and coded in a XML file, which gives it a high level of flexibility to integrate, compare, and cross-validate findings with future research. Other advantages of the CAKE software tool are that it can be extended to offer more functions, such as running statistical analysis in the Statistical Package for Social Sciences (SPSS) (IBM, 2011) and for database creation and query functions.
Similar to the Visual Research Package tool, CAKE generates perceptual maps as the visual output. Further, CAKE can also generate multidimensional perceptual maps that are mapped with multiple adjectives. However, to obtain these visual outputs, data must be exported to a statistical software package such as SPSS for analysis. Once the analysis has been completed, the data are then transferred back to CAKE and presented visually in a perceptual map. Conducting analyses in SPSS requires some knowledge of both descriptive and inferential statistics, which is likely to be problematic for design students who, as discussed earlier, are not taught statistics in their training. In addition, the multidimensional map (more than 2-dimensions) can be very complex to interpret and correctly infer consumers’ perception of products, considering the lack of knowledge of analysis and data interpretation among design students. Hence, this tool is considered as not suitable for design students.

**Web-based 2D analytical tool**

The Web-based 2-Dimensional (2D) analysis tool (Lin & Huang, 2006; Lin, Chang, & Huang, 2007) allows participants to position images of products with a Drag-and-Drop tool on a 2D map using SD scales (Osgood & Suci, 1955) inspired by the 2D image scale often used in design enterprises for studying market segmentation and user preferences (Lin & Huang, 2010). A 2D map comprises X and Y coordinates (x, y) positioned in four quadrants as illustrated in Figure 5. For example, imagine that a collection of Products (PA, PB, PC, PD, PE) were positioned on the map according to adjectives (Boring – Interesting, Ugly – Pretty) as perceived by five consumers.
As indicated in Figure 5, the tool allows participants to drag-and-drop product images indicated on the left side of screen (labelled A) onto the 2D map (labelled C) at the point they perceive the product to ‘belong’ in terms of the adjectives shown at the ends of the dimensions until all products have been placed somewhere on the 2D map. Section (B) is an Animation Control whereby participants can play with a 3D view of the product image in (A) for a more complete view before positioning it in section (C). As discussed earlier, products located close to each other are perceived to be similar, while products located far apart are considered to be different. The 2D map space along with a drag-and-drop technique comprises visual and interactive criteria deemed suitable for a design student because both have no involvement of numbers and they are easy to handle and understand. In addition, the 2D map as a platform for input data can efficiently reduce human error in data entry, quickly and easily, as opposed to users manually entering the textual data. For these reasons, the techniques of 2D map and drag-and-drop are considered suitable for the design students and will be discussed further in this thesis.
At its best, the Web-based 2D Analytical Tool generates results visually using MANOVA, a statistical analysis function, and the tool extends its capability with the integration of a Morphological Analysis to further analyze the product forms, such as colors, textures, shapes and structures, that can serve as references for future development of new products.

Another advantage of using a Web-Based 2D Analytical Tool is that users can filter the visual results according to either 1) the position of all products, for example, all ten products placed by all participants, or 2) the positions of only one product placed by all participants. This tool enables users to see how consumers perceived the product(s) according to the adjectives shown on the two orthogonal scales. This tool is unique because it involves a 2D map for both data entry and output. That is, users are able to enter data in the form of product images and obtain the output visually on a 2D map. The input data vary with activities such as sorting images into groups, combining, or rating products on a semantic differential scales, attribute ratings or a similarity type of judgment. Nevertheless, the analysis part provided by this tool is complex, especially for users such as design students who are unfamiliar with inferential statistical analysis techniques such as ANOVA and MANOVA. Thus, Web-based Analytical Tool is not considered ideal for design students.

Focus-on-Stimulus, Focus-on-Attributes, Drag & Drop

Chuang and his colleagues (Chuang et al., 2008) developed three computer programs that also employ attribute-rating tasks for measuring multiple visual stimuli with multiple scales. In their study, the performance of the three programs was compared with the manual Paper-and-Pencil approach. The three programs used a particular method that differed from the others. The first program used a separate evaluation rating-method known as Focus-on-Stimulus. The others used two joint evaluation-rating methods called Focus-on-Attributes and Drag-and-Drop. For Focus-on-Stimulus, each stimulus is separately rated on a number of scales. In the Focus-on-Attributes, a few stimuli are rated in comparison with each other on a specific scale. Drag-and-Drop on the other hand, requires participants to drag and drop stimuli to the
chosen location on a Semantic Differential scale. All stimuli appear simultaneously in Drag-and-Drop. These three methods allow participants to perform re-adjustments even after all stimuli have been rated. Figures 6, 7 and 8 illustrate the three methods respectively.

**Figure 6: Focus-on-Stimulus Method**
**Figure 7**: Focus-on-Attributes Method

**Figure 8**: Drag-and-Drop method

Source: These three figures were redrawn from Chuang et al. (2008, p. 5)
Their findings showed that the computer-based rating methods yielded similar results to the Paper-and-Pencil approach. These methods reduce missing values and therefore improve the data quality. It is well understood that human beings have a tendency to make mistakes while entering data into computers. Hence, an automated technique is one way to avoid human error in the data collection and data entering processes. In addition, the new feature of real-time adjustments that allow participants to adjust their final sorting makes all the three programs unique; this feature was found to be a pleasing point for participants during the sorting tasks.

Chuang et al. stated that the two joint evaluation-rating methods, Focus-on-Attributes and Drag-and-Drop, performed better than the Focus-on-Stimulus method. This was based on criteria such as usage experience with the tool, test–retest reliability, and the possibility of simulating real-life daily shopping experiences where consumers usually compare multiple products simultaneously. However, of the two methods, the Drag-and-Drop method received better subjective evaluation. While all three programs can be used automatically to gather and enter data into computers, none can produce visual output directly. Chuang et al. employed Multi-Dimensional Scaling to generate a perceptual map. Although this function can be performed using SPSS, it is unclear which type of software the authors used as it was not noted in the paper. Running MDS analysis in SPSS, again, can be problematic for design students. Therefore, this tool would seem to be not ideal for the present purposes.

Hierarchical Sorting Method and Divide-and-Conquer Method

Chuang & Chen (2008) further developed their methods evaluating a larger number of stimuli based on multiple scales using attribute-rating tasks respectively called the Hierarchical Sorting Method and Divide-and-Conquer Method. The former method is based on a Paper-and-Pencil approach while Divide-and-Conquer is based on sorting algorithms for computing. In Hierarchical Sorting, participants were asked to sort a large number of stimuli in a hierarchical manner whereby they first sort the stimuli into a number of groups such as ‘rational, neutral and emotional’, then re-sort these groups into more smaller groups and subgroups. By contrast, the Divide-and-
Conquer Method uses computer algorithms to first sort a large number of stimuli randomly and then to present these groups to participants to continue refining stimuli into smaller groups and sub-groups. The differences between these two programs are that the Hierarchical Sorting Method requires participants to sort the raw stimuli while in the Divide-and-Conquer Method, a computer automatically divides the large number of stimuli randomly into three sub-groups, to be sorted later by participants. In other words, participants sort fewer stimuli than in the other methods.

In the study by Chuang and Chen (2008), 30 participants evaluated a collection of 100 armchairs with five rating scales for Divide-and-Conquer and two rating scales for the Hierarchical Sorting Method. All participants used both scales. The five rating scales involved were traditional – contemporary, rational – emotional, complex – simple, heavy – light, and exaggerated – realistic. In the Divide-and-Conquer method, participants took an average of 48.22 minutes to complete the sorting task, and less than 90 minutes for the Hierarchical Sorting Method. This compares with a total of 225 minutes (45 minutes for each attribute scale) for manual sorting in a study by Andreassen & Fletcher (2007). Evidently, the study proves that both methods performed better, more efficiently and effectively than the manual card-sorting method.

Both methods have some advantages: Divide-and-Conquer is faster to complete, and Hierarchical Sorting is preferred by participants because they can focus on the details of the stimuli after they have grouped them by similarity at the initial stage, even though the process is more time-consuming. These two programs, while providing efficient platforms for design students to obtain data, again require an additional knowledge of statistics not just to run MDS but also to interpret the output. Similarly, this tool used MDS for data analysis to generate perceptual maps, so is unsuitable for a design student.
Discussion

Taken together, the investigations found various software tools catering to both input and output, and relying on more or less complex inferential statistical analyses as summarized in Table 4.

Table 4: Summary of visual existing tools for data collection and analysis for design students

<table>
<thead>
<tr>
<th>Software Tools</th>
<th>Input</th>
<th>Analyses</th>
<th>Output</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Aided Kansei Engineering</td>
<td>Attribute rating tasks</td>
<td>Data exported to SPSS</td>
<td>PM</td>
<td>(Chuang &amp; Chen, 2003)</td>
</tr>
<tr>
<td>(CAKE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web 2D Analytical Tool</td>
<td>2D map - Drag and Drop</td>
<td>MANOVA</td>
<td>PM</td>
<td>(Lin &amp; Huang, 2006)</td>
</tr>
<tr>
<td>Focus-on-Stimuli, Focus-on-Attributes,</td>
<td>Attribute rating tasks,</td>
<td>MDS</td>
<td>PM</td>
<td>(Chuang et al., 2008)</td>
</tr>
<tr>
<td>and Drag-and-Drop</td>
<td>Drag and Drop</td>
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</tr>
<tr>
<td>Hierarchical Sorting Method and Divide-</td>
<td>Attribute rating tasks and</td>
<td>MDS</td>
<td>PM</td>
<td>(Chuang &amp; Chen, 2008)</td>
</tr>
<tr>
<td>&amp;-Conquer</td>
<td>Sorting</td>
<td></td>
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</tbody>
</table>

As Table 4 shows, several visual data collection techniques have been used to gather feedback from consumers using a variety of tasks ranging from sorting tasks to attribute rating tasks and 2D maps with image positioning capabilities. It is important to note the differences between these techniques with relevant examples. In sorting tasks, participants are given a collection of stimuli, for example watches to be assigned into groups according to certain criteria that the researcher selects. These may include opposing adjectives such as “like” versus “dislike”, or choices such as “I would choose” versus “I would not choose”. In attribute-rating tasks, participants are provided with a collection of product stimuli, for example, telephones, and asked to rate each based on attributes such as, “traditional – modern”, “big – small”, or “simple – complex”. A 2D
map is very similar to the attribute-rating tasks in the sense that it involves attributes or pairs of adjectives as guidance for the judges to evaluate products, but a 2D map technique employs image-positioning tasks in a 2D space. As discussed earlier, a 2D map with image-positioning task or drag-and-drop can be considered further in this thesis as having visual and interactive criteria, allowing a design student to see products projected on a 2D space clearly and visually.

The tools reviewed in this chapter rely entirely on the designers’ own experience, knowledge, and intuition to decide which attributes or adjectives to use in a study intending to further their understanding of consumers’ perceptions of products. As noted elsewhere (Kälviäinen & Miller, 2005), product images that have been pre-assigned to certain adjective-pairs can lead to a limited range of possible solutions. Kälviäinen & Miller suggested that designers should allow participants more freedom to evaluate or rate products based on their own judgments rather than on the designers’ preferences. This argument would appear to support Hsu, Chuang, & Chang’s (2000) findings in the sense that designers and consumers are likely to perceive the same products differently. In addition, consumers’ understanding and interpretations of adjectives may also differ from that of designers. Hence, it would be worthwhile to ask consumers to suggest relevant attributes for product evaluation rather than relying wholly on the designers’ points-of-view. None of the existing tools reviewed in this thesis address this issue, suggesting a new tool must be developed, enabling a design student to gather attributes from the consumers’ points-of-view.

Apart from offering consumers an opportunity to articulate their perceptions of products presented visually via interactive displays, however, with respect to statistical analyses, excluding the Visual Research Package that did not mention any analysis method, none of these tools took into account designers’ expertise in descriptive and inferential statistics in generating results. Most of the existing tools require various types of complex statistical analysis that can be problematic for a design student. In addition, none of the tools help designers to understand issues and biases associated with sampling. For example, assigning participants into groups to be able to compare results between different demographics, and having an equal number of participants per group could possibly help designers to understand the basic concept of data sampling.
for user testing. These suggest that the new tool to be designed must offer simple rather than complex statistics, considering the limited knowledge of statistical analyses among design students and at the same time allowing them to understand the basic concepts of statistics, at least for a start. The elements of data sampling, user testing and its implications should also be incorporated into the new tool.

All visual software tools explored also use Perceptual Maps as the visual output, suggesting its widespread use is not just in the design field but also in marketing and so deserving further exploration in order to be incorporated in the new tool.

**Summary**

This chapter reviewed the existing visual software tools that might be suitable for a design student to collect and analyse data to inform design decisions. The study concluded that the existing tools reviewed in this thesis did not specifically address the lack of systematic data collection and analyses knowledge and skills among design students, suggesting the need to design a new tool. The study found several techniques that might be meaningful to design students and deserve further explorations, such as a 2D map for collecting data, simple and quick statistical techniques for analyzing, and Perceptual Mapping as the means for presenting the visual output. The next step is to explore suitable data collection and analysis techniques to be incorporated in the new tool for design students that will be discussed in the following chapter.
Phase III – Design & Evaluation

**Chapter 5**: Investigations of Data Collection & Analysis Techniques for the New Tool

**Chapter 6**: Theoretical Models

**Chapter 7**: Reviewing and Selecting a Suitable Technique

**Chapter 8**: Initial Design and Usability Testing of the New Tool

**Chapter 9**: Design and Evaluation of DACADE Tutorial, and the Second Iteration of Usability Testing

**Chapter 10**: User Acceptance Test

**Chapter 11**: Discussion, Future Work and Conclusion
Chapter 5: Investigations of Data Collection and Analysis

Techniques for the New Tool

The purpose of this chapter is to explore and find the techniques for data collection and statistical analyses that might be appropriate to assist design students in running user testing and interpreting data. This chapter continues with Phase 3 of the research: Design and Evaluation. Techniques for data collection are discussed first, followed by a discussion of data analysis techniques. The criteria of interactive and visual techniques were selected considering design students who prefer visuals than textual and numerical information. Implications for the design of a new tool are then presented. The chapter concludes with a summary.

An investigation of the visual techniques for collecting data

Van Kleef, van Trijp, and Luning (2005) argued that eliciting information directly from consumers, for example, interviews and focus groups, may not be helpful because consumers often find it difficult to express, or are unaware of, their needs (Donoghue, 2000; Vidal, Ares, & Giménez, 2013). This limits the information that can be obtained. Instead, Van Kleef et al. suggested using indirect ways of getting consumers to share their thoughts. This section reviews several indirect techniques that appear relevant to gathering consumers’ perceptions of products appropriate for design students.

Projective Technique

Projective techniques are a type of qualitative methods that provides indirect measures to study consumers’ perceptions of products. A feature of such techniques is that respondents are unaware of the information needed by the researchers when surveys are conducted (Will, Eadie, & Susan, 1996; Roininen, Arvola, & Lähteenmäki, 2006). The information gathered includes their attitudes, feelings and thoughts.
(Steinman, 2009). This technique appears to avoid Haire’s contention that consumers usually give deceptive answers when directly asked to respond to products in marketing research (Haire, 1950).

There are five types of projective techniques, namely: 1) association; 2) completion; 3) construction; 4) expressive, and 5) choice ordering tasks (Will et al., 1996). Elaborating further, in association tasks such as word association, subjects are requested to respond to presentations that contain objects by using words, images or thoughts (Donoghue, 2000). An example is “Coca Cola.” When respondents look at the name (word) or a bottle of “Coca Cola” (image), these would automatically convey the message behind them. To name a few associated words, “beverage, thirst, fun and relaxation,” would reveal the consumers’ thoughts or attitudes towards a product (Will et al., 1996). Another type of association task is brand personification. In this task, respondents are given a group of words or pictures when looking at any specific brands or products. They select words or pictures from them and state why they were chosen.

A completion task is also divided into two categories: sentence completion and story completion. Sentence completion is similar to completing a slogan such as, “I love watching this movie because....” Respondents are allowed to finish the line as they feel appropriate. This task is good for gathering information quickly but limits the opportunity to obtain more underlying information (Steinman, 2009). On the other hand, story completion is more straightforward: respondents will tell a story of a product or brand presented to them without any restrictions or rules. The freedom in storytelling allows researchers to uncover respondents’ feelings and attitudes to products or brands in greater detail.

Construction tasks that are popular in the marketing and consumer research community (Steinman, 2009) are divided into two types; third person questioning and bubble drawing. In third person questioning, subjects express their judgment of someone’s behaviour or movement (Steinman, 2009). Using this technique, the third person and respondent are not relating personally to each other, thus researchers are able to reveal information that the respondents do not express directly. Alternatively, bubble drawings are tasks that require respondents to fill in thoughts or speech bubbles related to a cartoon character (Steinman, 2009). For example, respondents are asked to write in
bubbles the thoughts that a cartoon character might be thinking when choosing some vegetables from shelves at the supermarket. Similar to third person questioning, respondents will project their own thoughts or judgment onto other people, in this case the cartoon character.

Expressive tasks are tasks in which subjects are asked to role-play, act, draw, or paint a specific concept or situation of a product or brand (Donoghue, 2000). This technique focuses on the way the subject constructs something, rather than on what the subject represents.

The final category of projective techniques is choice ordering tasks. In this technique, subjects are asked to describe why certain things are considered as "most important" or "least important" according to their own judgment of factors related to a product, brand or service (Donoghue, 2000).

At best, these projective techniques provide insightful information by plotting participants’ thoughts and perceptions in interactive environments, and some can be performed using a visual medium of interaction such as association, expressive and choice-ordering tasks. At worst, however, these techniques of information gathering have a number of limitations. First, the executions could be very time-consuming. Another problem is that they require complex analysis knowledge and skills that can be challenging for a design student. Design students may need all the required skills of conducting a study, communicating with participants, probing for more input, understanding the feedback, putting the consumers’ feedback into meaningful data, and analysing and interpreting these data if they were to use any of these techniques. For these reasons, projective techniques were not considered further in this thesis.

**Projective Mapping or Napping®**

Another indirect measure for gathering consumers’ feedback is a type of quantitative technique: Projective Mapping. Traditionally, in the food industry Projective Mapping has been applied by researchers for sensory analysis, which was originally pioneered by Risvik, McEwan, Colwill, Rogers & Lyon (1994). This technique was used only infrequently among researchers in the food industry for a few
years. The reason for this decline has not been fully investigated, but Kennedy (2010) highlighted a shortage of computer-aided data and a lack of confidence in the results obtained as among the main causes. However, in 2005 Pagès (2005) reintroduced Projective Mapping under the name Napping®. The term Napping® is derived from the word “nappe” which means “tablecloth” in French. It is important to realize that Projective Mapping and Napping® are actually referring to the same technique.

In the Napping® technique, Euclidean distances are calculated for every subject in a session. For example, during one experiment ten wines were simultaneously served to all subjects. Subjects were then asked to position those wines on a large paper tablecloth 40cm x 60cm, based on their own criteria. Subjects were informed that wines would be regarded as similar if they were very near to each other and different if they were far apart, a concept similar to Perceptual Mapping. In Napping®, however, all wines were numbered, and subjects were asked to write the number of each wine on the paper tablecloth after completing the tasks. After the experiment finished, data were collected and recorded in a table with 10 rows for ten wines, and 22 columns for 11 tablecloths, with X and Y coordinates. Next, a Multiple Factor Analysis (MFA) was performed on the data to generate the results (Perrin et al., 2008). In his study, Pagès asked participants to write down on a tablecloth as many words as they liked describing the products based on their own criteria (Pagès, 2005). Other examples of research that used the Napping® technique have investigated responses to citrus juices (Nestrud & Lawless, 2008), and hot beverages (Moussaoui & Varela, 2010). Generally, the Napping® technique is spontaneous and has flexibility. However, it best handles a maximum of 20 samples at a time to avoid fatigue for subjects (Perrin et al., 2008).

The main limitation of Napping® is its reliance upon complex statistical analysis such as Multiple Factor Analysis. This could be difficult for a design student to run and understand. This technique would have been more useful if a simple form of data analysis was used to generate the visual results. However, the main advantage of Napping® is that this technique produces a list of adjectives suggested by consumers and not one derived from designers. This helps avoid what Hsu, Chuang, and Chang’s (2000) observed, that designers and consumers have two distinct perceptions regarding products and their attributes. This is consistent with Lin and Huang’s contention. “The
design of product form, functions and interface should be triggered from the user’s points-of-view. In a competitive market, the product that can truly meet the user’s needs, but not those of leading techniques, will turn out successful” (2006, p. 1) This idea of asking consumers for their point-of-view of products could be beneficial to a design student in developing a product based on consumers’ perspectives. For this reason, Napping® will be considered further in this thesis by enabling design students to use this technique to first ask consumers, to suggest some suitable attributes of products. Design students can then use these attributes for user testing.

2-Dimensional map

A 2D map technique allows respondents to drag-and-drop pictures or stimuli on a 2-dimensional space based on two sets of pre-assigned adjectives or Semantic Differential (SD) scale (Osgood & Suci, 1955) for the purpose of products evaluation (Lin & Huang, 2006). The 2-dimensional space is an intersection of X and Y coordinates forming four quadrangles. In their study, Lin and Huang (2006) developed a web-based 2-dimensional image scale analytical tool as discussed in the previous chapter. To refresh, the example of a 2D map is shown in Figure 9.
Figure 9: An example of a 2D map with six products (blue circles) located based on two sets of adjectives (Good – Bad, Pretty – Ugly).

This 2D map technique plots consumers’ perceptions of products that can later be analyzed by researchers without asking direct questions. Participants were asked to position products (see Figure 9 – the blue circles) on the map according to the adjectives and the participants’ perceptions. They were told that, products which are placed close to another product are considered to be similar, and products placed further apart are assumed to differ from one another. This technique shares the same characteristic with the projective techniques discussed earlier, concerning the ability of getting consumers’ opinions without directly asking them. However, for the purpose of data analysis, a 2D map technique portrays better characteristics because this technique could generate the results more quickly than the projective techniques.

While other techniques require data entries, transformation and processing in order to be analyzed, this technique allows direct or automated data entry to a computer software tool and can be analyzed immediately. Potential human errors can thus be avoided; for example, mistyping the data. Another advantage of this technique is that the use of visual image positioning on the 2D space could well fit with design students’ visual skills, considering their ability to see and appreciate objects visually (Kälviäinen
& Miller, 2005). At its worst, however, the authors overlook the fact that this technique involves statistical analysis (i.e. one way MANOVA) to generate the results and this can be difficult for a designer (Lin & Huang, 2013). Another weakness is that the authors offer no explanation as to how the results were obtained, such as the type of software tool used.

Nevertheless, this 2D map technique appears suitable for a design student to gather data from target consumers. This technique can be more useful if a simpler statistical analysis was involved and this process can be carried out automatically. This way, no training is required for design students to run analyses and to obtain real data in supporting their product creation, as long as they can understand and interpret the results. Therefore, a 2D map technique is considered further in this thesis as the second data collection technique after Napping, allowing design students to use the attributes found through Napping, into the 2D map technique and run user testing in understanding consumers’ perceptions of products. However, the type of visual analyses for processing data gathered through Napping and a 2D map technique suitable for design students need to be investigated.

An investigation of visual techniques for data analysis

Preliminary analyses from the archival research and interviews suggest that design students have no training of associated skills for user testing and data analysis. Hence there is a strong possibility that they may have problems running statistical analyses and trying to understand the output. Exploring complex statistical analyses such as Principal Component Analysis or Multiple Factor Analysis appears futile. Moreover, the existing software tools might have been far more relevant and useful to a design student if the authors had considered using the most basic statistics such as the Mean and Frequency distributions.
Descriptive Statistics

This researcher decided that including descriptive statistics that could be of value for a design student, such as the central tendencies of a distribution, namely the Mean, Median, Mode as well as Frequency, should be included in the new tool. Of course, in order to apply statistics in research, more techniques are needed involving, for example, data sampling, variable selection and data distribution. To use advanced statistics such as inferential statistics, researchers must have the solid knowledge of fundamental statistics. For the purposes of this research, the descriptive statistical concepts were selected as a starting point to introduce a design student to the power of statistics. More analysis options will be added in the future.

Other analyses

This study also explored other types of statistical analyses that are suitable for design students to conduct systematic analysis and interpret data, besides Descriptive Statistics. One possible approach is to use a different type of MDS known as the Non-Metric Guttman-Lingoes statistical series such as Smallest Space Analysis, Partial Order Scalogram Analysis, and Multidimensional Scalogram Analysis. These techniques were selected because they have unusual characteristic, namely, they are assumption-free and distribution-free (Field, 2009). In other words, they make few assumptions as to the type of data that can be used, whether or not the data were normally distributed or if some of the data were missing. These techniques work on the data ranking principle; for example, the highest score will be ranked as ‘1’, the second highest score ranked as ‘2’, and so on. This type of analysis is therefore carried out on the rank (ordinal data), not on the actual data. Additionally, these techniques generate visual and intuitive output that could be of use to a design student. Further discussions of these analyses follow.

Smallest Space Analysis

Smallest Space Analysis (SSA) is “an attempt to find the minimum number of dimensions in which a body of data can be adequately represented” (Nutch &
Bloombaum, 1968, p. 116). Bailey further described SSA as a technique that “provides a graphic or visual portrayal of points in some smallest space” (1974, p. 4). The points can be any objects such as persons, occupations, variables (e.g. age, sex, ethnicity, space, volume), or places (Amar & Toledano, 2001). Bloombaum (1970) cited one advantage of SSA.

“This method is recommended for those jobs where the investigator desires a rigorous multivariate analysis under the constraints of no special assumptions. A pleasing related feature of the techniques discussed here is that the results achieved are directly and intuitively interpretable by relatively untutored persons, as well as by the scientist who takes responsibility for his project in its entirety” (p. 409)

SSA produces graphical outputs that are used exclusively to study relationships in a data set. This technique uses distance coefficients as input data, and generates a point space (x, y coordinates) as the output.

To better understand this concept, Shye (1985) described SSA based on a data matrix. For example, a group of six respondents was assessed according to certain traits such as some kind of ability, or characteristic. The traits were evaluated based on a set of tests and the results were recorded based on a score: for example, the scores of ‘1’ and ‘2’. Hence, a data matrix of six respondents and nine tests could be as follows, shown in Table 5.
Table 5: An example of a data matrix

<table>
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<tr>
<th>Individual No</th>
<th>Test No</th>
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</table>

Table 5 shows the data matrix with six profiles of scores based on individuals in all nine tests. For example, the profile for Individual 4 is 121111112. Shye highlighted that the “individuals” need not be people; they can be any objects such as buildings, years or countries. SSA focuses on the trait perspective, by mapping variables or tests (according to columns in Table 5), reflecting the similarities and differences among them (Shye, 1985). These qualitative data gathered were then exported to the statistical software tool to generate the results as illustrated in Figure 10.

According to Figure 10, each test is represented as a point in a Euclidean space. For this example, items 2, 7, and 8 are considered similar, whereas items 1 and 2 are far apart, thus considered to be different. Apparently, the map generated by SSA was
similar to the perceptual map obtained from typical MDS including the way to interpret both maps. It can be concluded that SSA could also create Perceptual Maps similar to normal MDS. In fact, the map formed through SSA was regarded as being more easily interpretable than other techniques. Bloombaum added, SSA “requires little in the way of statistical assumptions” (1968, p. 328). For these reasons, SSA could be a useful technique for a design student to generate maps and understand data. Hence, SSA is considered ideal for the analysis technique of the new tool and will be discussed further in this thesis by generating output similar to a perceptual map. Design students would be able to interpret the results because it is simple and easy to understand.

**Partial Order Scalogram Analysis**

Another empirical analysis technique of the Guttman-Lingoes series is Partial Order Scalogram Analysis (POSA). According to Sabbagh, Cohen & Levy (2003), POSA “orders individual users according to their patterns (styles) of responses across a series of stimuli” (p. 328). While SSA focuses on tests/variables, POSA focuses on individuals’ profiles (please refer to Table 5, on rows in the data matrix). POSA ranks these individuals based on their possession of the trait. Hence, with POSA, users are able to explore the individuals’ styles of responses as shown in Figure 11.
Figure 11: An output of POSA

Figure 11 shows the mapping of individuals’ responses according to five variables (A, B, C, D, and E) with its frequency in brackets. In this example, the scales used were dichotomous with ‘1’ = Yes, and ‘2’ = No. It can be seen that the most frequent answer profile was ‘11111’ (with the highest Frequency of 676), which means participants answered ‘yes’ to all five variables. The second highest was ‘11121’ (with a Frequency of 83) which means, these participants answered ‘No’ for variable number 4, with the other variables as ‘Yes’. The process continues until all data have been read.

However, the map of POSA, for the design students may be difficult to interpret, considering their limited knowledge of user tests and running analyses. For this reason, POSA was not considered further in this research.

**Multidimensional Scalogram Analysis**

Multidimensional Scalogram Analysis (MSA) is the third type of Guttman-Lingoes statistic for visual data analysis considered here. It has been widely used in applied psychology, particularly in the investigation of crime (Wilson, 2000; Bradford & Wilson, 2013). This technique is used to provide a geometrical representation of
categorical data. MSA, compared to other techniques, enables users “to explore possible multivariate relationships between the variables” (Morrison, 1990, p. 62). The inter-relationships between behaviours can also be investigated through MSA (Bradford & Wilson, 2013). Zvulun (1978) explained MSA as a technique that “creates a multidimensional space where the structuples are represented as points, the items as partitions, and the categories of the items as regions of the partitions” (p. 240). The map can be interpreted in a similar way to Perceptual Mapping, in which profiles close to each other are considered to be similar, while profiles more widely separated are considered to be different (Morrison, 1990). MSA can be described with the following example.

Morrison (1990) used MSA in a study of the use of seclusion in acute psychiatric settings. In his study, each patient was considered according to six variables: “the status of patient,” “the staffing level at the time of the seclusion,” “the frequency of seclusions,” “the time spent in seclusion,” “the sex of the patient” and “the number of different staff authorizing seclusion for each patient.” Hence, the possible profiles or structuples generated could reach up to 64 with two categories for each variable (2 x 2 x 2 x 2 x 2 x 2 = 64). Each variable was assigned a dichotomous code: for example, for “the sex of patient”, the variable was represented by two strings of Male = 1 and Female = 2. Hence, one example of a profile could be ‘111212’, according to categories and variables. However, MSA only plotted and analyzed profiles that are unique or different from each other, with no frequencies stated on a map (Zvulun, 1978). Therefore, one profile plotted on a map can represent more than one respondent. An advantage of MSA is that, users would be able to view and contrast profiles and variables on separate maps to see the similarities and differences, as illustrated in Figures 12, 13 and 14. First, the overall profiles were plotted.
Figure 12: Overall MSA plot

Then followed a plot for each variable (see Figures 13 and 14).
Figure 13: MSA Plot - According to the variable of gender

Figure 14: MSA Plot – According to the variable of age group

Users will then interpret the map by drawing a line manually on the output according to the distribution of categories to identify regions. For example, in Figure 13, a straight line dividing the two categories of ‘1’ and ‘2’ was drawn. The same
process continues with Figure 14 and other variables (if any). Once the regions are
drawn, the users can compare these regions’ overlap between variables and profiles
(Wilson, 2000).

MSA can be considered unique because the technique enables users to explore
the inter-relationships between responses and variables gathered. Still, interpreting the
MSA maps can be complex; they require some knowledge of visual analysis,
particularly in identifying regions and relating between outputs to find more insight.
Hence, this technique was considered less than ideal for design students and is not
discussed further in this thesis.

Discussion

The investigations identified several techniques for collecting and analyzing
data, potentially appropriate for design students to run user tests.

For data collection, two techniques were mentioned: the Napping® procedure
and 2D maps. As discussed earlier, Napping®, borrowed from the food industry, is a
promising technique for consumers to evaluate products and suggest relevant adjectives
describing the products. This issue of allowing consumers to suggest relevant adjectives
for evaluation rather than from the designers’ points-of-view was also found in Chapter
4 (p. 62). With respect to this research, Napping® could be incorporated in the new tool
such that participants would be asked to position product images on a blank interface
screen. There will be no criteria provided, except to say that products close to one
another are similar and products located far apart are different, also discussed in Chapter
4 (p. 55). Respondents would later be asked to enter adjectives that they think relate to
the products. The new tool would then process these data and generate a list of
adjectives for future reference. This technique allows design students to establish
opposing adjectives appropriate for further studies based on the judgment of users, not
the researcher. This way, a design student would be able to apply the most frequent
adjectives mentioned by participants in the second technique, a 2D map.

Using a 2D map technique, based on sets of opposing adjectives derived from
the first technique, a design student may further study a user’s perceptions of products
at a later stage with more relevant sets of adjectives. This technique may be beneficial to design students and novice designers who may lack the skills, knowledge and experience to communicate with clients and consumers and to carry out empirical research.

For data analysis, this study concluded that, as well as introducing the basics of statistics through Descriptive Statistics, Smallest Space Analysis could be another way of presenting the visual results to a design student. The new tool will produce results with a combination of Smallest Space Analysis as a general visual output, and Mean, Frequency, Median and Mode as another extension of the general results. These analyses can be carried out automatically in the new tool with no statistical skills needed.

**Implications for an effective data collection and analysis tool for a design student**

Design students need a mechanism for collecting and analyzing data and using these data to support design decision-making to create successful products. At the same time, it must also help to convince clients to invest in the development of the proposed new product. Hence, this study proposed developing an interactive and systematic data collection and analysis tool for design students. Based on the investigations conducted thus far, this researcher believes an effective tool would fulfill the four criteria presented next.

I. **Enable a design student quickly to design a systematic visual survey**

   This includes setting up the details of a study, sample size, choosing appropriate demographic questions, importing stimuli and adjectives relevant for investigations. It has been observed that none of the existing tools investigated integrate any of these components to guide a design student to carry out effective and systematic user testing.

II. **Enable a design student to collect and analyze data quickly and easily, with no statistical knowledge and skills required.**
Most of the existing tools require various types of complex statistical analyses that can be problematic for a design student. Thus, an effective tool should provide an automated analysis, where users can simply collect data and Run Analyses with little to no knowledge of statistics.

III. Enable a design student to understand how statistics can be of help in analysis.

One major drawback of existing tools is that they use complex statistics. An effective tool should provide simple and easy-to-understand visual analysis results using statistics to encourage them to use these statistical concepts in the future. The new tool will offer, at least for a start, simple analysis techniques that can help a design student to get to know statistics. This could influence design students to learn more.

Summary

This chapter reviewed existing techniques of data collection and analysis to be potentially integrated in the new tool that were deemed appropriate for a design student to conduct user tests to inform design decision-making. The study found two data collection techniques; Napping® procedure to generate a list of adjectives from consumers’ points-of-view; and a 2D map to run an image-positioning task using adjectives either recommended by consumers or by a design student. The study also identified Descriptive Statistics and Smallest Space Analysis as suitable techniques for analyses. In order to develop the new tool, the next step is to find appropriate theoretical models to guide and test this research. These will be discussed in the next chapter.
Chapter 6: Theoretical Models

This chapter presents a critical review of relevant theoretical models necessary to guide this research, namely to design and evaluate a tool to help design students systematically to collect and analyze consumer data. At the time of writing Chapter 2, it was unclear that a new tool would be needed. Therefore, it is essential now to investigate additional theoretical models to guide that part of the research. The prime candidate theories are presented in this chapter. Accordingly, a brief outline of Goals, Operators, Methods and Selection rules (GOMS) and Cognitive Complexity Theory are first presented, followed by a discussion of Cognitive Load Theory and then of Cognitive Theory of Multimedia Learning. A summary is presented at the end of the chapter.

Goals, Operators, Methods and Selection rules (GOMS)

The GOMS framework proposed by Card, Moran and Newell (1980; 1983) for user interface design comprises a set of procedures including goals, operators, methods and selection rules used to predict the efficiency of a computer system or comparing two or more systems by calculating the time it will take for a user to complete a given task (Schrepp, 2010).

Some advantages of GOMS are that a thorough task analysis can be completed without user involvement, which renders it an inexpensive method for evaluating the efficiency of a tool (Schrepp, 2010) and does not require high-fidelity prototypes or a running system (Huang, Hwang, Wang, & Liao, 2012). However, one major reason why GOMS is not suitable for this research is that it does not consider aspects of user learning and recall. The emphasis of the GOMS framework was to maximize the efficiency of skilled users carrying out repetitive routine tasks rather than to support novices or intermediate users (Olson & Olson, 1990). Olson & Olson (1990) argued that the framework focuses only on errorless performance, assuming that highly skilled users make no errors. Yet users at all skill levels do commit errors. In fairness it should be noted that GOMS evolved before direct manipulation interfaces were available,
when there was only one ‘best’ way for users to complete their routine tasks. Thus, GOMS enabled system developers to map the ‘critical path’ of tasks a given system was designed to support. In the present case, more advanced direct manipulation technologies were used in a design methodology that involves users throughout the design and development phases to ensure high levels of usability. For these reasons, GOMS was not considered further in this thesis.

Cognitive Complexity Theory

A second model related to designing user interface is Cognitive Complexity Theory (CCT) introduced by Kieras and Polson (1985) and used in Human-Computer Interaction (HCI) in the mid-1980s, also in the era of command-based and menu-driven interfaces. While GOMS aimed at the structure and content of the knowledge, CCT represents the amount of knowledge users need to successfully complete their tasks. That knowledge is represented by a set of system rules. In that sense, CCT may be regarded as an extension of GOMS (Bovair, Kieras, & Polson, 1990).

The main concern of CCT is to ensure that a new computer system is ‘easy to learn’ and ‘easy to use’ (Bovair, Kieras & Polson, 1990), addressing Olson & Olson’s concerns that GOMS focuses only on skilled users’ errorless performance. CCT thus extends GOMS by predicting the usability and ease of learning in operating new software, databases or operating systems based on task-completion time and user performance (Byrne, 2009). The aim is to quantify what and how much a new user would need to learn to operate a particular system effectively and successfully when performing particular tasks taking into account the learning and performance time (Bovair et al., 1990). Polson and Kieras (1984) argued that one must have the ability to predict users’ learning times and performance in order to use CCT for investigating the usability of a tool. A question arises; therefore, as to how one can predict precisely the time taken for learning and performance, when the users’ existing knowledge of using a tool and the ability of processing information is usually unknown and will vary. Another drawback of CCT is that it is limited to traditional system interfaces similar to the era of GOMS that require the use of specific selection rules in order to perform a task such as...
editing text (Polson, Bovair, & Kieras, 1987: Bovair et al., 1990). By contrast, the new tool developed in this thesis will be using a graphical user interface with no formal description of selection rules or commands needed for effective user operation.

CCT also suggests providing users with procedural knowledge or ‘how-to’ knowledge (Polson et al., 1987) when using a tool to execute a task. However, with today’s direct manipulation techniques, several different steps or alternative procedural knowledge are typically involved in achieving a goal. One could thus offer several techniques for collecting data, leaving it to the user to choose the best technique for the particular product design context. Once a technique has been selected, the user should then be able to follow a step-by-step procedure; for example, to create a survey, taking them through the sub-tasks of defining a study, deciding upon the sample size, defining demographic questions, entering a series of questions, saving and running the study with potential respondents. Reliance on procedural knowledge to perform a task is similar to the concept of Scripts mentioned in Chapter 2 (p. 27) whereby people behave according to a series of steps in a particular situation or to accomplish a task. The procedural knowledge is therefore useful for novices. To the extent that several data collection methods are offered in a single tool, this renders the tool very flexible. It would enable users to compare results obtained through different data-collection and analysis techniques. Nevertheless, flexibility would also increase the amount of learning for novices to use the application effectively and efficiently. However, if a flexible application offers too many ways to complete tasks, that could prove too complex for novices with no knowledge about user testing and data analysis. The preliminary data gathered in the present research (p. 47) showed clearly that design students had no working knowledge of statistics and hence no recollection of the steps and actions necessary for calculating, for example, the arithmetic mean or the median of a dataset. It therefore seems essential to provide adequate step-by-step information in the proposed tool to help them comprehend and eventually anticipate the steps needed when analyzing data statistically. Hence, this study follows CCT in the sense that it is essential to provide procedural knowledge or step-by-step instruction as highlighted in Scripts for a design student to accomplish a task in the proposed tool.
Cognitive Load Theory

A third model relevant to user interface design is known as Cognitive Load Theory (CLT), proposed by Sweller and his colleagues in 1980s. It focuses on problem solving and learning, for example in mathematics (Sweller, 1988). It has been widely accepted in educational psychology, computer technology and HCI (Chalmers, 2003). Consistent with CCT, CLT addresses “the amount of information processing expected of the learner” (Polson et al., 1987), hence, the main concern of CLT is on “the total amount of mental activity imposed on working memory at an instance in time” (Cooper, 1998, p. 11).

According to Cooper (1998), human memory comprises sensory memory, working memory and long-term memory that are integrated to form a human cognitive architecture. Incoming information is received from the five senses of sight, sound, smell, touch and taste into the relevant sensory memory. Sensory memory is activated quickly to ‘identify, classify and assign meaning’ to incoming information before transferring it to working memory (Cooper, 1998). Working memory is also known as short-term memory (STM). Working memory is used to attend to and process information (Baddeley, 1983; de Jong, 2010). Activities in working memory involve reading, problem solving, reasoning and learning (Baddeley, 1983, 1992), but information is only held temporarily and for short periods. By contrast, long-term memory (LTM) stores huge amounts of information permanently (Cowan, 2001). CLT, therefore is associated with learning and is concerned mainly with the limitation of working memory because a learning task that is too complex, requiring too much working memory capacity, hinders learning (de Jong, 2010). It is therefore important for learners to be able to process the new information in their working memory, and retain the knowledge permanently in the LTM for future use as well as to expand their existing knowledge.

Cognitive load is either intrinsic, extraneous or germane (Sweller, 1988). Intrinsic cognitive load inherently involves certain tasks that can be harder to learn and master. For example, answering the question of the outcome of 4 + 4 involves low intrinsic cognitive load for learners who are familiar with the method of addition. By contrast, a greater intrinsic cognitive load is required to solve a problem such as
complex algebraic equations. Instructors preparing materials or information for learners to master such a problem cannot alter the intrinsic cognitive load, which varies as a function of the learner’s level of existing knowledge rather than of the instructor’s presentation of the material. By the same token, an effective teacher will be able to present even complex material such that it becomes accessible to novice learners.

In comparison, an extraneous cognitive load involves irrelevant tasks or unnecessary information that forces learners to use working memory to process the information. For example, giving long and complex instructions for performing a task could increase the extraneous cognitive load. However, preparing the information with different techniques can reduce this extraneous cognitive load. For example, the modalities in which tasks are presented may affect the learnability of certain material that can be presented in writing, with audio, or via practical demonstrations (Paas, Renkl, & Sweller, 2003; Schnitz & Kürschner, 2007).

Germane cognitive load involves processing, construction and automatic activation of existing schemas to facilitate learning related to Schema Theory, discussed in Chapter 2 (p. 24). An important aim of CLT is thus to encourage low intrinsic cognitive loads and extraneous cognitive loads by providing simple instructions or information but with a high germane cognitive load to facilitate learning. When this is done successfully, the user will be able to store the new knowledge learned in LTM, expanding their existing knowledge as a whole. Keeping this in mind, information related to user testing, such as sampling and data collection, is a new skill for design students so it is important to provide a simple tool enabling a design student to understand and apply the new information when making design decisions for new products.

CLT suggests that a major contributor to cognitive load is the quantity of elements that need to be attended to by learners. "Elements" means the content of information presented to an individual (Cooper, 1998). For example, an Australian phone number generally has eight digits such as 11824455. By chunking the numbers into several ‘elements’ such as 1182-44-55, it is easier to remember and store in LTM. Complex information, such as mathematical calculations, can be difficult to learn - especially for design students who are not accustomed to rely on numbers in any way,
as the preliminary data showed. Chunking information into elements or smaller sections is similar to Miller’s (1956) theory of retention, according to which individuals can retain information better if it is presented in eight (±2) elements. However, retaining information in working memory for a given period was not applicable to the present research. Instead, design students were required to understand and use the new tool by following instructions and performing particular tasks. Even so, the notion of chunking information into smaller sections is still relevant, considering the lack of skills and knowledge of user-testing among design students. Hence, the tool should be organized into several sections.

The difference between intrinsic and extraneous load could also depend on the educational objectives (Schnotz & Kürschner, 2007). As those authors pointed out, reading complex legal documents by law students can be regarded as intrinsic load if they are unable to grasp their content due to comprehension issues. Legal documents could have been presented in a simpler version with comprehensible legal terms. Alas, this same situation would not be considered as an extraneous load because understanding complex legal terms and writing styles are part of a budding lawyer’s learning process. Hence, legal documents should not be changed to reduce the extraneous load when presented to law students. Applying the same concept to this research, in which it is important for design students to understand the value of basic descriptive statistical terms and the reasons for conducting user tests, would help them to become successful product designers. Therefore, providing proper interface design for design students is crucial to reduce extraneous load and promote learning.

CLT suggests several effects related to cognitive load such as split-attention effect and redundancy effect. Split-attention effect relates to placing several elements on the screen, forcing learners to split their attention between these elements, hindering learning (Cooper, 1998). For example, watching a movie with subtitles, video and audio all at the same time, could cause split-attention effect if the learners need to attend to all these elements at once. Redundancy effect, on the other hand, emphasizes the importance of placing only necessary information or elements on a computer screen (Cooper, 1998). If some information is sufficiently presented in text alone, adding a graph to illustrate the same information could cause redundancy effect. These two
effects provide an additional guideline to this present research and will be kept in mind in designing the new tool.

CLT also emphasizes the use of different instructional techniques to nurture learning, such as visual representations (Cook, 2006). According to Cook, considering the limited capacity of working memory, information should be designed with the goal of decreasing intrinsic and extraneous loads by using different instructional techniques. Providing visual illustrations could help learners make sense of textual information. This is highly relevant to providing a new tool designed especially for design students, given that they are naturally attracted to visual information and are typically more visually literate than students whose chosen field is not design.

Using different instructional techniques is the main aim of the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2005). It promotes the use of multimedia elements such as graphics, words, sounds, animation, video and gesture to foster learning. Mayer’s theory is based on three central assumptions.

First, it is assumed that human information processing is divided into two separate channels: one is visual/pictorial and the other is auditory/verbal. When visual information such as illustrations, video or animation is presented, information processing begins in the pictorial channel. If sound-based information is presented, such as nonverbal sound or narration, the processing starts in the verbal channel. This assumption of CTML is based on Paivio’s (1991) classic dual-coding theory that describes the use of mental images to assist learning. In particular, Paivio emphasized both verbal and visual forms of representing information because these involve separate channels for processing information, thereby freeing up space in working memory for deeper learning. Paivio, however, did not explain the use of elements other than verbal and visual to represent information.

Mayer’s (2005) second assumption is based on Baddeley’s theory of working memory, according to which each channel has limited processing capacity to process and store information simultaneously. The third assumption of CTML is that people possess active processing capacity. This implies that learners will attempt to make sense of information when they pay attention to the relevant material by selecting, organizing and integrating it with their prior knowledge (Mayer & Moreno, 1998; Mayer, 2005;
Sorden, 2012). This active processing refers to the ability of an individual to relate and combine information received through separate channels forming a single mental representation. One question that needs to be asked, however, is how would design students be able to select, organize and integrate information for which they have no existing knowledge? It is likely that design students have some experience selecting a mobile phone, for example. By doing so, they would probably have compared different deals, different service providers, and different phones to ensure they select what best suits their needs. They would thus have sampled data from different sources in the process of making a good decision. Therefore, it can safely be anticipated that they do know something about data collection, but they have not thought about it in connection with their work. This would also suggest that learners construct knowledge meaningfully when they pay attention to the relevant material, organize it into a coherent manner, and assimilate it with their prior knowledge, similar to the Conceptual Change Theory discussed in Chapter 2, (p. 30).

Although there is some evidence to support the claim that presenting information in several techniques, such as the use of graphics or other elements, aids learning (Mayer, Bove, Bryman, Mars, & Tapangco, 1996), other research suggests that this is not normally the case. For example, Westelinck, Valcke, De Craene, and Kirschner (2005) carried out an experiment to investigate the validity of CTML specifically on the multimedia, spatial contiguity and coherence principles to facilitate learning by adding external graphic representations on paper-based and electronic learning materials among first-year students at a university. In CTML, multimedia principle focuses on the use of multimedia elements such as graphic, text, video and animation to facilitate learning, spatial contiguity principle emphasizes placing words and pictures on the same page/screen, and coherence principle highlights the need to exclude extraneous sounds, words and pictures to facilitate learning (Cooper, 1998). The study took special care in producing the graphical representation for both printed and animation materials by consulting at least 20 fourth-year students to find the best graphics. The materials given were considered to be difficult and new to the first-year students because they had no prior knowledge of the materials. They were given a pre-test to determine their prior knowledge, training with the relevant materials, and post-
test questions for retention and transfer tests. Students learned with no graphics representation; with illustrations that were not spatially integrated; and with animations and sound but no narration, performed better. The study concluded that instructional designers could not simply apply CTML in designing instructional materials. However, this study suggests that instructional designers need to take extra care when choosing any graphical representation for a learning material relevant to individuals’ differences. This was a crucial issue that was not addressed in this experiment and could lead to different results. This finding appears comparable to Cook (2006) in the sense that suitable design and consideration between different learners need to be taken into account due to different prior knowledge, experience, skills and preference among learners.

Presenting information with many elements, however, could also impede rather than facilitate learning (Mayer, Heiser, & Lonn, 2001). Mayer, Hegarty, Mayer, and Campbell (2005) conducted an experiment for teaching psychology students how lightning develops. One participant-group received a paper-based version (static diagram and text) and the other a computer-based (animation and narration) version where the narration was simply speaking the text. The graphical materials used were the same for both modalities. Retention and transfer tests were conducted immediately after reading/watching the material by asking participants about lightning, and having them answer four questions on applying the lessons learned in other situations. Questions such as “What does air temperature have to do with lightning?” were asked in the transfer tests, all requiring written responses. Performance between the groups did not differ statistically, suggesting that animation does not necessarily aid learning. This finding suggests that animation may, on occasion, be unnecessary when designing new software. Additionally, information about the prior knowledge of participants was unfortunately not mentioned in the study.

In addition to the three major principles outlined above, CTML adds several others, some of which may be considered parallel to CLT principles. For example, in CTML, according to the temporal contiguity principle words and pictures should be presented simultaneously, and the spatial contiguity principle emphasizes placing words and pictures on the same page/screen. These aim to avoid the split-attention effect in
CLT (Cooper, 1998; Cook, 2006). It can be avoided by presenting only task-relevant material on the screen. The CTML coherence principle, highlighting the need to exclude extraneous sounds, words and pictures to facilitate learning, is comparable to the redundancy effect in CLT according to which information presented in a single mode to encourage learning may be more effective than adding modalities that are not necessary to convey the topic effectively (Cooper, 1998). Indeed, adding unnecessary information could confuse the learner, thereby making the material more difficult to learn. These suggest that the principles of CTML are parallel to CLT that had already been introduced (in the 1980s).

CLT is regarded as very suitable for guiding and testing the design of the new tool in this thesis. Although some evidence points to benefits of adding sound and animation to learning material, neither of these were deemed necessary in the design of the new tool that should be simple and quick, that involve exclusively the two important tasks of collecting and analysing data. Also, although it is reasonable to accept Mayer’s three main assumptions of CTML, it is beyond the scope of this research to put any of those to the test. Therefore, it is safe to conclude that CTML provides those principles that are already outlined in CLT, which makes CTML superfluous for designing the new tool.

CLT was selected as the most relevant theory to guide the design and development of this research due to several reasons with respect to design students’ prior knowledge to run user test and perform statistical analysis. This theory provides useful guidelines to be considered. Firstly, it provides a simple tool that allows design students to easily understand and appreciate the tool. Secondly, designing a tool in such a way that it can be divided into smaller sections, frees up more space in their working memory to process and use the tool effectively. Thirdly, using different instructional techniques to present the information in the new tool; in this case, visual techniques for data collection and analysis, are highly relevant to designers generally, and design students particularly.
Summary

This chapter has critically reviewed several theoretical models relevant to guiding and testing the design of the new tool. The investigation suggests that GOMS, while historically interesting, is not suitable for the present purposes. However, a small part of Cognitive Complexity Theory was deemed relevant to this thesis by providing a step-by-step instruction, allowing a design student to follow the procedure for better learning. The review also revealed that the Cognitive Load Theory is highly relevant to the research, and that it shares several elements with the Cognitive Theory of Multimedia. Nevertheless, the Cognitive Load Theory was more useful and relevant because it would be able to underpin this research, considering the limited knowledge of user testing and statistical analysis among design students. It is necessary to design a simple software tool for data collection and analysis, presented in different instructional techniques and smaller sections to reduce cognitive load and foster learning. Given that the proposed tool is technology-based and interactive, software development methods are reviewed in the next chapter.
Chapter 7: Reviewing and Selecting a Suitable Technique

This chapter reviews candidate user interface design and evaluation methods in order to select the most suitable technique to guide the design and interaction of the student support tool to be developed. The goal of all user interface design is to apply an interaction model to accomplish usable, pleasant and effective user experiences. Within the field of software development, there are numerous techniques for the software development process. However, this chapter focuses exclusively on user interface design techniques, which are the major techniques encompassed all other techniques in User Interface Design. Accordingly, the review of Usability Engineering Lifecycle is presented first, followed by a discussion of Usage-Centered Design. The User-Centered Design model is presented next, followed by a summary at the end of this chapter.

Usability Engineering Lifecycle

The Usability Engineering Lifecycle model was proposed by Mayhew (1999) as one of the modern software engineering methods after the traditional system-centered design, the Waterfall model (Royce, 1970) that preceded other software development models. The Waterfall model carried out systems development in a set of linear phases (Requirement Analysis > Design > Implementation > Testing > Installation > Maintenance) where each phase must be completed before proceeding to the next. One major drawback of the Waterfall model was that it gave no opportunity to revisit any phase. The Usability Engineering Lifecycle then embedded usability elements into the traditional Waterfall model, but in the usability framework the target audience of a system was iteratively involved in the user interface design, thereby increasing the chances of developing usable systems.

The Usability Engineering Lifecycle model starts with a systematic and structured requirements analysis that includes user profiles, contextual task analysis, and platform capability constraints (Mayhew, 1999; 2009). In the present research, the user profiles of design students were already known, as reported in Chapters 3 and 4.
Hence, it was unnecessary to generate user profiles to gather information about the target users. Likewise, the contextual analysis in this thesis was limited to collecting and analyzing user-based data. Platform issues were not settled early on, as it was decided that the new tool should be compatible with desktop as well as tablet platforms to maximize flexibility.

Data gathered via requirements analysis are used to set up measurable usability goals for a new system to be proposed. Elaborating further, the model achieves the defined usability goals through iterative usability evaluation methods including work re-engineering, conceptual model design, user interface mockups, prototyping, as well as usability testing. The iterative process finishes as soon as the usability goals are met or all allocated resources consumed (Seffah, Desmarais, & Metzker, 2005). Each iterative evaluation process is run to refine the conceptual design model, user interface mockups or usability testing, depending on the level and task of the development phase (Mayhew, 1999). Each phase has separate iterative evaluation. In relation to the present study, while setting up usability goals was important to ensure the usability aspects were covered, other components of the Usability Engineering Lifecycle were deemed unsuitable for the present research. For example, the concept of work re-engineering is very useful when designing work-related systems, but the objective of designing the new tool in this thesis was mainly to assist design students carrying out systematic research rather than to replace existing design practices, although one could argue that some of the rather ad hoc practices uncovered and reported in Chapter 2 should be amended to incorporate systematic data collection and analysis techniques. However, work re-engineering as outlined in Mayhew’s model was beyond the scope of this thesis.

As highlighted by Mayhew, the Usability Engineering Lifecycle has been successfully applied in various projects including scientific applications and medical equipment, varying in budget, size, complexity and time frame (Mayhew, 1999). At its best, besides the integration of usability practices throughout the process, facilitating system ease of use and learnability was the aim of the Cognitive Complexity Theory (p.84), Mayhew’s model covers comprehensive and structured processes for software development with organizational and managerial strategies to guide the software
developers (Mayhew, 1998). This model would appear to be highly suitable for guiding the design and development of large and complex systems in large organizations in which the back-end system involves many tasks performed by a wide range of users. This present research, on the other hand, is searching for a method that is quick and easy for designing a simple tool that could focus exclusively on users (in this case, design students) as the main stakeholders and ensures that the tool is precisely tailor-made according to design students’ needs and requirements.

Usage-Centered Design

Usage-Centered Design, introduced by Constantine and Lockwood (1999) is used widely in software engineering to improve product usability. As the name suggests, Usage-Centered Design focuses on system usage so as to support all the user tasks to be accomplished (Kubicki & Halin, 2010). This method focuses on the software usability including understanding the user intentions and usage patterns; that is, how people do things.

The method comprises three components, the role model, the task model and the content model. According to Constantine & Lockwood (1999) the role model describes a sequence of interactions between users and a system that identifies the possible roles various users can play when interacting with a system. In the present research, role models are unnecessary since the tool involves very clearly defined users and purposes. The new tool targets design students solely for the purpose of helping them to collect data systematically, conduct user tests and analyse data. Hence, no role models are required.

The task model refers to a series of user tasks, capturing what users do (Constantine & Lockwood, 1999). This model is based on ‘use cases’ that refer to lists of actions between a user and a system in performing tasks that are usually written in a textual form. Use cases are deliberately abstract; they do not prescribe how the user actions must be performed, or what kind of user interface will be used. This enables platform and UI decisions to be separated from the bare actions, thereby enabling the project team to focus entirely on actions required by both user and system. The purpose
of use cases is to facilitate discussion among the software development team and their business partners to document the anticipated actions of a user and a system for future reference, and to represent services that a system offers users (Constantine & Lockwood, 2001). The present research involves no use case because the scope of the new tool is relatively small and restricted to only two main tasks - data collection and analysis - so use cases are unnecessary.

At its best, this method provides a systematic and structured model to develop a software tool (Constantine & Lockwood, 2002). However, the Usage-Centered Design method may limit the possibilities of providing a better user experience because the design is practically based on the UI designers’ perspectives, not driven by user input. Furthermore, evaluations and refinement of the prototypes occur only during the implementation stage (Constantine, Biddle, & Noble, 2003), which is too late for iterative usability assessments. Nevertheless, this method is appropriate if the software developers have no idea of what the users initially need and do. This study, however, is more concrete since the concept and purpose, users, tasks and techniques have been determined based on the preliminary data; therefore this method is regarded as not suitable for the present research.

**User-Centered Design**

The third software development method discussed is the User-Centered Design (UCD) model. Norman coined the term ‘user-centered design’ in the early 1980s, although there was no exact date of the original idea that products should be designed “…based on the needs and interests of the user, with an emphasis on making products usable and understandable” (Norman, 1988, p. 188). UCD puts users at the center of the design from the start through to the user acceptance studies (Abras, Maloney-Krichmar, & Preece, 2004). This simple model is regarded as the key to product ‘usefulness’ and ‘usability’ (Mao, Vredenburg, Smith, & Carey, 2001). In the present research, UCD, with its emphasis on users, could be relevant to the concept of providing a tool dedicated for design students specifically to conduct user testing and to run statistical analyses by optimizing users' needs, wants and what users can do, rather than forcing
them to become familiar with the new tool. A tool is defined as “a piece of software that carries out a particular function…” (Oxford Dictionary, 2012). This study defines a tool as a piece of software that carries out functions of collecting and analyzing data supporting a user to understand data.

Deliberations within the early UCD community focused on how to gather information from users. Gould and Lewis (1985) argued that a system designed for users should be designed for usability that included easy-to-learn, memorable, beneficial, suited to the users’ needs, easy and pleasant to use. They suggest three principles for creating usable systems. Firstly, user interface designers must gather data directly from users, such as through interviews or observation prior to designing a new system, rather than relying on secondary data. Secondly, they recommended the use of ‘empirical measurement’, for example prototyping or simulation to represent the actual system, whereby users must be given a chance to use the prototypes, and then studying users’ responses. Thirdly, they proposed carrying out iterative evaluations through user testing to refine the prototypes. ‘Iterative’ means, “there must be a cycle of design, test, and measure, and redesign, repeated as often as necessary” (Gould & Lewis, 1985, p. 300). A cycle of design, for example the transition from evaluation to analysis, occurs when the same usability issue is found during user testing; the evaluation stops, analysis is carried out to redesign the prototypes, then testing is repeated until no more usability issues are found.

Usability, according to ISO 9241-11, is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (1998). Usability of a product can be accomplished by running usability testing and, as described by Abras et al. (2004), usability testing is regarded as the most accepted method in UCD. Similarly, other researchers found that usability testing is regarded as one of the informal and flexible methods that have been well accepted and most established among UCD practitioners (Mao et al., 2001; Vredenburg, Mao, Smith, & Carey, 2002). The tests are employed to ensure a tool is usable, ready to be implemented and released for widespread use. This test can be considered as user requirements analysis as demonstrated by Lindgaard, Dillon, et al. (2006) where low-fidelity prototyping in usability testing is sufficient to
gather user requirements and to refine the prototypes and achieve better ideas before the actual implementation phase. Therefore, usability testing is regarded as suitable for the purpose of this research and will be used to evaluate the new tool to ensure the tool is usable.

There are two important concepts of usability: formative usability and summative usability. While summative usability concerns evaluating a product through defined measures instead of identifying problems, formative usability focuses on detecting and eliminating usability problems (Lewis, 2014). Both concepts require a number of similar properties in assessing usability including the “initial instructions and debriefing protocols; participants; and appropriate tasks and environments” (Lewis, 2014, p. 9). However, summative usability is more traditional with no interaction between observers and participants. Further, no enhancement is made to a system throughout the test but the emphasis is more on measuring the efficacy of the final design with respect to usability. In comparison, formative usability is more formal (although it can sometimes be informal) and involves participants working on either low or high fidelity prototypes for evaluations. In other words, formative usability testing involves design, evaluation and redesign to ensure that the prototype is usable before its release, while summative usability testing is usually done after the software has been developed for example, running User Acceptance Test (UAT) to measure and validate the usability and satisfaction of a tool. Hence, there is little support for product enhancement. However, in the present research, both formative and summative usability testing are seen as ideal and important to help designing and evaluating the new tool with the involvement of design students. For these reasons, both formative and summative usability testing will be used to design and evaluate the new tool.

Prior to running usability tests, one needs to determine several variables, including usability goals, to guide the evaluation procedures and the selection of benchmark tasks (Lindgaard, 1994). Usability goals set the parameters for the expected user performance in the various tasks to help the designer determine if a given task is a ‘pass’ or a ‘fail’ (Lindgaard, 1994). Potential hints, questions and errors allowed are all decided upon for that same purpose. Performance measures are decided upon before running a usability test. Lindgaard and Chattratchart (2007) emphasized the importance
of user tasks in usability testing to guide users evaluating a tool and ultimately to reveal usability problems. These guidelines of running usability tests are considered appropriate for the present research and will be kept in mind when evaluating the new tool.

Another important variable of usability testing is of course to use a valid and robust rating scale to measure the usability of a system. The System Usability Scale (SUS) developed by Brooke (1986) is a “quick and not so dirty” (p. 1) usability rating scale that has been well-accepted in testing the usability of a system since the 1990s. While various excellent alternatives of usability rating scales are available from which to choose, including USE (Lund, 2001) and WAMMI (Kirakowski & Cierlik, 1998), SUS holds several significant advantages. SUS has been widely used by usability professionals until recently because of its validity, reliability and, most importantly, because it is very simple and easy to administer with only a 10-item scale used (Bangor, Kortum, & Miller, 2008; Kortum & Bangor, 2012). Additionally, SUS is free for use by any researchers or practitioners, as well as being flexible and can be used to evaluate any kind of website and a variety of products including mobile applications and health systems (Kortum & Bangor, 2012). The objective of this research was to develop a simple and quick tool enabling a design student to collect and analyze data; therefore, SUS is deemed suitable for this purpose. For these reasons, SUS will be used to evaluate the usability of the new tool to be developed.

Together with the definition of usability by ISO 9241-11 (noted earlier) that relates to effectiveness, efficiency and satisfaction which leads to a usable product, Rogers, Sharp and Preece further emphasized usability as “ensuring that interactive products are easy to learn, effective to use, and enjoyable from the user’s perspective” (2011, p. 19). They argued that well-designed products must take into consideration other aspects of design to offer effective user experience (UX) as the center of interaction design (Rogers et al., 2011). As outlined by Garret, “Every product that is used by someone has a user experience: newspapers, ketchup bottles, reclining armchairs, cardigan sweaters” (Garrett, 2010, p. 10). Rogers et al. (2011) recommended that in the effort to create enjoyable user experiences of a product, aspects of aesthetics and look and feel need to be considered. The experience of interacting with a product
that includes how people use, hold, feel, and look at it may affect their preference and liking for the product. This appears similar to a definition provided by Hassenzahl (2008) that refers to UX as “a momentary, primarily evaluative, feeling (bad-good) while interacting with a product or service” (p. 2).

Elaborating further, in recent years it has been progressively accepted that the design of websites and user requirements have shifted from usability to user experience, with the visual appeal or aesthetics as the main attention (Lindgaard & Dudek, 2003; Hassenzahl & Tractinsky, 2006; Thielsh, Blotenberg, & Jaron, 2013). The term ‘aesthetics’ is, however, interchangeably used between authors; for instance, ‘beauty’ and ‘pleasure’ (Thielsh et al., 2013). Aesthetics is defined as “an immediate, pleasurable, subjective experience that is directed toward an object and not mediated by intervening reasoning” (Moshagen & Thielsh, 2010, p. 690). Traditionally, the shift from usability to aesthetics can be traced back to 2000, when Tractinsky, Katz, and Ikar (2000) extended earlier results by Kurosu and Kashimura (1995) that showed a significant relationship between perceived visual aesthetics and subject evaluations of usability. Tractinsky et al. (2000) concluded that aesthetically pleasing or beautiful design is usable, which then inspired much research on the association of perceived usability and aesthetic appeal of products (Hassenzahl, 2004; Sutcliffe & De Angeli, 2005; Ben-Bassat, Meyer, & Tractinsky, 2006). Other researchers have suggested that aesthetic appeal could improve performance (Sonderegger & Sauer, 2010), satisfaction (Lindgaard & Dudek, 2003), fun and pleasure (Jordan, 1998) and ultimately foster learning (Pomales-Garcia, Liu, & Mendez, 2005; Zain, Tey, & Goh, 2011). With respect to the present research, given design students’ sensitivities to aesthetics, that measure was considered especially important. Hence, inventing the new tool with a pleasurable experience is suitable for the design students and will be kept in mind when designing the new tool.

Visual aesthetics play an important role to give a good first impression to users. This element has been integrated as an important criterion in evaluating websites (Lindgaard, Fernandes, Dudek, & Brown, 2006; Lindgaard, Dudek, Sen, Sumegi, & Noonan, 2011). This ensures users will be interested to revisit the website, for example, buying products through online shopping websites or for learning. Visual Aesthetics of
Website Inventory (VisAWI) is a sound rating scale to accurately measure visual aesthetics of websites. It covers four facets: simplicity, diversity, colours and craftsmanship (Moshagen & Thielsch, 2010). Simplicity concerns perception and the making of the layout: for example, clarity, orderliness, homogeneity, grouping and balance. Diversity, on the other hand, focuses on visual richness, dynamics, variety, creativity, and novelty. Colourfulness, of course is related to colours and their composition. Craftsmanship refers to whether the site was created with care and skill through the latest technologies. At its best, VisAWI is regarded as a precise, inclusive and consistent instrument to measure visual aesthetics because this rating scale contains both practical and theoretical aspects of the interface (Moshagen & Thielsch, 2010).

visAWI has integrated simplicity and diversity as standard factors of aesthetic appeal since the work of Lavie and Tractinsky (2004). Simplicity, for example, is important in the sense that, if users cannot access information needed because a website is too complex, they can get frustrated and opt for another website. visAWI also covers colours as an essential factor of aesthetically-pleasing products because colours can stimulate psychological, cognitive and emotional responses (Elliot & Maier, 2007). Other research has found that website colour appeal is an important factor for website trust and satisfaction (Cyr, Head, & Larios, 2010). Craftsmanship ensures that a website was designed with appropriate skills in line with today’s latest technologies. VisAWI is limited to merely evaluating visual aesthetics and not other components of aesthetics such as audio or video (Papachristos & Avouris, 2013). However, these components are beyond the scope of this research and so not applicable. visAWI is flexible and comprehensive for evaluating the visual aesthetics of the new tool in this thesis. It will be used in the User Acceptance Study of the implemented tool to determine the level of satisfaction and aesthetic appraisal of the new tool. The relevant factors of influencing aesthetic appeal discussed earlier will be kept in mind when designing the new tool.

Given the rapid evolution of interactive technology, it is important to highlight that there were things that could simply not be done previously using the earlier models discussed above. Although sometimes considered as expensive to administer (Abras et al., 2004; Lindgaard & Chattratichart, 2007), UCD is one of the more practical ways of developing a software tool that possesses a broader focus than the other models, with a
greater emphasis on the user and less of a focus on the formal methods for requirements
gathering and specification. In addition, UCD provides a shift from linear, rigid design
processes to a more flexible, iterative design method. Moreover, UCD includes
additional aspects suitable for the design students, such as aesthetics as an important
indicator in designing successful products, as well as usability. The decision to use UCD
method for the design and evaluation of the new tool was made bearing in mind the
intended user, being design students, who are sensitive towards aesthetically pleasing
interfaces, as was found during the interviews (Chapter 3, p. 41). Aesthetic appeal is
capable of motivating a design student to keep using the new tool for collecting and
analyzing data, pleasurably. For these reasons, UCD is selected for the creation of the
proposed tool.

Summary

This chapter has reviewed candidate user interface design and evaluation
methods in order to select the most suitable method to guide the design and interaction
of the new tool. The Usability Engineering Lifecycle Model was reviewed first,
followed by the Usage-Centered Design. The review found that these models were not
suitable for the design of the new tool. The search found User Centered Design with
visual aesthetics is a suitable method for designing a new software tool for user testing
and statistical analyses specifically for design students, and UCD was selected
accordingly. The next chapter demonstrates the first formative usability testing carried
out in this thesis.
Chapter 8: Initial Design and Usability Testing of the new tool

This chapter discusses the initial design and usability testing of paper prototypes of the new tool. After designing the paper prototype screens, a pilot study was run, then the first formative usability testing, following the same methods. Then the results and discussion sections for both pilot and first formative usability study are discussed. Finally, a summary of the testing is presented.

Designing the prototypes of the new tool

The new tool, called Data Collection & Analysis tool for Design Students (DACADE) is an interactive software tool for assisting design students to systematically collect and analyze data for understanding consumers’ perceptions of products early in the design process. Another purpose of DACADE was to encourage design students to interact with consumers face-to-face during the data collection process, giving both parties more opportunities to share ideas and simultaneously to improve a design student’s communication skills. Some advantages of using DACADE over existing tools are that the user can collect data using two visual user interface modes, either a 2D Map or a Blank Screen, and generate visual statistical results such as the Smallest Space Analysis. The user would be able to save, download and print the results out for future reference or for presenting to a client.

Following the User-Centered Design method as discussed in Chapter 7, (p. 98), paper prototypes were first designed and tested. Rough paper screens were used because they are easy to handle, cheaper and quicker to produce than high-fidelity prototypes. In accordance with UCD, high-fidelity prototypes are “fully interactive, users can enter data in entry fields, respond to messages, select icons to open windows and, in general, interact with the user interface as though it were a real product” (Rudd, Stern, & Isensee, 1996, p. 78). However, high-fidelity prototypes are time-consuming and expensive to handle. By contrast, paper prototypes help users and designers to focus on the user interface (UI) and usability rather than worrying about colours, layouts, fonts, buttons, or metaphors. Psychologically, low fidelity paper prototypes make people feel
more relaxed and free to criticize than when exposed to high-fidelity or computer-based systems (Gerber & Carroll, 2012).

For a design student to use DACADE, the UI consisted of four main components.

**New Study**

This component enables the user to create a New Study for evaluating products based on consumers’ perceived similarities, differences and various adjectives. This component was divided into five steps.

1. The user enters the study details such as the study name, study description and the start and end dates of the study.
2. To enter the number of participants and, if relevant, the number of groups and to choose the type of demographic questions for the intended participants such as age group, gender, and work experience.
3. To enter an introduction to the study, for the consumers participating in the study.
4. To insert product images either from an existing DACADE database containing images or images stored in the user’s own files.
5. To assign descriptive adjectives on a 2D map(s) to guide consumers evaluating products unless a blank screen is used, in which case this step is superfluous.

**Edit Study**

The second component of DACADE works as an editor, allowing the user to change or amend the content of a study such as replacing some image products or adding more participant-groups to collect additional data. The UI of this component is a simplified version of the New Study section.
Collecting Data (i.e. running the study)

This third component of DACADE is to collect data by running a study created in (1) or edited in (2) with consumers. To do so, four simple steps were designed to guide the users through the data-collection process, starting by giving them an introduction to the study followed by a set of demographic questions, then the image-positioning task, which is based on perceived similarities and differences between the to-be-judged product images. In the 2D map method, the user simply positions products based on the adjectives assigned in the New Study module. Upon completion of positioning all images, participants exit the task. In the blank screen condition, the user positions products anywhere on the screen in whatever way they like. Once all images have been placed, they type in adjectives describing the images or clusters of images. Finally, the participant exits as the task has been completed.

Running Analyses

This last component enables the user to run one or more analyses on the data gathered in (3) above to generate results. They can choose among three types of analyses. For a 2D map, a Smallest Space Analysis generates a Perceptual Map and a Table of Statistics that consists of Frequency, the Mean, the Median, and the Mode. For the Blank Screen, DACADE offers a Table of Terms that generates a list of descriptive words or adjectives as suggested by participants during the image-positioning task.

The DACADE paper prototypes were prepared in two different platforms. The first three components of New Study, Edit Study and Run Analyses were designed as a browser-like template for desktop computers. Meanwhile, the Collecting Data component was designed on a tablet-like template. Dividing the prototypes into components was decided on a step-by-step approach to learning that was proposed by Kieras & Polson’s Cognitive Complexity Theory, Chapter 6 (p. 85) enabling a design student to simply follow the steps provided. The idea of dividing the prototypes into
components or sections was also inspired by Sweller’s Cognitive Load Theory (p. 88), reducing the cognitive load to use DACADE aiming to foster learning. The browser-like platform was chosen as the first template because the researcher intended to develop DACADE as a web-based application, allowing design students to create a study on a desktop computer due to greater storage capacity and DACADE would then be accessible anywhere at any time, providing easy access for design students to collect data using either desktop or tablet computers. Additionally, the tablet-like template was also designed to encourage design students to physically interact with consumers using a tablet computer such as an iPad. These two basic templates were downloadable via the Internet provided by a software company named UI Stencils (2009). In addition, the use of these two templates (web browser and tablet) was to give both the researcher and study participants a rough idea of the size, position and view of menus, buttons, and functions in DACADE.

For the purpose of evaluation, this study used the ISO-9241/11 (1998) definition of usability: “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” for the UI design of DACADE. Usability goals therefore must address all three usability components to ensure that DACADE is effective, efficient, and safe to use, as well as having good utility, being easy to learn and easy to remember how to use (Quesenbery, 2001).
First Formative Usability Study

The purpose of the first formative usability study was to identify usability issues in DACADE with a view to rectifying these before going on to the next version of the prototypes and the second formative usability test. As the method for the pilot study and the formal study was identical, the method section represents both of these.

Method

Participants

Two non-design students (one male) participated in a pilot study, and a sample of four communication- and industrial design students (two female) recruited from the Faculty of Design, Swinburne University of Technology, Australia, participated in the first formative usability test. These undergraduate and postgraduate students ranged from 20 to 37 years of age. Participants were tested in individual sessions taking between 30 and 45 minutes each. Participants in the pilot study were not paid; those taking part in the first formative study were given a $20 voucher at the completion of the test. The sessions were audio recorded with permission and transcribed verbatim. The test took place in a quiet laboratory at the Faculty of Design, Prahran campus.

Materials and Design

An audio recorder was used for voice recording during the sessions. Instructions to participants, the informed consent form and consent information statement and a demographic information form were prepared. Ethics clearance is attached in Appendix B, p. 227. At the end of each test, participants verbally answered the four questions shown in Table 6.
Table 6: The questions asked after completion of the formal study

<table>
<thead>
<tr>
<th>No</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What did you think about these prototypes?</td>
</tr>
<tr>
<td>2</td>
<td>What did you like the most about these prototypes?</td>
</tr>
<tr>
<td>3</td>
<td>What did you like the least about these prototypes?</td>
</tr>
<tr>
<td>4</td>
<td>On a scale of 1 to 10,</td>
</tr>
<tr>
<td></td>
<td>a) How usable did you think these prototypes were?</td>
</tr>
<tr>
<td></td>
<td>b) How satisfied were you with these prototypes?</td>
</tr>
</tbody>
</table>

To assess the different components of DACADE, the four paper prototype modules were produced to enable completion of four main tasks in DACADE as described earlier, namely:

1. Designing a new study was labeled New Study (10 screens);
2. Editing an existing study was labeled Edit Study (7 screens);
3. Collecting data (i.e. running the study) was labeled Collect Data (4 screens), and
4. Conducting simple descriptive statistical analyses, called Run Analyses – (5 screens).

Task scenarios and cover stories were prepared for each task and for each of the two analysis-types. Task requirements were generated for each task and given to participants one at a time. For the pilot study, one participant completed a task for blank screen UI, and the other for a 2D map. For the first formative usability study, two participants completed the tasks using a blank screen UI and the other two using the 2D map. These were counterbalanced. All tasks were completed in the same order: (1) Designing a new study, (2) Editing an existing study, (3) Collecting data from consumers and (4) Conducting simple descriptive statistical analyses.

For the 2D map UI, the adjectives assigned in the New Study task were Semantic Differential (SD) (Osgood & Suci, 1955) opposing adjectives that were
borrowed from previous research (Effendi R.A., 2011; Hashim, 2012), namely Like – Dislike and Cheap – Expensive. The stimulus set shown in Figure 15 included 10 cars adopted from Effendi (2011), to be judged using the adjectives and placed on the relevant screen. The same stimulus set was used in the blank screen UI.

![Stimulus Set Image](image)

*Figure 15: The selection of 10 cars used in the study*

An A4 size blank sheet and a pen were given to each participant to write down their answers. A marker pen was used as a pointer indicating how participants wanted to navigate the screens. During the positioning task in the ‘Collect Data’ task for the 2D map UI, each participant was given a large paper sheet (A3 size) for bigger projection and asked to select one image at a time and place it on the paper screen according to where they felt it should be placed relative to the two adjective-pairs on the paper screen as shown in Figure 16.
For positioning cars on the blank screen, participants were given a large blank sheet (A3 size) and required to write down as many adjectives as they felt they needed to describe the cars to represent their opinion.

The last task, Running Analyses, enabled calculation of the Frequency, the Median, the Mode, and the Mean of the research data. For the 2D map, a visual output of the distribution of cars was provided according to Guttman's 'Smallest Space Analysis' (SSA) (Guttman, 1968) that represents configuration points in a coordinate space. That is, the analysis plotted objects in a visual space, much like a perceptual map. In contrast, for the blank screen UI, the analysis task required participants to generate the list of adjectives of their own choice.
Cover Story and Tasks

The cover stories and tasks given to participants in this test were listed in Appendix B. Both Edit Study and Run Analyses tasks are shorter than the New Study and Collect Data; hence the Run Analyses tasks were added as the second task in Edit Study. See Appendix B – Tables 22 & 23.

Usability Goals

In order to determine the success of DACADE, usability goals were set in terms of the number of questions, hints and errors allowed according to tasks during the usability test shown in Table 7. The numbers between were based on the author’s best guess of the degree of difficulty associated with each task.

Table 7: Usability goals set in the first Formative Study

<table>
<thead>
<tr>
<th>Interface/task</th>
<th>Questions</th>
<th>Hints</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blank screen</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Edit Study</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Collect Data</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Run Analyses</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>2D map</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Edit Study</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Collect Data</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Run Analyses</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>
Hints, and the conditions under which these were given, were defined *a priori* to ensure that all participants would receive standardized, same amount of information. As Table 7 shows, questions were allowed in all four tasks and both methods; hints were allowed in two of the blank-screen, and in three of the 2D map tasks, and errors were allowed only in the New Study task.

For a hint to be given, participants were allowed 3-5 minutes to perform a task, depending on the task in question. In the event that a participant would get stuck and did not ask any question, the researcher gave one hint. For example, when positioning images of cars, some participants needed to be reminded: “…to position the stimulus anywhere on the blank sheet with no criteria and in no particular order. Cars placed closer to each other are considered to be similar, and cars placed far apart are considered to be different” (For all hints given, please see Appendix B, p. 234.)

**Procedure**

Upon arriving at the lab, the researcher welcomed and briefed participants on the purpose of the evaluation, emphasizing that the aim of a Usability Test is to assess the usability of DACADE - not to assess the participants - and that they could take breaks at any time. Participants were then asked to read and sign the informed consent form and fill in the demographic information form. Next, they read the relevant cover story and then they attempted the tasks, one at a time, at their own pace. Participants were asked to verbalize their thoughts as they went; the researcher took notes throughout. Upon completion of all the tasks, participants answered four questions verbally and discussed the test as well as DACADE. Finally, they were paid and excused.

**Results and Discussion**

The summary of the pilot study is presented first, followed by the summary of the first formative usability testing.
Summary of the pilot study

While the pilot study helped the researcher to familiarize herself with the process of running the usability test, it did identify six usability issues associated with three tasks, namely New Study (n=3), Collect Data (n=1), and Run Analyses (n=2). No usability issue was found in the Edit Study task.

For example, in creating a New Study, participants did select relevant demographic questions as expected; they thought the questions had already been selected by default. The participants also suggested changing the folder icon to a file icon for the Edit Study menu. The usability issues found were fixed prior to conducting the First Formative study.

Results and Discussion of the First Formative Usability Study

The results and discussion are presented in two sections below. The first reports the analyses of the performance data, followed by the results and discussion of the verbal questions made after completion of the tasks.

- Performance Data

Participants’ feedback given during the test reflected mostly usability issues, but also some comprehension problems. Issues concerning individual preferences or likeability were ignored since the purpose of the test was to identify usability issues. A total of 29 usability issues were discovered. Of these, 14 concerned refinements needed to the prototype. For example, in New Study, three participants did not understand the purpose of assigning participants to groups. Another problem occurred in Collect Data with two participants getting stuck at the blank-screen image-positioning task for which instructions were missing on the paper-screen. Figure 17 shows the blank screen UI given to participants with no instruction appearing on the paper screen. In this example, a participant had positioned the images into three clusters: ‘luxurious and expensive’, ‘cheap’ and ‘plain and boring’.
Nine issues arose in the New Study task, with another three in the Collect Data module and two in the Running Analyses section. The most frequently occurring issue occurred in the New Study section – selecting demographic questions, which all four participants encountered. Two participants selected all demographic questions without referring to the actual task requirements; the other two did not recognize the design of check box buttons displayed on the paper screen. A paper screen of demographic questions given to participants in the New Study creation task appeared confusing to all four participants. The paper screen is shown in Figure 18.
Several other issues occurred three times. For example, participants did not understand how to add a new map at the ‘Add Descriptive Terms’ screen in Edit Study as shown in Figure 19 below.

*Figure 18: A screenshot of the list of demographic questions*

*Figure 19: A screenshot for adding descriptive terms and adding more maps with the Add Map button encircled in red.*
Participants apparently did not notice the encircled button for adding more maps, but over-wrote the existing term with new terms rather than adding a new 2D map.

Another example was that participants refused to click on the Save button in each screen in the New Study and Edit Study tasks; they thought it was too cumbersome to keep repeating the same step.

The remaining 14 usability issues were mainly related to navigation issues, new account registration and unclear terminology. For example, the Save and Exit buttons on the Ipad template for collecting data were unnecessary, and the flow between choosing files/operation for Running Analyses section was confusing. All usability issues are presented, together with their solutions, in Appendix B - Tables 24, 25, 26 for New Study, Collect Data and Running Analyses respectively.
Of the 15 issues that were not about usability, six concerned comprehension, another five were suggestions, and the remaining four were idiosyncratic preferences that were not considered further.

The most important comprehension issue concerned the statistical concepts used. Three of these clearly indicated that the students had not grasped the underlying statistical concepts concerning the central tendencies of a distribution. Two participants were unable to understand the purpose of the Smallest Space Analysis map or how it should be used. One participant said:

“I think I like them, but I think it assumes that I already know what does this mean or even what Frequency or Mean is. I want to do that, but maybe I don’t even know what that is. It seems like a basic thing someone should know in statistics.”

That person also mentioned that he had no idea what "Mode" is. This feedback, in particular, suggested that for design students to understand the data analyses, it would be necessary to add a tutorial component to DACADE.

Another problem was of the requirement to insert the number of participants. One participant entered 20 groups instead of 20 participants for each group. This issue was subsequently addressed in the tutorial.

Another two comments were related to buttons that were slightly confusing. For example, some greyed-out buttons were regarded as representing active buttons. Likewise, one participant did not recognise the function of check-boxes drawn on one screen, possibly because they appeared to be quite rough, as recommended for the first-cut paper prototypes (Snyder, 2003).

Five suggestions were also made, all of which were incorporated into the second prototypes. For example, as one participant said: “I don’t see why I have to press ‘cool’ and click Insert. Wasting my time. Should be done automatically, just click ‘cool’”. The change was made on the second iteration of DACADE. Another example was to add a tooltip for various functions, buttons and actions that need to be taken on each screen for better understanding and ease of use. This was also added in the implementation of
DACADE. Lastly, it was suggested that a bar graph should be created to visualize the results. This suggestion was also incorporated in the implementation of DACADE in visualizing the analysis results for greater understanding.

Usability goals

The total number of questions and hints was counted, as was the number of errors in every task to assess the degree to which the usability goals were met. Of the four tasks assessed using each of the two image-positioning methods, five passed and three failed the goal criterion.

Participants using the blank-screen UI asked no questions, but those using the 2D map asked three questions, mainly about the statistical concepts. Relevant explanations were subsequently included in the tutorial.

A total of five hints were given. Two concerned the New Study task, two in the Collect Data task, and one in the Running Analyses section. Two of these hints led to changes to the DACADE UI: the sign in/register screens and the Smallest Space Analysis section.

Three simple errors occurred, including participants mistakenly importing images from the DACADE database instead of from a file (n=2).

- Opinion Data

In response to Question 1, concerning what participants thought about the prototypes, three participants commented that the tool was ‘simple’, ‘a good tool to have’, and ‘easy and intuitive’. One participant was concerned about having to save the original files: “I am concerned to have lost my information though; I would love to keep my original information before editing. I would like to ‘Save as...’ with a new file name, rather than editing on the existing file and save.” A ‘Save As’ function would only be available in the implemented version of DACADE.

In terms of what participants liked about these prototypes, two again mentioned simplicity and ease-of-use. With respect to what they liked the least about these
prototypes, one did not like the pre-defined image database provided by DACADE; two participants mentioned navigation, thinking there were too many Back, Next, and Save buttons. Another two were missing definitions of the statistical terms used such as the Smallest Space Analysis, Frequency, Mean and Mode.

Results for the rating-scales questions concerning participants’ opinions about DACADE are presented in Table 8. With the average score ranging from 7 to 7.5 (on a scale of 1 to 10), it is safe to conclude that participants found these prototypes usable and pleasant to use.

Table 8: Averages and standard deviations of question number 4

<table>
<thead>
<tr>
<th>On a scale of 1 to 10,</th>
<th>Average (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How usable did you think these prototypes were?</td>
<td>7 (1.41)</td>
</tr>
<tr>
<td>How satisfying did you think of these prototypes?</td>
<td>7.5 (1.73)</td>
</tr>
</tbody>
</table>
Summary

This chapter discussed the initial design and the first usability testing for evaluating DACADE. As expected, the results revealed some usability issues as well as generating some valuable comments. Some of these were resolved with specific changes to DACADE, while others, mainly those based on idiosyncratic preferences, were ignored. Usability goals were outlined, and the results showed that five of the eight tasks passed, with the New Study task proving the most difficult to complete. Due to some serious misunderstandings, it was decided to add a tutorial to accompany the use of DACADE. The design and evaluation of the tutorial and the second formative usability test with enhanced prototypes based on the feedback gathered in this initial formal study are presented and discussed next in chapter 9.
Chapter 9: Design and Evaluation of DACADE Tutorial, and the Second Iteration of Usability Testing

This chapter discusses the design and evaluation of the DACADE tutorial and the second formative DACADE usability test. The tutorial for assisting design students in using DACADE was designed first. Then an evaluation of the tutorial was conducted, the results of which are summarized. The second iteration of the usability study followed with the tutorial observing the same method, results and discussion sections to ensure that the enhanced DACADE prototypes are free from usability flaws. Finally, a summary of the testing is presented.

Summary of the design and evaluation of the DACADE tutorial

The DACADE tutorial was designed in textual form with some graphical representations for the purpose of illustrations. The paper prototypes of the tutorial cover the four DACADE components as well as basic explanations and illustrations of descriptive statistics. Following the feedback gathered from the first formative usability study, the purpose of adding a tutorial was to enable users to:

1. Understand how-to use DACADE correctly;
2. Understand the rationales behind the two techniques offered in DACADE;
3. Learn the concept of statistical techniques used in DACADE, and
4. Familiarize users with the concept of DACADE as a whole that involve much explanation and illustrations.

For these reasons, the DACADE tutorial was first prepared in a standard Word document format, divided into two sections including three exercises.

1. Introduction to the tutorial.
2. How-to use DACADE was divided into four sections.
a. Creating a New Study with Exercise 1 that concerns the understanding of a perceptual map by asking participants to explain the map.

b. Editing an existing study

c. Collecting Data with two techniques:
   i. 2D map UI, and
   ii. Blank screen UI.

d. Analyses in DACADE:
   i. Perceptual Maps with Exercise 2 that focuses on the understanding of the perceptual map, by asking participants to locate best, worst, and ambiguous products on the map;
   ii. Descriptive Statistics (Mean, Median, Mode, and Frequency) with Exercise 3 asking participants to calculate the Mean from a set of values;
   iii. A list of adjectives.

Participants and Procedure

The tutorial was first tested with four new participants (one male) who did not complete the tasks in the formative test. Each took approximately 40 to 60 minutes; all students volunteered their time and were not paid. Participants were asked to read through the tutorial and give feedback on various aspects including the overall content, wording and diagrams used as well as to respond to the exercises.

Results and Discussion

Among several suggestions participants made, five were taken up for further consideration. A participant suggested that the explanation of the two data collection techniques should be presented at the beginning of the tutorial in two separate locations: “I would suggest to put the two approaches up front so that users will understand the techniques that they can choose, rather than putting the approaches separate, better make it under one point.” This suggestion was accepted because it does gives a clearer
explanation to the users, particularly for a beginner who has no idea of DACADE and how the tool works.

Two suggestions concerned understanding the concept of perceptual maps - the outcome generated by DACADE. One was to “show the way how prospective consumers entered adjectives. A clear instruction to the consumers is needed so that they will get the message that it has to be adjectives, not other things.” This was highlighted because consumers who will be participating in a study will not be reading the tutorial and will not know what to do when they see the blank screen or the 2D map. The other suggestion was to ensure that the user would know when a map contained data from all consumers who had rated products: “The map should come with the input of individuals to show that all these data were entered by prospective consumers, combined together and get the final output, the overall map. The individuals should be labeled as consumer1, consumer2, and so on.” Figures 20 and 21 show the changes made from an early design to the one tested in the second iteration of usability testing.
Figure 20: The initial perceptual maps shown in the tutorial, with no examples of input data given by consumers.

Figure 21: The four individual input data by consumers 1, 2, 3 and 4 were added.
An explanation of descriptive statistics was also given. However, one participant mentioned that there should be a definition and example of what ‘sample’ and ‘measure’ mean in the explanation because they might not understand these terms. To address that suggestion, simple examples and definitions were added to the descriptive statistics.

With respect to the illustration of the Mean, Median and Mode as another type of analysis results generated by DACADE, pictograms were used as shown in Appendix B, p. 237.

![Figure 22: The replacement illustration of the Mean, Median and Mode](image)

Upon deliberation (see Appendix B - p.239), the ‘books’ appeared to convey the meaning as intended as shown in Figure 22.
Exercises in the DACADE tutorial

Three exercises were included in the tutorial. The first exercise had three questions that asked users to identify the quadrangles containing the ‘best’ 1(a) and the ‘worst’ 1(b) products shown in a 2D map by referring to a diagram shown in Figure 23. The third question, 1 (c), asked users to find the best bottle displayed on the map.

*Figure 23: A 2D Map In Exercise 1*
Figure 24 shows a 2D map generated by DACADE based on the input of four participants to test their understanding in reading the 2D map.

For Exercises 1 and 2, one of the four participants could not explain the meaning of the images in Figure 24 (Exercise 2). The other two participants completed both exercises correctly.

Finally, the third exercise required participants to calculate the Mean, Mode, and Median of a set of numbers that differed from those in the illustration.

‘Find the mean, median, and mode, for the following list of values:’

13, 18, 13, 14, 13, 16, 14, 21, 13
Unfortunately, the Median had inadvertently been placed in the center of the distribution in the illustration in Figure 25. With respect to completing Exercise 3, rather than calculating the Median as required, one participant simply started from each end of the data set in the unordered sequence shown above, counted towards the middle of the distribution, and selected "13", the central number in the distribution without considering the relative values of the numbers in the data set. Another participant was unsure of the term Mode. However, after referring back to the tutorial, she managed to find it. Evidently, the concept was still not conveyed clearly enough. The illustration was therefore changed again such that the Median was not in the central position.

As there were no further usability or other apparent comprehensibility issues, the next test involving the revised tutorial and the revised DACADE tool was conducted as discussed in the next section, the second formative usability study.
Second Formative Usability Study

The second Formative Usability study was run on the enhanced DACADE prototypes. The ultimate goal of this second iteration of usability testing was to further refine DACADE prototypes from any usability flaws before implementation. The method, results and discussion are presented in this section.

Participants

A new sample of six participants (two males) was recruited from the Faculty of Design. These undergraduate and postgraduate students ranged from 18 to 40 years of age and represented various areas of design. They were tested in individual sessions taking between 50 to 60 minutes each. They were given a voucher to the value of $20 at the completion of the test, which took place in a quiet laboratory at the Faculty of Design. The ethics approval certificate is presented in Appendix B, p.227.

Materials and Design

Instructions, cover stories, tasks and stimuli used were the same as in the first Formative Usability study. Sixteen items had been changed, based on feedback gathered in the first study. For example, the two ‘Welcome’ screens in the initial design were combined so that users could see the differences between Sign in and Register. Another enhancement was an expanded selection of demographic questions in the New Study section, provided via a more specific template. Instructions for image positioning in the Collect Data task was also added.

As before, participants were given four tasks, which had them (1) create a new study, (2) edit an existing study, (3) collect data and (4) analyze a study. The enhanced prototypes are presented in Appendix B, p. 236.

Unlike in the first formative test where only a verbal questionnaire was used, participants were given two questionnaires at the end of this second iteration of usability test. They were first required to answer four questions seeking their opinion about
DACADE verbally as follows.

1. Which task did you enjoy the most?
2. Which task did you enjoy the least?
3. Which task did you find the hardest?
4. Assume that a commercial quality application similar to this could be created. Do you feel that such an application could be a valuable tool for a design student?

Second, the System Usability Scale (SUS) (Brooke, 1986) was administered to assess participants’ perceptions of usability and satisfaction. The 5-point SUS scale (in which a score of 1 = most negative and a score of 5 = most positive) comprises 10-items. The instrument is inexpensive and has been shown to be effective, valid and reliable for evaluating usability across various ranges of products or systems including cell phones, web sites, TV applications and others (Tassabehji & Kamala, 2012). The audio records were transcribed verbatim and notes were taken throughout the sessions. All materials for the formal study are similar to Test #1 with an additional of a tutorial.
Usability Goals

To determine the success of DACADE, usability goals were updated as shown in Table 9.

Table 9: Usability goals set in the second Formative Usability study

<table>
<thead>
<tr>
<th>Interface/task</th>
<th>Questions</th>
<th>Hints</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blank screen</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Edit Study</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Collect Data</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Running Analysis</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>2D map</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Edit Study</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Collect Data</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Running Analysis</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 9 shows questions were allowed in all four tasks using both analysis methods. Hints were allowed in most of the tasks, and errors were allowed only in the New Study task. The number of questions, hints, and errors was reduced compared to the first formative study, due to the addition of a tutorial in this, the second usability test. It was assumed that the presence of the tutorial would enable participants to understand the descriptive statistics and (or) the interpretation of the perceptual maps.

An example of a hint given was on the setting up of demographic questions in creating a New Study. For a list of all hints and errors, please see Appendix B, (p. 241).
**Procedure**

The test followed the same procedure as before, with the addition of the tutorial. When participants arrived at the venue, they were welcomed and briefed about the purpose of the evaluation, emphasizing that the aim of the test was to assess the usability of DACADE - not of the participants, and that they could take breaks at any time. Participants were then asked to read and sign the informed consent form and fill in the demographic information form. Next, they were asked to read through the tutorial and complete the tutorial exercises. Then they were required to read the relevant cover story and then to attempt the tasks, one at a time at their own pace. Participants were asked to verbalize their thoughts as they went; the researcher took notes throughout. Upon completion of the tasks, participants answered the four questions verbally, then completed the items in the SUS usability and satisfaction evaluation rating scale. Finally, participants were paid and excused.

**Results and Discussion**

The results and discussion are presented in three sections. The first shows the tutorial data analyses followed by analyses of the user performance data, and then the results of the questions given after completion of the tasks.

- **Tutorial**

With respect to the tutorial exercises, Table 10 shows that performance was best in Exercises 1 (a) and (b) in which participants were asked to identify the best and worst quadrangles. They also performed well in Exercise 3 concerning the descriptive statistics. However, only one participant completed all exercises correctly.
Table 10: Number and percentage of correct answers to tutorial exercises

<table>
<thead>
<tr>
<th>Exercise</th>
<th>N correct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (a) – Identifying the best quadrangle</td>
<td>5/6 (83.33%)</td>
</tr>
<tr>
<td>1 (b) – Identifying the worst quadrangle</td>
<td>6/6 (100%)</td>
</tr>
<tr>
<td>1 (c) – Identifying the best bottle</td>
<td>3/6 (50%)</td>
</tr>
<tr>
<td>2 – Explaining the 2D map</td>
<td>4/6 (66.67%)</td>
</tr>
<tr>
<td>3 – Calculating the Mean, Median and Mode</td>
<td>5/6 (83.33%)</td>
</tr>
</tbody>
</table>

Table 10 shows that performance was quite poor when asked to identify the best bottle in the 2D map display (Exercise 1c) in which each bottle had a unique ID. For example, one participant said “The answer is R, because it is made of metal, so you can bring it outdoors or go [on an] expedition. That’s my judgment.” Another participant said, “The best bottle, it depends on environmentally, or the needs, like a flask or something, for me I’ll just go for B.” Apparently, both answers were based on the design student’s personal perception rather than from a potential consumers’ perspective, even after they had read the tutorial.
With respect to Exercise 2 in which participants were asked to explain what they understood about the map shown in Figure 26, one participant explained,

“A lot of those bottles, the traditional ones are soft. People find, I think, those clear bottles are generally traditional and boring, in this quadrant [pointing to quadrant IV], and a bottle that has a more fancy design or has colour to make it more decorative, are in the interesting and modern quadrant.”

However, the other two participants were still unable to grasp the concept. One of them said: “It’s like more of a sample; I would say they should be in the same place, because they are all the same. Similar bottles should be in the same place, like now they are kind of everywhere. They are all the same”.

And, finally, one answered:

“The bottles with bold colors are interesting and modern, really bright solid colours, traditional, more traditional sort of bottle shapes, straight and narrow neck, like a cap, traditional and boring. The shapes are interesting and traditional. These are very new sort of bottle design, could be perceived as modern or traditional design. I find it interesting they are there.”
Another participant, who was unsure of the position on a 2D map, even after reading the tutorial, asked, “Does it matter if it is located further up on the quadrant?” This participant further commented that the 2D map, “…itself looks very statistical and technical; you need to make it more fun and interesting. I want to be able to enjoy the graphics. It really depends on how you design this later.” Evidently, these participants had not understood the meaning of the four quadrants or what they could deduce from looking at the relative placement of the water bottles.

Five of the six participants completed Exercise 3 correctly, in which they were required to calculate the Mean, the Median and the Mode. However, two of these referred back to the tutorial to solve the problem. Another participant simply selected the number in the center of the distribution as the Median without first rearranging the values in ascending order. One possible reason for these errors could be that participants had paid insufficient attention to the concepts while reading the tutorial, or else that they were unable to remember the concepts they had studied directly before attempting the exercise.

Of the six participants, three complained that the tutorial was too long and had too much text. Some participants looked bored while working through the tutorial. This suggests that drawings and/or animations may be a better way to create a useful and comprehensive tutorial that covers every issue identified as causing confusion or misinterpretation, while at the same time meeting the requirement to appear to keep the tutorial brief.

One participant suggested placing both a figure and its description on the same page for easy reference. This was taken up so the related figures and text will appear together in the implemented version.

- Performance Data

The results confirmed that the new version of DACADE was an improvement to the first usability test, revealing that, of the 35 issues raised in the second test, only three (8.57%) were related to usability. Contrary to the researcher’s expectations concerning the comprehensibility of the purpose of the tool and the calculations of simple
descriptive statistics, 10 (28.57%) issues still suggested a lack of comprehension. Another 17 (48.57%) were suggestions, one (2.86%) was a participant’s comment, and four (11.43%) represented participants’ personal preferences.

One usability issue was found in each of the three tasks, namely New Study, Edit Study and Run Analyses tasks. The most frequently occurring issue was with the Run Analyses task, (Figures 27 and 28) where participants could not find the Run Analysis button on the left panel of the screen in order to navigate or reverse from Screen 11 (a visual result of perceptual map), back to the analyses menu on Screen 10, which four participants experienced. The main menu for the implemented DACADE is then redesigned and discussed in Chapter 10.
Several other issues occurred once: for example, in New Study task, one participant commented that the timeline was confusing. “I thought I am moving forward but it seems I am still at the same step.” The timeline was therefore re-phrased in the implemented version. Another example was in Edit Study, in which a participant thought that there should be a way to skip some steps and go straight to where she wanted to go for editing. Clicking on the timeline on the implemented screens can do this. For the full list of usability issues, please see Table 11.
Table 11: Summary of usability issues found in the second iteration of usability study for all tasks, the number of participants facing the problem (n) and suggestions for enhancements/changes

<table>
<thead>
<tr>
<th>No</th>
<th>Summary of Usability Issues</th>
<th>Task</th>
<th>n</th>
<th>Changes / Enhancements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The timeline is confusing, A participant said, “I thought I am moving forward but it seems I am still at the same step.”</td>
<td>New Study</td>
<td>1</td>
<td>The timeline was re-phrased in the implemented DACADE.</td>
</tr>
<tr>
<td>2</td>
<td>A participant thought that there should be a way to skip some steps and go straight to where she wants to go for editing.</td>
<td>Edit Study</td>
<td>1</td>
<td>The timeline is linked to each associated screen, hence the implemented DACADE already has this function.</td>
</tr>
<tr>
<td>3</td>
<td>A participant could not find a way to go back to the main menu of analyses.</td>
<td>Running Analyses</td>
<td>4</td>
<td>The menu screen was redesigned so participants can now choose both study name and operation at the same time.</td>
</tr>
</tbody>
</table>
Among the 10 comprehension issues, six were found in the New Study section, two issues each in Edit Study and Run Analyses modules, while no issue found in the Collect Data task. The two most frequently occurring misunderstandings found among three of the participants were (1) mistaking the number of participants in each of several groups for the total N, and (2) confusion between ‘study description’ and ‘instruction to participants’ in the New Study. Concerning the concept of participant-groups, it appeared that the participants failed to grasp the difference between n participants and participant-groups; hence their suggestion that the group concept be removed. Eliminating that concept, however, is infeasible because the tool is designed to guide design students to conduct systematic research. This includes the ability to compare responses between different groups of participants, e.g. senior citizens and teenagers or males and females. Participants did not understand the term ‘adjectives’ used on the 2D map screen in the New Study section although it had been defined in the tutorial, which also provided some illustrative examples such as weak – strong and fast – slow.

One participant even mentioned,

“The word adjective might confuse people. I think 90% of people don’t read an instruction manual; there should be some rough instructions. You can add a link or a question mark symbol so that people can click on them to get some hints. Or roll over to get some tips.”

This was resolved by providing tooltips in the implemented version of DACADE. Likewise, participants did not understand the "Add Descriptive Terms" function in the Edit Study task. Instead of adding a new map, they just changed the adjectives on the existing map. However, the purpose of the function is to enable presentation of several 2D maps comparing products in several dimensions. Unfortunately, it was obvious that some participants failed to read the tasks thoroughly before attempting them. The same is likely to have been true of the information provided in the tutorial. Table 12 contains the full list of comprehension issues.
Table 12: Summary of *comprehension* issues gathered in the second iteration of usability study for all tasks, and frequency (n).

<table>
<thead>
<tr>
<th>No</th>
<th>Summary of Comprehension Issues</th>
<th>Task</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Participants were confused between ‘study description’ and ‘instruction to participants.’</td>
<td>New Study</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Participants misunderstood the number of participants for each group as the total number of all participants.</td>
<td>New Study</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Misinterpreted the ‘add new term1’ and ‘add new term2’ on a drop down menu (on Screen 8) as highlighting the selected terms. The buttons are meant for adding adjectives that are not on the list.</td>
<td>New Study</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Participants were unsure of the checkbox buttons used on the demographic questions. The participant mentioned that they do not need to go to the detail of the questions; they only need to choose what questions to ask.</td>
<td>New Study</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Participants were unsure of the term ‘adjectives’, only after referring to the tutorial.</td>
<td>New Study</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>A participant did not understand the concept of assigning the number of participants, assuming it should be zero if they did not want to limit the number of participants.</td>
<td>New Study</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>A participant did not understand the function of buttons New Study, Edit Study, and Run Analysis.</td>
<td>Edit Study</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Participants did not understand the Add Descriptive Terms button.</td>
<td>Edit Study</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>A participant did not understand the task of Running Analyses at Screen 10 (the main menu of Running Analyses). Did not know what to do on this screen, where they were supposed to choose the study name and pick the analysis operation.</td>
<td>Running Analyses</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>A participant was unsure of the Preview button on Screen 13.</td>
<td>Running Analyses</td>
<td>1</td>
</tr>
</tbody>
</table>
Of the 35 issues identified as shown in Table 13, 17 were suggestions with seven for the Collect Data section, five for the Run Analyses module, four for the New Study task, and one for Edit Study. One suggestion was to enable a simultaneous display of all images to be placed on the map. At the time, images were presented one by one, but they could be moved once they had been positioned. The researcher decided to display all images on the side of the screen to give evaluation participants a general idea of the looks of the entire range of product images to be positioned on the map from the beginning of the task. This solution differs from previous research (Antikainen et al., 2003; Chuang & Chen, 2003; Lin and Huang, 2010) in which images are presented one at a time or in pairs. Another suggestion was that the screen for image positioning should be editable, enabling evaluators to re-adjust the position of products even after moving to the next screen. It was decided to incorporate these into the DACADE implementation.

In the Collect Data section, one suggestion was to provide clear instructions to position images on a 2D map or a blank screen because it was expected that future evaluators would not be reading the tutorial. However, in the light of the comment that “...90% of people don’t read instructions” it is always difficult to balance the amount of instructional text and diagrams. As mentioned earlier, changing the tutorial to a ‘show and tell’ show instead of forcing evaluators to read several pages of text could be a potential solution. However, students who are unfamiliar with terms such as ‘adjectives’ will not be helped by that solution. Implementing that approach was beyond the scope of the present thesis; it was therefore not considered further.

Positive comments were made about DACADE providing a pre-conceived list of adjectives; apparently, it was “unexpected but convenient. I thought I would go somewhere else.” Table 18 contains the full list of suggestion. Finally, another four issues related to idiosyncratic likeability or personal preferences were not considered further as they were unrelated to usability.
Table 13: Summary of *suggestions* gathered in the second iteration of usability study for all tasks, frequency (n), and its remark

<table>
<thead>
<tr>
<th>No</th>
<th>Summary of Suggestion</th>
<th>Task</th>
<th>n</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A participant suggested the program can type up the instructions or suggest instructions because it's just two techniques, such as ‘based on the themes, please place the photo on any of the sectors.’</td>
<td>New Study</td>
<td>1</td>
<td>The instructions template that are editable according to UI will be added in the new implemented DACADE</td>
</tr>
<tr>
<td>2</td>
<td>A participant did not understand button Add on screen 7 after she has added images on the screen. She suggested the button should be changed to Add More Images after users selected images.</td>
<td>New Study</td>
<td>1</td>
<td>The idea was not acceptable because a system could not detect how many images users would like to import.</td>
</tr>
<tr>
<td>3</td>
<td>A participant thought that the word ‘adjectives’ on Screen 8 might confuse people. He added that “90% of people did not read instruction manuals, there should be some rough instructions.” For example, to add a link or a question mark symbol so that people can click on them to get some hints, or roll over to get some tips.</td>
<td>New Study</td>
<td>2</td>
<td>Tooltips will be added in the implemented screens.</td>
</tr>
<tr>
<td>4</td>
<td>A participant said that there should be the End button on the last screen, not Next button that was greyed out.</td>
<td>New Study</td>
<td>1</td>
<td>The End button will be created in the implemented screens.</td>
</tr>
<tr>
<td>5</td>
<td>Inconsistent use of Add/Edit button in NewStudy and Edit Study modules.</td>
<td>Both New Study and Edit Study</td>
<td>1</td>
<td>To avoid confusion, these buttons were standardized with only Add button used throughout, because Edit button is only applicable for editing the content of a study, such as changing the completion date, or adding more groups - not</td>
</tr>
</tbody>
</table>
for image editing as perceived by some participants.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Data Collection</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>A participant felt that the 2D map used was very statistical and technical.</td>
<td>Collect Data</td>
<td>1 The design of the 2D map on the implemented screens will be enhanced, to encourage design students using DACADE.</td>
</tr>
<tr>
<td>7</td>
<td>Before entering screen 3, one participant felt that there should be an instruction like ‘please drag and drop.’</td>
<td>Collect Data</td>
<td>1 The instruction to drag and drop products on a 2D map UI and blank screen UI will be added at the top of the screen, for easy reference.</td>
</tr>
<tr>
<td>8</td>
<td>Participants suggested that it would be nice to have all images appear simultaneously, rather than one by one.</td>
<td>Collect Data</td>
<td>3 The idea was accepted and will be implemented.</td>
</tr>
<tr>
<td>9</td>
<td>On the last screen, a participant suggested having an Exit or Close button.</td>
<td>Collect Data</td>
<td>2 The idea was accepted and will be implemented.</td>
</tr>
<tr>
<td>10</td>
<td>A participant suggested that a demographic question, such as ‘Area of Study’ should be really broad, and general to the public. She suggested providing just ‘Other’ option for participants of a study to type in their area of studies.</td>
<td>Collect Data</td>
<td>1 The option for Area of Study was re-designed with more general options for the public. The answers template for demographic questions remains unchanged because the idea of DACADE is to guide a design student to create a systematic research. Limiting the options is one way of doing this.</td>
</tr>
<tr>
<td>11</td>
<td>A participant suggested there should be more instructions given for participants in the image positioning tasks.</td>
<td>Collect Data</td>
<td>1 A step-by-step instruction will be added in the implemented screen.</td>
</tr>
<tr>
<td>12</td>
<td>Participants suggested having an option for people to re-adjust the position of products even after they have moved to the next screen. In other words, the screen is editable.</td>
<td>Collect Data</td>
<td>2 This should be available automatically with the implemented screens.</td>
</tr>
<tr>
<td></td>
<td>Suggestion</td>
<td>Run Analyses</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---</td>
</tr>
<tr>
<td>13</td>
<td>A participant suggested having a description of a perceptual map rather than just the map.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Run Analyses 1 The idea was not accepted because it would be impossible for the system to know and explain the position of products generated by DACADE to users. It should be sufficient for the users to read and understand the map through more training.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>A participant felt that the Running Analyses section should be more visually appealing for her to use it.</td>
<td>Run Analyses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 The visual results on the implemented screen will be enhanced to encourage design students using DACADE.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>The last screen of Screen 13 should have an Exit button</td>
<td>Run Analyses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 There will be a Log Out button added to the implemented screens.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>When choosing the analysis type, a participant thought that she could choose multiple analyses operation, then click Next to proceed</td>
<td>Run Analyses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Users can only choose one operation at a time; hence, this suggestion was not accepted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>A participant thought the number generated for a list of adjectives mentioned by participants of a study might be misunderstood. They might think the number is referring to the frequency of participants mentioning the adjectives, not the participant themselves.</td>
<td>Run Analyses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 An explanation of the list of adjectives was given in the tutorial, thus this comment was not accepted.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Usability goals

Questions, hints, and errors were too scarce to report separately. Thus, of the eight tasks evaluated, only one, namely the ‘New Study’ task, failed for reasons mainly concerning comprehension rather than usability as shown in Table 14. This suggests that, in cases in which comprehension may be as important as, if not more important than, usability, comprehension should be added in the task protocol as a separate variable in the performance assessment.

Table 14: Summary of hints given and errors made during the second iteration of the usability test

<table>
<thead>
<tr>
<th>UI/Task</th>
<th>n</th>
<th>Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hint</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>Study Details - Participants were informed that they can enter some information such as aim or details of the study.</td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>Importing images – a participant was trying to edit the images instead of proceeding to the next screen. A hint was given to inform that they could click Next button to proceed to the next screen, not editing the images. DACADE does not provide image editing.</td>
</tr>
<tr>
<td><strong>Error</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>A participant did not specify the number of participants and groups.</td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>A participant had chosen the wrong demographic question by assigning adjectives to the occupation category.</td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>A participant decided not to assign adjectives when asked even though she was given a 2D map task that requires adjectives.</td>
</tr>
<tr>
<td>Edit Study</td>
<td>2</td>
<td>Instead of adding a new map, participants changed the adjectives on the existing map.</td>
</tr>
</tbody>
</table>
Opinion Data

With respect to the task participants enjoyed the most, three mentioned Collect Data task, one the New Study, and one preferred the Edit Study task. The Run Analyses task was not mentioned at all. With respect to the task they enjoyed the least, three mentioned the New Study task, adding that the task was “not really painful” or “not that bad”, only because the task “requires the most work, more hassle compared to others.” Two participants nominated Run Analyses because “the instructions were not clear enough.”

In response to the third question, asking which task was the hardest, two participants mentioned New Study. These same participants suggested that New Study was the least enjoyed, as highlighted earlier. One participant thought that the Run Analyses task was hard, saying, “The statistical part needs to be visualized [such as] pie chart, bar chart, [or] percentage. After I read the tutorial, I am still confused when I see Frequency.” Another participant thought Collect Data was the hardest task because “I couldn’t see the car just based on the picture.”

The next question, asking if participants thought DACADE could be a valuable tool for design students, was answered in the positive, with several reasons offered. One participant said, “It’s doable and quite easy to use. As a design student it is valuable just to get a broad data.”

Another participant said,

“I think it would be. Anything that helps visualize the process of research and a tool that actually makes the benefits more accessible to people, students or designers, can aid to make the process easier and make the outcome more self-explanatory. It will be a benefit for sure.”

The SUS scores ranged from 82.5 to 7.5 with an average, $M = 51.67$, $SD = 30.11$. Both average and SD scores are large as one participant rated really low with a SUS score of 7.5. Looking at the rating pattern given by this participant, she could have misjudged the ten positive and negative items used in SUS, because the rate given for each item was consistent, with a very low rating given to a positive item and vice versa.
The observation was made as this same participant had an affirmative opinion when asked about DACADE, saying:

“I think because creating a research project, you know thinking about the method and that sort of stuff, I think if it can be a program to help you, it can be quite helpful. And I think they will use it because it might be easier. I think the analysis part, that was easy to understand, and as a new research student, I like the idea; I just click a few buttons and the analysis is done for me. Rather than going into SPSS and totally freaking out, because there are so many options, but having limited options in front of you are a little bit easier. But, then again I think in the future, I would want to do some complex analysis. So it's a beginning thing, maybe teaching analysis would be good, also as a learning tool.”

The maximum score was 82.5. Therefore, for the measure of usability in this test, median is also reported which could be more meaningful than the mean and SD, with a score of 62.5.

Based on the overall results, it is safe to conclude:

1: DACADE was perceived to be usable;

2: Participants were interested in the idea of DACADE;

3: Participants claimed they would use it for future data collection and analysis, as well as learning statistics, and

4: Finally, the prototypes were then ready to be submitted to the software developers for implementation.
Summary

This chapter discussed the design and evaluation of tutorial and the second iteration of usability testing of DACADE. The study revealed that very few usability problems remained. However, finding effective ways to convey even simple statistical knowledge as well as the concept of perceptual maps was fraught with unforeseen difficulties. Usability goals were outlined, and the results showed that seven of the eight tasks passed. The New Study task was the most difficult to complete, similar to the first formative test. Changes and enhancements were identified, most importantly the statistical analysis section that would be solved for the development and implementation of the software tool. The tested prototypes were then sent to the software developers for implementation. Next, a user acceptance test to evaluate the performance of implemented DACADE was carried out and will be discussed in the next chapter.
Chapter 10: User Acceptance Test

This chapter discusses the User Acceptance Test (UAT) conducted to determine the level of satisfaction and aesthetic appraisal of DACADE as well as to ensure that no new usability problems had crept into the tool during its implementation. This study aimed to achieve a high acceptance level of perceived usability, satisfaction and visual aesthetics of DACADE. A summary on the DACADE enhancement is discussed first, followed with DACADE implementation-related decisions and the process of choosing the colour palette for DACADE. Then a pilot study is presented, the results of which are summarized. Next, the formal UAT is reported in a method, results and discussion section respectively. Finally, a summary is presented.

Summary of DACADE enhancement

DACADE is then implemented to run on a desktop computer. This implemented version of DACADE was based on findings from both usability tests. The documentation given to the software developers included the prototypes, sequencing and contents of screens, flow charts, screens behaviour and tooltips. All documents including the prototypes were prepared using the Microsoft PowerPoint software tool.

The same tasks as in the two preceding Usability Tests were used here. As in the Usability Tests, participants were asked to create a new study, edit an existing study, run a study and analyse a study. Enhancements were made based on the results gathered in both Usability Tests. The enhancements were only related to Running Analyses section that was divided into several categories. For example, based on the results yielded in both Usability tests, Median and Mode were removed from the screen, focusing more on visualizing the Mean and Frequency on a 2D map. Product Select and Participant Filter were added to Running Analyses section enabling design students to compare results between groups, participants and gender visually as illustrated further in Table 15.
Table 15: List of enhancements made on DACADE for implementation

<table>
<thead>
<tr>
<th>Title</th>
<th>Screen</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td><img src="image" alt="Image of a paper screen" /></td>
<td>First, Figure 29 shows the paper screen that was used in the Usability Tests with the list of Frequency, Mean, Median and Mode presented in numbers. The idea was that users get to see the list of these descriptive statistics by clicking on the link of pairs of adjectives such as ‘like-dislike’ that were listed at the bottom of the table. Design students, however, had difficulties understanding the meaning of Mean, Median and Mode and Frequency.</td>
</tr>
</tbody>
</table>

*Figure 29: The paper screen for descriptive statistics used initially in the Usability Tests*
Therefore, the Median and Mode were removed, leaving Mean and Frequency in the implemented tool as in Figure 30.

As depicted, Mean is encircled in red. Once selected, the visual position of the overall Mean for all products is displayed visually on the 2D map. Users can also change the map if they have more than one map (Map 1 and Map 2 encircled in black) or group (a drop down menu to change between groups encircled in blue).

The visual presentation was intended to inspire design students to recognize the value of statistics.

Figure 30: The Mean is shown visually for each product upon clicking the checkbox.
Secondly, design students also had difficulties understanding the meaning of Frequency. Therefore, as recommended by participants in Usability Test #2, the Frequency in the implemented tool was visually displayed with bar graphs for better illustrations.

In the implemented version of DACADE, users could simply click on each Quadrant to see the Frequency displayed in a Bar Graph. Figure 31 shows the screenshot of the Analysis Menu where users can find and filter the Frequency by each Quadrant visually.

The instruction to get the Frequency was marked in a red rectangle for participants’ reference.

*Figure 31: A screenshot of Analysis menu - where users can click on each Quadrant to get the Frequency.*
Figure 32: The Frequency is shown visually when users click on Quadrant 2.

In the example shown in Figure 32, the user clicked on the upper right quadrant to display the bar graph of the Frequency in that quadrant.

First, DACADE now enables users to filter the Frequencies in each of the four Quadrants, which was not possible in the paper prototypes. Second, images of the relevant products are also displayed beneath the bar graph.

And third, the Frequency with which each product appears in the relevant quadrangle is shown above each bar with a number, and the relevant product is shown below each bar.
Figure 33 shows the menu of Running Analyses whereby users can click on the buttons provided accordingly. The new additions are Product Select and Participant Filter as highlighted in red. Thirdly, Product Selection allows the user to filter the 2D map according to product(s).

Figure 33: Implemented Analyses screen with the new features encircled in red
To select results by products, users can click on the Product Select button, then a dialog box as shown in Figure 34 will be displayed. Selected products are highlighted in blue.

**Figure 34:** A dialog box for filtering the 2D map by product(s)

Upon selecting any one or more products, the 2D map will then display the result as desired and as shown in Figure 35.

**Figure 35:** The results of Product Selection as an example
Fourthly, users can filter the map by participants such as age range or gender. To get this dialog box, a user needs to click on the Participant Filter button as shown in Figure 36 earlier.

Upon selecting gender or age range, the 2D map will then display the result as desired and as shown in Figure 37. This less cluttered visual result will be displayed. This example shows ‘Male’ with age range of ‘Under 20’.
DACADE implementation-related decisions

The look and feel of the UI was decided upon during implementation, which was impossible to do earlier with the use of paper screens because the main objective of paper screens is to focus mainly on the usability issues not aesthetic issues such as background colour, font size or font colours. The developers were asked to apply a Mac-friendly design interface and to comply with the accessibility standards for the World Wide Web. However, when discussing the possible platforms, I was advised to focus on a desktop version only, as the programming for an Ipad-friendly version would be technically problematic and very time consuming, especially for the Collect Data section. Even so, the web browser still can be viewed on an Ipad tablet. With respect to screen orientation, it was decided to use landscape instead of portrait for a better view of the image-positioning task.

Choosing the color palette of DACADE

The DACADE color palette was also decided at the time of implementation. It was determined via a quick online Google survey. In consultation with designers in the Faculty of Design, several color palettes had been designed. The survey form, open to designers, was distributed randomly via Facebook and email communication. The targeted respondents were 18 years old or more. Potential participants were asked to rate three similar interfaces of screens 1, 2 and 3, as shown in Figures 38, 39 and 40 with different color palettes on a scale of 1 to 10, with ‘1’ being ‘not pleasing at all’ and ‘10’ being ‘extremely pleasing’. A total of 24 designers volunteered in the survey.
Figure 38: Screen #1 – with White background colour

Figure 39: Screen #2 – with 5% Grey background colour
The results show that screen #2 with 5% grey color had the highest mean with 6.96 and was selected as the colour palette for DACADE, as summarized in Table 16.

Table 16: Summary of the online survey on a color palette for DACADE

<table>
<thead>
<tr>
<th>Screen # / Color</th>
<th>Mean (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. White</td>
<td>6.83 (1.90)</td>
</tr>
<tr>
<td>2. 5% grey</td>
<td>6.96 (1.94)</td>
</tr>
<tr>
<td>3. Darker grey</td>
<td>4.58 (2.28)</td>
</tr>
</tbody>
</table>

The 5% grey color palette was then sent to the developers for implementation.
Despite the DACADE prototypes having been thoroughly tested in the formative stages, the developers independently made changes to the design of certain buttons, actions, and navigation paths during the implementation due for consideration of technical, time, and cost as summarized in Table 17.
Table 17: List of implementation-related decisions

<table>
<thead>
<tr>
<th>Title</th>
<th>Screen</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Menu</td>
<td><img src="image" alt="Main Menu Screen" /></td>
<td>The ‘Main Menu’ was changed from Figure 41 to Figure 42 in the implemented tool because it was too complicated and required more time to program.</td>
</tr>
</tbody>
</table>

*Figure 41:* A screenshot of the 'Main Menu' sent to the developer
Figure 42 is the implemented screen for the ‘Main Menu’. All action buttons for Run, Analyse, Edit, Duplicate, Delete are placed on the most right panel, on each study name such as Cars, Cars1. This way was quicker and easier for the developers to program.

*Figure 42: A screenshot of the implemented 'Main Menu'*
Demographic Questions

The ‘demographic questions and answers template’ was removed from the implemented tool because it was too complicated and required more time to program as shown in Figure 43.

The original idea was to enable design students to select preferred questions with the answers option. The answers option can also be edited.

Figure 43: A screenshot of 'Demographic Questions' sent to the developers
The implemented screen for 'Demographic Questions' is shown in Figure 44. The developers simply put the four questions related to participants’ demographic. By default, the tool will automatically generate the answers option. No editing is allowed.

*Figure 44: A screenshot of implemented 'Demographic Questions'*
The software developers also made suggestions that would be simpler to code, but which were not implemented, such as presenting the selection of data collection techniques before proceeding to the study creation section as shown in Figure 45.

![New Study](image)

*Figure 45: A screenshot of New Study wizard suggested by developers*

However, the suggestion by the software developers was not acceptable for two concrete reasons. Firstly, considering the lack of knowledge of systematic data collection and analysis among design students, asking them to decide on the type of techniques to use before they get to see the study creation section is problematic. They might get stuck not knowing which technique to use and which is which. Secondly, changing the navigation of the New Study creation was regarded as a major change that was not tested in the first two Usability tests. Hence, the original idea of asking design students to follow a step-by-step instruction (based on the Theory of Cognitive Complexity discussed in Chapter 6, p. 85) was used as shown in Figure 46.
Figure 46: The implemented version of choosing a technique in New Study section

The template guides the design students from one step to another, until they reach the ‘Instructions’ template – Step 4 (as shown in Figure 46). They get to decide which technique to use to collect data with the target consumers based on the description provided. Upon selecting the instruction, for example, a 2D map (the first option), users will be prompted with the next two steps, Step 5 (importing images) and Step 6 (inserting adjectives). However, in the case of users selecting the second option a blank screen, Step 6 will be automatically skipped, because it is not relevant. It is important to note here that the two default instructions displayed on Figure 46 are not permanent; users can edit the instruction, as they like.

These reinforced the importance of involving software developers in the prototype design very early in the process as the UCD method recommends. It was not possible here, as the software developers were paid and funds were limited.
User Acceptance Test

The User Acceptance Test (UAT) is important to determine the degree of user acceptance among design students who represent the main DACADE target audience as well as to ensure that the software is fit for purpose before releasing it for widespread use. Recall also that one of the objectives of this research was to introduce design students to the concept of statistics and demonstrate how statistics can assist them in obtaining meaningful data. Hence, the UAT tested the degree to which DACADE could encourage design students to use statistics in the early phases of design projects. As the method for the pilot study and the formal study was the same, the method section represents both.

Method

Participants

A sample of 13 design students (5 female) from the Faculty of Design took part in the formal UAT. (Two non-design female students took part in the small pilot study). These undergraduate and graduate students ranged from 18 to 40 years old and represented various areas of design (Communication Design, Industrial Design, Interior Design and Film & Television); none had participated in an earlier evaluation. It is important to note here that, since there was no new problems arose during the User Acceptance Test, therefore the limited sample size is adequate. Participants were tested in individual sessions taking between 30 and 60 minutes each. Participants in the formal UAT were given a voucher to the value of $20 at the completion of the test; the two pilot study participants volunteered their time. The ethics clearance certificate for UAT is attached in Appendix C, p. 242.
**Materials and Design**

The cover story was the same as before. Each participant received one set of 4 tasks, using either the 2D map (participants, n = 7) or the blank screen method (n = 6). The presentation of these was counterbalanced to avoid serial order effects.

Four issues were investigated upon completion of the tasks, namely:

1. Usability & Satisfaction
2. Aesthetics
3. Other questions related to their thoughts about DACADE
4. Open questions:
   a. Most liked about DACADE
   b. Least liked about DACADE
   c. Suggestions for improvement

Participants’ perception of Usability & Satisfaction was assessed by the SUS scale (Brooke, 1986) as in Usability Testing #2 (Chapter 9). Two new sets of rating scales were added. One measured the users’ perception of Aesthetic values using the Visual Aesthetics of Website Inventory (visAWI) scale (Moshagen & Thielsch, 2010) as discussed in Chapter 7 (p. 102), using a 7-point Likert scale. The remaining five questions sought participants’ opinion about DACADE also on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) as shown in Table 18.
Table 18: The opinion rating scale

Participants’ opinion about DACADE

| Q1. DACADE is valuable to design students |
| Q2. Interaction with DACADE is pleasant |
| Q3. I would recommend DACADE to other design students |
| Q4. DACADE inspired me to collect and analyse data in future design projects |
| Q5. I would like to learn more about the power of statistics after using DACADE |

An Apple iMac desktop computer with 8GB 1333 MHz DDR3, and a processor of 2.8 GHz Intel Core i7 was used for the UAT. The computer runs on an OS X Version 10.8.3. Although DACADE is compatible with any browser; the software developers recommend using the most recent version of Google Chrome. The UAT was thus run on Google Chrome Version 30.0.1599.101. A wireless Logitech K400R touch keyboard was attached to the computer-processing unit through a USB port to allow an additional control between the tester and researcher. All sessions were audio recorded with permission and transcribed verbatim.

**Procedure**

When participants arrived at the venue, they were welcomed and briefed about the test. They were reminded that the purpose of the UAT was to test DACADE not them, and that they could take breaks at any time. Participants were then asked to read and sign the informed consent form and fill in the demographic information form. Next, they were required to read through the tutorial and complete the exercises at their own pace before reading the relevant cover story and then attempting the tasks, one at a time. Participants were asked to verbalize their thoughts as they went; the researcher took notes throughout.

Upon completion of the tasks, participants filled out the questionnaires and discussed the test as well as DACADE before being paid and then excused.
Summary of the pilot study

The pilot study was designed to ensure the smooth running of the UAT, to identify any flaws in the implemented DACADE, to check the flow of the tasks and the comprehensibility of the questionnaires. The pilot study did not identify any usability issues.

Results and Discussion of the formal UAT

The results and discussion are presented in three sections. The first deals with the tutorial performance data, followed by the DACADE performance data and then the opinion data.

- Performance: Tutorial

Table 19 shows that participants performed best on exercises 1A, 2A and 3, and worst on exercise 2C. It is rather disconcerting to note that not one of the exercises resulted in a 100% correct score, and that only one participant completed all exercises correctly. Even so, she still referred to the tutorial when calculating the Mean during the tutorial exercise. It is thus not surprising that participants also experienced problems using the actual tool. Performance was better when identifying positive quadrangles (1A) and products (2A) than when asked to identify negative quadrangles (1B) or products (2B) for reasons that are unclear. One reason for the low score on exercise 2D could be a lack of familiarity with the word ‘ambiguous’, as three participants asked about the meaning of it.
Table 19: Number and percentage of correct answers to tutorial exercise

<table>
<thead>
<tr>
<th>Exercise</th>
<th>n correct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A) Selecting the <strong>best</strong> quadrangle</td>
<td>10/13 (76.92%)</td>
</tr>
<tr>
<td>1B) Selecting the <strong>worst</strong> quadrangle</td>
<td>8/13 (61.54%)</td>
</tr>
<tr>
<td>2A) Selecting the very <strong>best</strong> bottle</td>
<td>10/13 (76.92%)</td>
</tr>
<tr>
<td>2B) Selecting the very <strong>worst</strong> bottle</td>
<td>8/13 (61.54%)</td>
</tr>
<tr>
<td>2C) Selecting the most <strong>modern</strong> and <strong>boring</strong> bottle</td>
<td>7/13 (53.85%)</td>
</tr>
<tr>
<td>2D) Selecting the most <strong>ambiguous</strong> bottle</td>
<td>8/13 (61.54%)</td>
</tr>
<tr>
<td>3) Calculating the <strong>Mean</strong></td>
<td>10/13 (76.92%)</td>
</tr>
</tbody>
</table>

Ten participants completed task #3 correctly, but five of these referred back to the tutorial to find how to calculate the Mean value of the dataset. One possible reason for this is that they failed to pay sufficient attention while reading the tutorial so as clearly to understand the concept of the Mean. One participant confused the Mean with the Median; one made an arithmetic error summing the data, and one divided the sum with the number of values in the example of the tutorial (n=7), instead of referring to the question given in the exercise (n=9). Overall, it took participants 20 minutes ($SD = 11$ min) on average to complete the tutorial including the exercises.

Taken together, results of the performance on the tutorial show that participants performed better on positive than on negative quadrangles, indicating that they needed more exposure, training and exercises on the concept of the 2D map, interpreting positive and negative quadrangles. Giving more exercises using descriptive statistics could also be of help. In addition, it was also clear that target users could benefit from enhancements such as providing more visual examples of the Mean to facilitate comprehension. The word ‘ambiguous’ needs to be rephrased to ‘unclear’ to avoid confusion among design students in future DACADE iterations.
Performance on DACADE tasks

Of a total of 50 issues emerging in the task performance, 43 were of some consequence to the design of the tool. These were sorted into four categories, namely (1) groups and participants, (2) Frequency and Mean, (3) Blank screen technique, and (4) other issues. These are discussed next.

Groups and participants

Most of the problems occurring in the New Study task were related to the notion of groups. Some eight participants had problems understanding the concept of group(s), and they were unable to identify the button allowing them to add groups despite the presence of a mouse-over tooltip. On the one hand, the problem appeared to be a lack of understanding of the importance of assigning participants to groups (n=6), and on the other hand, it was confusion about the concept of adding a new group (n=2).

Problems concerning the concept of groups had already been identified in the paper prototype Usability Test #1 as shown in Figure 47, where users could simply choose the number of groups needed and select the number of participants for each group. Ideally, these groups should be created automatically based on users’ selection in the New Study section and displayed in the Run Analyses section for the consumers’ views. However, apart from confusion with both the number of groups and number of participants’ concepts, several participants also suggested removing the function, enabling them to assign an unlimited number of participants to a test in which participants were not divided into groups. An explanation of the function of groups and how it works was originally added to the tutorial for the paper prototypes and tested in Usability Test #2.
Yet still, in Usability Test #2, three participants confused the number of participants in each group with the total number of participants in the test. One user even preferred different numbers of participants in each group in a given test. Both examples suggest that several participants failed to grasp the meaning and intentions underlying the concept of participant-groups.

The explanation of the concept of groups provided in Usability Testing #2 was implemented in the Tutorial as shown in Figure 48 and used in UAT.

Again, participants did not grasp the basic concept of assigning participants into groups, and their misconception of assigning a different number of participants to each group kept occurring despite the fact that all UAT participants had read the tutorial in

Figure 47: A paper screen of adding groups and number of participants

Figure 48: An implemented screen of the information about groups in the DACADE tutorial
the implemented version. One possible explanation could be that the wording of the tooltip saying ‘Click to add more groups’ appearing when the users mouse over the button, may have misled participants into believing that one group has already been created. That is, the button would enable them to add more groups as shown in Figure 49. This could be overcome by adding a default text box where users can immediately enter the first group name as soon as they enter this screen, and later add more groups if necessary. Nevertheless, this would not address the issue about design students’ idea of assigning a different number of participants to each of several groups. This notion of groups is a concept used in experimental science in which design students have no training. The present data would therefore suggest that some training on the concept of groups as an integral consideration to systematic investigations could benefit these students.

Figure 49: A screenshot of the button for adding groups
Several participants (n=7) had problems obtaining the Frequency of products in each quadrangle in DACADE. This issue had also been identified and addressed in Usability Test #2 by introducing the concept of Frequency in the tutorial. Hence, for the purpose of the UAT, the same explanation of Frequency had been implemented in the actual tool as in Figure 50.

**Figure 50:** An implemented screen of Frequency on the DACADE tutorial

However, in the UAT, five of the 13 participants understood the Frequency concept but counted the Frequency of the products manually instead of clicking on any quadrant to obtain it automatically. An instruction for obtaining the Frequency by clicking on a particular quadrant is presented on the Analysis menu and shown in Figure 51, but some participants (n=5), still had to be reminded to read it.
Figure 51: An implemented Analysis screen with instructions

One possible solution could be to reverse the location of the instruction for getting the Frequency, currently in the top line, with the line of buttons, currently presented below the instruction. That way, participants would see the instructions directly when looking at the 2D map. Another two participants had completely forgotten what Frequency meant, needing additional explanation even though they had read about Frequency in the tutorial. It is possible that participants failed to pay close attention while reading through the tutorial. An exercise for obtaining the Frequency could be added in future DACADE iterations to help participants better understand the concept. However, there is no guarantee that this would work, given that participants were also having problems obtaining the Mean, which they had read about and completed an exercise with the Mean in the tutorial. Two participants calculated the Mean manually by clicking on the quadrant instead of selecting the Mean button in the Running Analyses menu. With the tutorial and exercise involving the Mean as shown in Figures 52 and 53, some participants were still unable to comprehend the concept of the Mean.
Figure 52: An implemented screen of the Mean on DACADE tutorial

Another issue with the Mean was related to its look on the Running Analyses screen, being the only option with a check-box button placed in the same line as the other two buttons, shown in Figure 54. This line-up contains one drop down menu, three buttons, and the Mean option with the check box, which is conceptually less than ideal and confusing. Participants took longer and needed guidance to find where the Mean would be calculated.
To solve the problem, this study suggested placing the Mean with the check box on the side of the 2D map rather than alongside the other buttons. This was because the other buttons involved additional dialog boxes for further action, which was not the case for the Mean. However, because this was the first time the users had seen or used DACADE, immediate understanding of some functions may not be expected. It stands to reason that, as students gain more experience using the tool and perhaps a training in elementary statistics, this will help them better understand its purpose, in particular the statistical aspects.

**Blank screen technique**

Another issue was related to the data collection technique of positioning images on a blank screen (n=7). Even though a step-by-step instruction was given on the same screen, participants still needed additional guidance and reminders to read the instructions. It is possible that the instructions were unclear because they could not be tested properly on the paper-prototypes in the usability testing #2.
In the UAT, participants had problem entering adjectives and positioning these next to clusters of images. First, participants might confuse the task of entering and positioning adjectives with the ‘+adjective’ button used as shown in Figure 55 (encircled in red). Second, the instruction may have been too long, as it was presented in two sentences. Thus, it may need to be revised in future DACADE iterations. The button ‘+adjective’ would need to be changed to a text box with some text inside, e.g. ‘Type your adjectives here…’ that comes with a clear step-by-step instruction such as,

1) Pick and place images anywhere on the blank screen
2) Provide adjectives by typing these in a text box
3) Press the Return/Enter key to proceed
4) Position the adjectives to label the clusters
5) You can add and position as many adjectives as you like

Figure 55: An implemented image positioning for the blank screen technique
Other issues

Other issues concerned participants’ failure or refusal to read the instructions or tasks (n=2) and being lost on the task requirements (n=4). Some participants read the tasks but could not understand what needed to be done. They needed guidance and a reminder to read the instructions on the screen or to refer to the particular task they were trying to complete. One participant even refused to read the tasks, simply because she had spent considerably longer than others on the tutorial (45 minutes). Another participant did not understand the Running Analyses task, even though the researcher provided an explanation of the 2D map.

There were also some minor issues in relation to the requirement of signing in; one participant did not realize that, as a new user, he had to sign up. Participants also made some minor mistakes such as forgetting to add another group, creating a new study instead of editing an existing study, or accidentally deleting wrong images. Some participants performed activities that were not in the task requirements. Most of these mistakes appeared to occur because of a failure to pay sufficient attention to details on the screen while performing the task, or else they did not read the tasks carefully. The mistakes can probably be overcome by giving the users more time to explore and familiarize themselves with the tool during training.

Another minor issue was that three participants were not MAC users and thus may have felt a bit awkward when attempting to import images into DACADE as well as using the MAC keyboard. DACADE can run on both the MAC and Windows operating systems, thus providing appropriate platform for future DACADE training, and need to be considered to solve this issue. The full summary of performance data is listed in Appendix C (pp. 242-251).
- Opinion data

Consistent with the usability and satisfaction goal, the average score on the SUS did reach 70% ($M = 73.85$, $SD = 17.37$), suggesting that the tool was acceptable to the representatives of the target population sampled. The mean scores of each item in the SUS and the questions asked are attached in Appendix C (pp. 252-254). The perceived Aesthetics scores show a similar pattern with an average score on each of the four visAWI facets reaching at least 70% as per the aesthetics criterion shown in Table 20 below. DACADE was thus perceived as being visually pleasing along all four aesthetics dimensions tested.

Table 20: Average scores, Standard Deviations and percentages of the four facets

<table>
<thead>
<tr>
<th>Aesthetics</th>
<th>Average (SD, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td>5.49 (1.44, 78.43)</td>
</tr>
<tr>
<td>Diversity</td>
<td>4.91 (1.43, 70.14)</td>
</tr>
<tr>
<td>Colourfulness</td>
<td>5.85 (1.27, 83.57)</td>
</tr>
<tr>
<td>Craftsmanship</td>
<td>5.86 (1.63, 83.7)</td>
</tr>
</tbody>
</table>

Averages and standard deviations, as well as the percentages associated with the additional questions concerning participants’ opinion about DACADE are presented in Table 21. With three of the five questions reaching an average score exceeding 6/7, and the remaining two questions close to 5.7/7 each, it is safe to conclude that DACADE was perceived to be valuable, pleasant to use, that it would be useful in the future for this sample of participants, and that participants were interested in both collecting and analyzing future data as well as learning more about statistics.
Table 21: Scores, Standard Deviations and Percentages of five other questions asked

<table>
<thead>
<tr>
<th>Five other questions</th>
<th>Average (SD, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. DACADE is valuable to design students</td>
<td>6.23 (1.01, 89)</td>
</tr>
<tr>
<td>Q2. Interaction with DACADE is pleasant</td>
<td>5.69 (1.49, 81.29)</td>
</tr>
<tr>
<td>Q3. I would recommend DACADE to other design students</td>
<td>6.15 (1.68, 87.86)</td>
</tr>
<tr>
<td>Q4. DACADE inspired me to collect and analyse data in future design projects</td>
<td>6.23 (1.17, 89)</td>
</tr>
<tr>
<td>Q5. I would like to learn more about the power of statistics after using DACADE</td>
<td>5.85 (1.63, 83.57)</td>
</tr>
</tbody>
</table>

In response to the question concerning what they liked the most, 10/13 mentioned data analysis, and ease of use, with another 8/13 participants mentioning simplicity and 5/13 the colours. One participant mentioned the tutorial. One participant expressed his interest in DACADE by saying: “…I really like this tool I’m very impressed, I would like to know the history behind DACADE, where you get to this point. Congratulations! This is really interesting”

In terms of the features they liked the least, 8/13 thought there was too much text, preferring a multimedia or video-based tutorial with more images and sound effects. At the same time, some 4/13 participants thought there was a ‘lack of instructions’, mostly referring to the images in the tutorial that can be clicked on to enlarge, even though a tooltip was provided for each image. Nearly all participants needed to be informed that they could click on the images to view the larger image. Participants wanted more guidance/explanations of some actions in the tool itself even though these are provided in the tutorial that all participants worked through prior to attempting the tasks. Because participants were engaged in completing the tasks, they did not spend time exploring the tool. Comments indicating that participants had not detected features that were not directly involved in the tasks suggest that encouragement to explore the tool might benefit new users. Some 4/13 participants also commented on personal preferences than on the tool. Finally, one participant thought there was too much white space, a consideration that could be taken up in future DACADE iterations.
At the same time, participants also made several good suggestions for improvement. Interestingly, one participant recommended integrating this tool into one of their courses, “…I would recommend if the unit required this type of research, many unit require you to research of existing design solutions…this is helpful for the design students, I think this a good system” Another participant suggested naming the Maps (in Running Analyses screen), for example by using the adjectives used in the map instead of calling them Map1 and Map2, and one person suggested adding more analyses in addition to the Frequency and the Mean. All these constructive suggestions were relevant to improving DACADE; they will be taken into considerations in future DACADE iterations.

**Recommendations**

This section summarizes the findings of UAT and recommends the following changes or enhancements that could be made in the future iterations of DACADE.

**Provide more training of DACADE on:**

1. The concept of 2D maps and blank screen techniques
2. The importance of groups and sufficient or equal number of participants per group
3. The concept of descriptive statistics, in particular Frequency and Mean
4. The actual tool, where users can familiarize themselves and explore it further
5. Integrating this tool into one of the design courses related to sampling, data gathering and analysis
6. Both operating systems, MAC and Windows so that all users can benefit of DACADE

**For the exercises:**

1. To provide more exercises on the tutorial involving calculations of Frequencies
2. To rephrase the word ‘ambiguous’ with ‘unclear’ where appropriate
For the actual tool:

1. Groups and Participants, to create a default textbox for renaming the group, hence the tooltip can remain unchanged.

2. Positioning images on a blank screen, where the button of ‘+ adjective’ needs to be changed to Enter button and to add text ‘Type your adjectives here…’ inside the textbox. To also add clear step-by-step instruction on this screen.

3. Analysis screen, to label the Maps with sets of adjectives used, instead of Map1, Map2.

4. To standardize the buttons names used in DACADE, for example renaming Product Select and Product Selection into Filter Products similar to Filter Participants.

5. Adding more statistical analysis in the future DACADE iterations

For technical issues, to discuss further with the software developers on some errors or conceptual issues encountered during UAT such as:

1. To fix the bug on the Running Analyses screen. When users accidentally double click on a Quadrant, the tool froze, forcing the participant to go back to the Main Menu and then to the Running Analyses screen to obtain the Frequency. It appears that users can only click once on each Quadrangle.

2. To reverse the position of instruction for Frequency with the buttons so that the instruction appears above the 2D map.

3. To move the position of Mean from the list of buttons to the left side of the 2D map.

4. To enable the editing of the answers option for the demographic questions template. This issue was encountered even before the UAT was run, but due to some technical issues highlighted by the developers, this function had been disabled in the implementation.
5. This study also discovered that a better and cost-effective software tool could be developed if the software developer team had been involved from the very beginning, as early as the initial design stage.

Summary

This chapter discussed the User Acceptance Test (UAT) to determine the level of satisfaction and aesthetic appraisal of DACADE with no further usability problems during its implementation. This study concludes that the perceived usability, satisfaction, and aesthetic appeal of DACADE with the design students as the main target audience met the criteria. This study also revealed several enhancement issues of which some should be addressed in future versions of DACADE. These include both the tool and the tutorial. It also confirmed that design students would benefit from a more formal introduction to the purposes of sampling opinion, data collection, data analysis, interpretation, and application of statistical results. Further discussion on the theoretical implications and future work will be discussed in the next chapter.
Chapter 11: Discussion, Future Work and Conclusion

Summary of the main findings

The survey of design courses offered by Australian universities and other countries showed that no single course or course component related to systematic data collection and statistical analysis was being offered. This finding was confirmed in the subsequent interviews with design students and lecturers; none of the participants had ever used any data collection and manipulation tool. The search for statistical software tools relevant to design students showed that no such tool was available. It was therefore decided to develop a simple tool, DACADE, assisting design students to gather consumer opinions and to perform simple descriptive statistical analyses.

Paper prototypes were then designed and evaluated iteratively in two formative usability tests to satisfy the pre-determined usability goals. The first test revealed the need for a tutorial to accompany DACADE, as the students had difficulties understanding the data collection methods and interpreting the outcomes. Upon testing the tutorial prototype, it was tested together with the DACADE tool in the second test. Very few usability issues were found; these were eliminated prior to implementing DACADE. Importantly, the test demonstrated that the students were still unable to grasp the basic concepts involved in data collection, analysis, and interpretation. Once implemented, the User Acceptance Test was conducted to ensure that no additional usability problems had crept in as well as to determine the level of satisfaction, perceived usability and aesthetic appraisal of DACADE. All of these met the pre-set criteria, revealing several issues that would be worthwhile pursuing in future versions of DACADE.
Theoretical Implications

The findings of this study have several important theoretical implications as discussed in this section.

- Transfer of learning

This study followed the relevant guidelines provided by the theoretical models, such as first, dividing the task into the sections of New Study, Edit Study, Collect Data, and Run Analyses as recommended by Cognitive Load Theory. Secondly, the study followed the principle of Cognitive Complexity Theory, where the tasks were organized in steps, enabling users to simply follow the prompts in completing tasks. Nonetheless, it still seems insufficient for the design students to be able to grasp the gist of using DACADE and they did not perform well in the task. One possible reason for this could be that not enough attention was paid to the given tool and tasks. The findings suggest that the participants in the three usability studies did not know or grasp the notion of collecting data from several consumers prior to deciding on a particular design. Taking shopping for a mobile phone as an example that participants would be likely to have experienced, one would investigate several plan and phone options in different physical and online shops, looking for good deals before settling on a decision. That example suggests that they actually would have some existing knowledge of sampling and comparing different possible solutions. This would indicate that they do understand the idea of data, but that they did not manage to transfer that knowledge to the present context. That is, participants appeared to have neglected to activate the relevant mental model enabling them to transfer their knowledge to a different type of problem. This problem of transfer has not been addressed by the theories reviewed in this thesis such as Mayer's (2005) CTML.

- Appropriateness

The use of bananas as a graphical representation demonstrating arithmetical central tendencies was not ideal for the design student population. It appeared that they simply focused on the salient features of the object and interpreted that as having sexual
connotations, rather than recognizing them as representing the underlying meaning of the Mean, the Mode, and the Median. It would thus appear that one needs to very carefully select graphics that are socially and psychologically acceptable to the target population. The extent to which the apparent inappropriateness of the images initially selected may have affected participants’ performance cannot be determined post hoc, but it may have played an important role. No theories were found that discussed the appropriateness of symbols selected to support the tasks and the audience.

- Motivation

Another important finding of this research is that design students were hesitating to read the tutorial and the tasks, basically saying that they preferred illustrations, animations, and anything that would be more entertaining than text. Indeed, it took the researcher several attempts to encourage them to read before they would do it. Even so, several issues raised suggested that they did not pay as close attention to the explanations, examples, and even exercises as they needed so as successfully to complete all of the tasks in the tutorial as well as when using the tool. This suggests that learners in general, and design students in particular, at least in the present situation, need to be extrinsically motivated to learn. This important issue is not addressed in any of the learning-related theories reviewed in this thesis.

In spite of the considerable effort devoted to the design and development of DACADE, it is possible that the tool may have exceeded the cognitive capabilities of the design students by forcing them to read the tutorial; they may have felt overwhelmed with the nature of the tasks given that these involved numbers, a form of information that designers inherently dislike or believe they are incapable of mastering.
Advancement of knowledge contributing to the design of DACADE

- Schema Theory and Mental Models suggested that the tool needed to be simple and organized into several sections (p. 24 & 27).
- Scripts and Cognitive Complexity Theory suggested that providing procedural or step-by-step instructions would be beneficial in performing a task (p. 26 & 85).
- Cognitive Load Theory suggested that the tool should be organized into several sections (p. 87). It also suggested that providing visual illustrations to help users to make sense of textual or numerical information would be useful. The tool offers visual illustrations of descriptive statistics as well as filtering the results by products, or participants (p. 90).

Limitation of the Study

This research has a number of limitations.

- Small participants’ pool for data collection during the conduct of the Interviews and Surveys (Chapter 3), two iterations of Usability Test (Chapters 8 and 9), and User Acceptance Test (Chapter 10) were due to no new information or issue found.
- The archival searches of the design curricula (Chapter 3) were carried out thoroughly in all universities in Australia and in several other countries. The motivation of these selections were, at the time of this research, the researcher did not know if it is different in other countries, and the researcher is based in Australia.

Future Work

This present research revealed that design students were hesitant to read the tutorial that was presented in textual and graphical forms. Accordingly, this study proposed turning the DACADE tutorial into a ‘show and tell’ video-based instructional resource with less text to encourage them to focus on the contents.
Results obtained in this thesis suggest that design students find it difficult to understand why they should collect data from potential future users of their intended products. It would therefore be interesting to design a course dealing with these issues as well as teaching the fundamentals of statistical analyses, including simple analyses of parametric (t-tests, one-way ANOVAs, correlations) and nonparametric statistics (Mann-Whitney Tests, Wilcoxon Signed Ranks Tests, Chi Square). It may be possible to convey the concepts more successfully by providing students with examples to which they can easily relate, such as buying a mobile phone as discussed earlier. It is intended to expand the capabilities to DACADE add these as well as additional measures of central tendency.

Given that several participants had problems understanding the necessity for assessing the relative frequency of occurrence of participants’ different opinions, and nor did they appear to grasp the importance of calculating Mean opinions in their own work. The same was true for the notion of participant-groups; some had problems realizing why they would need to assign an equal number of participants to each group. Perhaps additional examples demonstrating the merits of assigning people to different groups and comparing the performance and opinions of these, might help to overcome the apparent mental block that evidently prevented participants from transferring existing knowledge to a, for them, novel context. Additionally, more explanations and illustrative examples to convey these concepts more effectively should be added.

DACADE is currently running only on desktop computers with MAC/Windows operating systems. Considering that most design students will eventually be working as practitioners in the field, it is also intended to expand DACADE such that it can be run on mobile platforms as well, and possibly also on other platforms.

DACADE had solved partial of the problem. More visual input and output techniques can be added in the future enhancement of DACADE such as Mode, Median, and Standard Deviations.

Although DACADE was designed specifically to support design students testing their design ideas and prototypes, it would be interesting also to learn more about what experienced practitioner designers might need in terms of a tool such as this. One would
imagine that at least some aspects of the tool would need to be redesigned for it to be acceptable to such an audience.

DACADE is a novel, innovative and significant tool suitable for use by design students for the following reasons. First, DACADE offers visual data collection techniques that are 2D map and Projective Mapping. Design students can simply and quickly collect data visually by following the step-by-step instructions. Secondly, DACADE will automatically process and analyse these data and generate visual results. For instance, DACADE displays the Frequency via bar graphs and the Mean via a 2D map. Thirdly, users can filter these visual results according to product(s), or participant(s) as they like. Other existing tools do not offer these facilities. DACADE is reasonable to be accepted by other design students.

Conclusion

The main goal of this study was to investigate about a lack of data collection and analysis skills among design students, and then to attempt to solve the problem of a lack of such knowledge. This was done by providing a simple software tool, designed to help students understand the merits of systematic data collection of consumer performance and opinion, and carry out well-designed user tests to produce successful products. This is in contrast to an over reliance of designers on intuitions, perceptions and personal experiences. Despite the effort of developing DACADE accompanied with a tutorial, the design students sampled seemed still not fully to grasp these concepts. Design students were found to have very little knowledge about data collection and analysis, interpretation and application to design.
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Appendices
Appendix A – Preliminary Investigations

Full lists of degrees reviewed from Australian universities

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Full lists of degrees reviewed from other countries

The list of universities was obtained from Core77, Design School Directory. (Link: [http://www.core77.com/design.edu/](http://www.core77.com/design.edu/))

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</tr>
<tr>
<td></td>
<td>PG</td>
<td><a href="http://www.florencedesignacademy.com/graphicdes">Link</a></td>
</tr>
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<tr>
<td>---</td>
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<td>---</td>
</tr>
</tbody>
</table>
| 22. Domus Academy, Milano, Italy | PG | http://www.domusacademy.com/site/home/master-programs/fashion-design/program.html  
http://www.domusacademy.com/site/home/master-programs/design/intro.html |
| 24. Hogeschool voor de Kunsten Utrecht, Netherlands | UG | http://www.hku.nl/web/English/Bachelors/BachelorOfDesign.htm  
PG | http://www.hku.nl/web/English/Masters/MasterOfArtsInDesign.htm |
<p>| 25. University of Lapland, Finland | UG and PG | <a href="http://www.ulapland.fi/InEnglish/Units/Faculty_of_Art_and_Design/Studies/Field_of_Studies/Graphic_Design_and_Media_Studies.iw3">http://www.ulapland.fi/InEnglish/Units/Faculty_of_Art_and_Design/Studies/Field_of_Studies/Graphic_Design_and_Media_Studies.iw3</a> |
| 26. Oslo University, Norway | PG | <a href="http://aho.nxc.no/eng/content/view/full/3426">http://aho.nxc.no/eng/content/view/full/3426</a> - Master of Industrial Design |
| 29. The Hong Kong Polytechnic, School of | UG | <a href="http://www.sd.polyu.edu.hk/web/Undergraduate/BADesign/Subjects">http://www.sd.polyu.edu.hk/web/Undergraduate/BADesign/Subjects</a> (BA in Design (Visual |</p>
<table>
<thead>
<tr>
<th>Design, Hong Kong</th>
<th>Communication, Industrial &amp; Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>30. Universiti Teknologi MARA, Malaysia</td>
<td>UG</td>
</tr>
</tbody>
</table>
Hi [Name of Coordinator/ Head of Unit or Department],

I am a research student at Swinburne University. I have one query regarding the courses offered to design students in [name of university]. Do you offer any course related to systematic data gathering or data analysis method to design students? If so, could you please provide me some details on the contact person or any information related to this.

The reason I asked is because I am currently looking at the design curriculum in universities and it is related to my research area. Your kind help in this matter is very much appreciated.

******************************************************************************

Madihah Binti S. Abd. Aziz
PhD Candidate,
Faculty of Design,
Swinburne University of Technology,
Melbourne, Australia.
Ethics certificate for Interviews

From: Kaye Goldenberg <KGOLDENBERG@groupwise.swin.edu.au>
Date: 7 February 2012 1:44:41 PM AEDT
To: <awhitfield@swin.edu.au>
Cc: Rachel Mosel <RMOSEL@groupwise.swin.edu.au>
Subject: SUHREC Project 2012/006 Ethics Clearance

To: Prof. Allan Whitfield, Design/ Ms Madihah Binti Sheikh Abdul Aziz
[BC: Ms Madihah Binti Sheikh Abdul Aziz]

CC: Ms Rachel Mosel, Research Admin. Co-ordinator, Design

Dear Prof. Whitfield,

**SUHREC Project 2012/006 An investigation of quantitative data collection and data analysis methods in design curricula at higher educational institutions**
Prof. Allan Whitfield, Design/ Ms Madihah Binti Sheikh Abdul Aziz
Approved Duration: 07/02/2012 To 07/07/2012 [Adjusted]

I refer to the ethical review of the above project protocol undertaken on behalf of Swinburne's Human Research Ethics Committee (SUHREC) by SUHREC Subcommittee (SHESC4) at a meeting held on 20 January 2012. Your response to the review as e-mailed on 2 February 2012 was reviewed by a SHESC4 delegate.

I am pleased to advise that, as submitted to date, the project has approval to proceed in line with standard on-going ethics clearance conditions here outlined.

- All human research activity undertaken under Swinburne auspices must conform to Swinburne and external regulatory standards, including the National Statement on Ethical Conduct in Human Research and with respect to secure data use, retention and disposal.

- The named Swinburne Chief Investigator/Supervisor remains responsible for any personnel appointed to or associated with the project being made aware of ethics clearance conditions, including research and consent procedures or instruments approved. Any change in chief investigator/supervisor requires timely notification and SUHREC endorsement.
- The above project has been approved as submitted for ethical review by or on behalf of SUHREC. Amendments to approved procedures or instruments ordinarily require prior ethical appraisal/clearance. SUHREC must be notified immediately or as soon as possible thereafter of (a) any serious or unexpected adverse effects on participants and any redress measures; (b) proposed changes in protocols; and (c) unforeseen events which might affect continued ethical acceptability of the project.

- At a minimum, an annual report on the progress of the project is required as well as at the conclusion (or abandonment) of the project.

- A duly authorised external or internal audit of the project may be undertaken at any time.

Please contact me if you have any queries about on-going ethics clearance. The SUHREC project number should be quoted in communication. Chief Investigators/Supervisors and Student Researchers should retain a copy of this e-mail as part of project record-keeping.

Best wishes for the project.

Yours sincerely

Kaye Goldenberg
Secretary, SHESC4
*******************************************
Kaye Goldenberg
Administrative Officer (Research Ethics)
Swinburne Research (H68)
Swinburne University of Technology
P O Box 218
HAWTHORN VIC 3122
Tel  +61 3 9214 8468
Interview questions and demographic questions

For Students - Demographics Questions
(To be given separately to participants so that they can tick accordingly)

<table>
<thead>
<tr>
<th>Gender:</th>
<th>___ Male</th>
<th>_____ Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ranges:</td>
<td>___18-24</td>
<td>___25-30</td>
</tr>
<tr>
<td>Level of study:</td>
<td>Undergraduate:</td>
<td>Year 1</td>
</tr>
<tr>
<td></td>
<td>Postgraduate:</td>
<td>Master</td>
</tr>
<tr>
<td></td>
<td>___</td>
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<td></td>
<td>___</td>
<td>____</td>
</tr>
</tbody>
</table>

Area of study:
___ Graphic Design
___ Product Design
___ Industrial Design
___ Fine Art
___ Other (please specify)

Specific Questions (To be asked by the interviewer)

1. In your study,
   a. Did you take any course(s) related to quantitative/systematic data collection? (Yes/No).
   b. Did you take any course(s) related to quantitative/systematic data analysis? (Yes/No).
   c. If Yes, Please give me the title and number of the course(s).
      If No, proceed to Question 3.

2. If Yes,
   a. When did you do this course(s)?
   b. What kind of data collection methods did you learn in this course?
   c. Were there any assignments related to systematic data collection and data analysis methods in this course? Yes / No, if No, proceed to Question (j).
   d. If Yes, was this an individual assignment or a group assignment?
   e. Did you apply the systematic methods you have learned in this assignment?
f. Can you please explain how you completed this assignment using the systematic data collection methods?

(In case no assignments related to data analysis were noted in Question 2c).

g. Did you also apply systematic data analysis to the data you gathered?  
   Yes/No, if No proceed to Question (j).

h. If Yes, What kind of analysis did you use? Did it involve any statistical analysis? (Yes/No) If No, proceed to question (j).

i. If Yes, what kind of statistical analysis did you use?

j. If No, who analyzed your data? The teacher? Or another group of students? Or someone else?

k. Would you want to learn more about systematic data collection and data analysis methods? If Yes, continue, if No, why? And move to Question 3.

l. Can you specify what you would like to learn? (Next, proceed to Question 4)

3. Do you think design students should learn systematic data collection and data analysis?

   a. Why did you think so?

4. Have you ever used any computer software tool to help you collect data? (Yes/No), If No, proceed to Question 5.

   a. Can you name the software tool(s) you used?

   b. On a scale from 1 to 9, where 1 is worst possible, and 9 is best possible:

      i. How would you rate the ease of use of the tool you used?

      ii. Accuracy?

      iii. Helpfulness?

      iv. Visual appeal of the user interface?

   c. Would you use this software tool in the future? (Yes/No)

   d. Was there something would you think should be improved in this software tool? Please elaborate…

Thank you for your time and participation
For Lecturers: Demographics Questions

(Given separately to participants so that they can tick accordingly)

<table>
<thead>
<tr>
<th>Gender:</th>
<th>___ Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>___ Female</td>
</tr>
<tr>
<td>Age:</td>
<td>___ 21-30</td>
</tr>
<tr>
<td></td>
<td>___ 31-40</td>
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<td></td>
<td>___ 41-50</td>
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<td></td>
<td>___ 51-60</td>
</tr>
<tr>
<td>Highest educational background:</td>
<td>___ Diploma</td>
</tr>
<tr>
<td></td>
<td>___ Bachelor</td>
</tr>
<tr>
<td></td>
<td>___ Master</td>
</tr>
<tr>
<td></td>
<td>___ PhD</td>
</tr>
<tr>
<td>Area of specialization:</td>
<td>___ Graphic Design</td>
</tr>
<tr>
<td></td>
<td>___ Product Design</td>
</tr>
<tr>
<td></td>
<td>___ Industrial Design</td>
</tr>
<tr>
<td></td>
<td>___ Fine Art</td>
</tr>
<tr>
<td></td>
<td>___ Other</td>
</tr>
<tr>
<td>(Please specify)</td>
<td>.................................................</td>
</tr>
<tr>
<td>Level of design students you teach</td>
<td>Undergraduate: Year</td>
</tr>
<tr>
<td>(Please specify)</td>
<td>.................................................</td>
</tr>
<tr>
<td></td>
<td>Postgraduate:</td>
</tr>
<tr>
<td></td>
<td>___ Master in.........................................</td>
</tr>
</tbody>
</table>

To be asked by the interviewer

1. How long have you been working in academia? Is Swinburne University your first university? YES / NO. *If Yes, proceed to Question 2, or else continue.

IF NO,

a) How many educational institutions that you have worked at before Swinburne University?
b) Where was/were your previous workplace(s)?

c) How long did you work there?

d) What courses did you teach in that university(s)?

e) Have you taught courses related to systematic data gathering and data analysis method in that university(s)? YES/NO. *If Yes, continue, or else proceed to Question 2.

f) What were those courses?

2. Have you ever worked outside academia? (YES / NO)

   IF YES, (If NO, proceed to Specific questions)

   a) Where did you work?
   
   b) How long did you work with that company (or those companies)?
   
   c) What were your roles / responsibilities in that company/those companies?

Specific Questions

3. Do you teach any course(s) related to data collection or data analysis methods to design students? If NO, proceed to Question 6.

4. What level of study are they in?

5. What is the title of the course?

   a) What kind of data collection methods do you introduce in this course?
   
   b) Could you please give me an example of an assignment related to data collection that you use in your course?
   
   c) Have students applied the data collection method(s) that you teach in this course for this assignment? (YES/NO)
a. If NO, what method(s) have they used?

d) Do you teach data analysis methods to students in this course? (YES / NO). *If Yes, continue, or else proceed to Questions 6.

e) Please tell me about the kinds of data analysis methods you introduce in the course.

f) Do any of these methods involve statistical analyses? (YES / NO). *If Yes, continue, or else proceed to Questions 6.

g) What kind of statistical analyses would be involved in the analysis of data students have gathered?

6. IF NO,

a. What do you think of systematic data collection and data analysis method?

   a) Do you think it is necessary or not necessary for design students to learn systematic data collection and data analysis method? Why?

   b) If NECESSARY, based on your personal experience, do you have suggestions of important techniques to be included in systematic data collection and data analysis methods if they were to be developed?

Thank you for your time and for participating in this interview session.
Information Consent Statement

Information consent statement for other data collection stages follow the same standard as the one attached here.

Consent Information Statement

Audience Members

Project Title: An Investigation of quantitative data gathering and data analysis methods in design curricula at higher educational institutions.

Principal Investigator: Professor Allan Whitfield
Student Investigator: Ms Madihah Sheikh Abdul Aziz

Dear participant,

This project is part of a PhD study in the Faculty of Design, Swinburne University of Technology. It investigates the design curriculum of higher education institutions to see if it contains components covering quantitative data gathering and statistical analysis. The ultimate objective is to develop an interactive instrument for systematic data collection and data analysis to assist designers in understanding consumers’ perceptions of products. In order to develop the new instrument, input and feedback from users before the development stage takes place is vital.

The project aims to gather feedback and input from the target users who are design instructors and design students. In a session of approximately 45-minutes you will be asked questions around demographic information, and specific questions related to the courses you teach/take. You will be asked to fill in the form asking about your demographic information before the interview starts. During the interview, all conversations between you and the interviewer will be recorded so they can be analyzed for use in a PhD thesis. Your participation in this interview is most welcome and your contribution to this research is highly appreciated.

Introduction to the project

Every product has a consumer who is an end-user. Therefore, it is important for designers to know if their product will be successful for the end-user. A way to discover this is to understand consumers’ perceptions of the product. One approach is to use statistical methods to gather data from prospective end-users. A problem, however, is that designers often lack the knowledge and skills to use such a method. Most of the statistical analysis software requires advanced knowledge of statistics and may be difficult for designers to use easily. This study aims to fill this gap by developing a new instrument to support designers in understanding consumers’ perceptions of products without the need for advanced statistical knowledge.

Project and researcher interests

The study seeks to discover the following information from participants:

1. If quantitative data collection and data analysis methods exist and are teach in the design school.
2. Perceptions of design instructors and design students towards teaching and learning quantitative data collection and data analysis methods.
3. Results yielded from the interviews will provide information for the development of the proposed instrument.

What participation will involve

In this study we are looking for design instructors and design students, male and female aged 18 and above who are willing to participate. You will be asked a set of questions including your demographic information and specific questions related to courses you teach/take. There are no right or wrong answers. You are free to answer based on your own understanding and experiences. All answers will be beneficial to our study and will be analysed later. The interviews will be carried out at the Faculty of Design, Swinburne University of Technology, Prahran Campus.
Participant rights and interests

This project is for the purpose of research and all information collected can only be accessed and analysed by the researchers conducting the research. The anonymity of participants is preserved and will not be identified in publications. However, minimal risks of identification of participants by other parties might occur. To prevent this, participants’ names/ staff ID/ student ID will not be used throughout the interviews and digital files will be destroyed after transcriptions.

Your participation is voluntary and you are free to withdraw from the project at any time without explanation. In case you choose to withdraw, all data associated with you will be withdrawn and destroyed. For the student participants, your participations and contributions in this study have no bearing on your academic results. This study is solely for the purpose of research and perhaps journal publications and to provide feedback for the development of the proposed instrument.

Your consent will be obtained by signing the consent form, which will be distributed to participants before taking part in the interviews.

The interview will be recorded. The researcher will ask permission from each participant through the informed consent form to record using an audio recording device, which will be covered in the informed consent form if he/she agrees to all conditions stated. Participants will remain anonymous and no identification of participants will be made in publications or research findings.

All files will be saved using Code-formatting to retain the anonymity and confidentiality to protect participants, and to avoid potential identification of the participants involved. All demographics forms, signed consent forms, and audio recordings will be kept together in a secured and locked filing cabinet at the Faculty of Design, Swinburne University, Prahran Campus. All data collected as mentioned above will be kept for a maximum of five years after the completion of study in a locked faculty research facility.

Further information about the project

If you would like further information about the project, please do not hesitate to contact the Principal Investigator:

Principal Investigator: Professor Allan Whitfield, Director, National Institute for Design Research, Faculty of Design
(Swinburne) Contact Address: PA614, 144 High Street Prahran
(Swinburne) Tel No: 03 9214 6882
(Swinburne) Email: awhitfield@swin.edu.au

Concerns/complaints about the project

This project has been approved by or on behalf of Swinburne’s Human Research Ethics Committee (SUHREC) in line with the National Statement on Ethical Conduct in Human Research. If you have any concerns or complaints about the conduct of this project, you can contact:

Research Ethics Officer, Swinburne Research (H68),
Swinburne University of Technology, P O Box 218, HAWTHORN VIC 3122.
Tel (03) 9214 5218 or +61 3 9214 5218 or resethics@swin.edu.au
Appendix B – The first and second formative usability testing

Ethics certificate for both usability tests

To: Prof. Allan Whitfield, Design/ Ms Madihah Binti Sheikh Abdul Aziz

Dear Prof. Whitfield,

SUHREC Project 2012/006 An investigation of quantitative data collection and data analysis methods in design curricula at higher educational institutions
Prof. Allan Whitfield, Design/ Ms Madihah Binti Sheikh Abdul Aziz
Approved Duration: 07/02/2012 To 07/07/2012 [Adjusted] Extension to 30/06/2013
Project Modification: December 2012

I refer to the annual report for the above project received in hard copy on 22 November 2012 in which you requested an extension of project duration and a modification to the protocol by the inclusion of a new participant group. Requests were made by the Delegate for clarification regarding the security of the data and corrections to be made to the advertising poster. Responses to these queries were received on 18 December and were put to a delegate of the relevant SUHREC Subcommittee (SHESC4) for consideration.

I am pleased to advise that, as submitted to date, the modified and extended project/protocol may continue in line with standard ethics clearance conditions previously communicated and reprinted below.

Please contact me if you have any queries about on-going ethics clearance, citing the SUHREC project number. Copies of clearance emails should be retained as part of project record-keeping.

As before, best wishes for the project.
Regards
Kaye Goldenberg
Secretary, SHESC4

Kaye Goldenberg
Administrative Officer (Research Ethics)
Swinburne Research (H68)
Swinburne University of Technology
P O Box 218
HAWTHORN VIC 3122 Tel +61 3 9214 8468 Fax +61 3 9214 5267
Table 22: Cover stories used in the First Formative Usability Testing

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Study</td>
<td>“Imagine that you are a Principal Designer working for the Toyota company. Your boss has asked you to design a new model of car for Toyota. To do this, you are required to gather some data, so you have decided to run a study to understand how consumers perceive cars available in the market place using our proposed system. We are pretending that this system is already up and running.”</td>
</tr>
<tr>
<td>Edit Study</td>
<td>“Imagine that you are a Principal Designer working with Toyota. Your boss has asked you to design a new model of car for Toyota. To do this, you are required to gather some data, so you have decided to run a study to understand how consumers perceive cars available in the market place using our proposed system. You have already created the study, but you suddenly discovered that you need to change some of the information before the actual survey can take place. We are pretending that this system is already up and running.”</td>
</tr>
<tr>
<td>Collect Data</td>
<td>“Imagine that you are a consumer who has been asked to participate in a study trying to understand consumers’ perceptions of cars. The study is carried out by Toyota. Your input to this study is crucial for helping Toyota to design a new car. To participate in this study, you will be using our proposed system. We are pretending that this system is already up and running.”</td>
</tr>
</tbody>
</table>
Table 23: Tasks used in the First Formative Usability Testing

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| New Study 1 | “You are asked to create a new study aiming at assessing consumers’ perception of cars. The target respondents are consumers aged 18 and above, male and female from various backgrounds. This study involves one group of thirty participants. The study will run from 10th January 2013 until 24th January 2013.  

"In order to collect and analyze data using this software tool, you are required to have your own account. New users may register by providing their email address and password.  

"The study involves positioning ten image-based cars on 2D maps based on 1 set of descriptive terms which are Like-Dislike vs Cheap-Expensive. The ten images can be retrieved from a database. A brief introduction for participants to the study needs to be prepared to encourage respondents to participate in the study. Please go ahead and create this new study". |
| New Study 2 | "You are asked to create a new study aiming to assess consumers’ perceptions of cars. The target respondents are consumers aged 18 and above, male and female from various backgrounds. This study involves two groups each of twenty participants. The study will run from 10th January 2013 until 24th January 2013.  

"You are already an existing user; you may use your usual email address and password.  

"In the study, participants will be asked to place ten image-based cars on a blank screen. You will need to retrieve the ten images from a file simply called “cars” stored in the F-drive. You need to write a brief introduction for participants to the study. Please go ahead and create this new study." |
| Edit Study 1 | Task 1a  

"Imagine you are a professional designer who has created a study to investigate what consumers think about the appeal of different cars. However, you need to add one more set of descriptive terms; Fast – Slow versus Strong - Weak.  

"Moreover, due to some unavoidable circumstances you need to extend the completion date of the study from 15th January 2013 to 4th February 2013. You will need to save the file." |
| Task 1b | "Data on cars have been collected from 10 participants. You need to present these data to a client to convince them to invest in your product. Your task is to analyze these data statistically.

"Specifically you want to see the visual results of the overall positions using Smallest Space Analysis (SSA) on both sets of descriptive terms, which are Like – Dislike versus Cheap - Expensive, Fast –Slow versus Strong – Weak. "Next, you want to find out the frequency and mean values of the Like-Dislike dimensions in the study."

| Task 2a | "Imagine you are a professional designer who has created a study to investigate what consumers think about the appeal of different cars. However, some of the images now need to be changed. You have decided to replace three images from the list of ten cars. Due to the unforeseen circumstances you need to also add one more group of ten participants to the study."

| Task 2b | "Data on cars have been collected from 10 participants. You need to present these data to a client to convince them to invest in your product. In this task you need to find out if the words bulky and modern are in the list that study participants selected to describe their perceptions of cars.
"Find out also which were the two most frequently mentioned terms."
Table 24: Summary of usability issues found in the formal study for creating a New Study, the number of participants facing the problem (n) and suggestions for enhancements/changes.

<table>
<thead>
<tr>
<th>No</th>
<th>Summary of Usability Issues</th>
<th>n</th>
<th>Changes / Enhancements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Existing users failed to sign in.</td>
<td>2</td>
<td>To create a tooltips for all buttons and text boxes.</td>
</tr>
<tr>
<td>2</td>
<td>New users failed to register.</td>
<td>2</td>
<td>Two different screens for Sign In and Register were combined into one screen to enable users to see the differences.</td>
</tr>
<tr>
<td>3</td>
<td>Participants did not understand the purpose of ‘number of groups’ and ‘number of participants.’</td>
<td>3</td>
<td>This part remains unchanged but the description of these two functions was made available in a tutorial.</td>
</tr>
<tr>
<td>4</td>
<td>Demographic questions: Two participants mistakenly selected all questions from the list.</td>
<td>4</td>
<td>More specific template of demographic questions with type of questions given as radio buttons, check boxes, or drop-down menu were added, also an option to add a new question.</td>
</tr>
<tr>
<td>5</td>
<td>Navigation issue – a participant refused to click multiple Back buttons to move backward from screen to screen.</td>
<td>1</td>
<td>A new feature of hyperlink was added to the timeline whereby users can click on the timeline at the top of each screen, to jump to other screens.</td>
</tr>
<tr>
<td>6</td>
<td>Participants misunderstood that the section of ‘The introduction of the study’ was intended for them as a reminder of the purpose of the study.</td>
<td>1</td>
<td>The wording ‘introduction of the study’ was renamed to ‘Instruction to participants’. The section is meant for the design students to create an instruction to their target consumers participating in a study.</td>
</tr>
<tr>
<td>7</td>
<td>Participants’ mistakenly inserted images</td>
<td>2</td>
<td>Instead of having one button Insert, two buttons were added before users choose the</td>
</tr>
</tbody>
</table>
from a database instead of importing them from a file. type of importing images, either From File or From Database.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Participants did not understand the purpose of ‘Adding a new map’ button.</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Participants failed to click Save button in every screen before proceeding to the next screens.</td>
<td>3</td>
</tr>
</tbody>
</table>
### Table 25: Summary of usability issues found in the formal study for Collect Data, the number of participants facing the problem (n) and suggestions for enhancements/changes

<table>
<thead>
<tr>
<th>No</th>
<th>Summary of Usability Issues</th>
<th>n</th>
<th>Changes / Enhancements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A participant found an unnecessary Exit button on all screens.</td>
<td>1</td>
<td>The button was deleted. The section was meant for getting feedback from prospective consumers, thus, having Exit button on every screen was misleading.</td>
</tr>
<tr>
<td>2</td>
<td>Participants were stuck at image positioning task on blank screen UI with no instruction provided.</td>
<td>2</td>
<td>The instruction was added to the prototypes for the second iteration.</td>
</tr>
<tr>
<td>3</td>
<td>In the section of Collect data – a Save button is no use.</td>
<td>1</td>
<td>The button was deleted.</td>
</tr>
</tbody>
</table>

### Table 26: Summary of usability issues found in the formal study for Running Analyses, the number of participants facing the problem (n) and suggestions for enhancements/changes

<table>
<thead>
<tr>
<th>No</th>
<th>Summary of Usability Issues</th>
<th>n</th>
<th>Changes / Enhancements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Navigation issue found when participants stuck at selecting either operation or file first.</td>
<td>2</td>
<td>The submenu of Running Analyses was redesigned. The filenames and operations were combined on one screen.</td>
</tr>
<tr>
<td>2</td>
<td>Navigation problem at the analysis section, whereby button Next is active allowing users to proceed to the next screen without first selecting an operation/ filename.</td>
<td>2</td>
<td>The Next button was greyed-out, becoming a passive button. Instead, they were required to choose the filename and analysis first.</td>
</tr>
</tbody>
</table>
Hints and Errors for the First Formative usability testing

Table 27: Summary of hints given to participants during the test

<table>
<thead>
<tr>
<th>UI/Task</th>
<th>Hint</th>
<th>Screen</th>
<th>Description of hint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank screen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>Selecting demographic questions</td>
<td>Participants were reminded to read the task again, and refer to the information provided.</td>
</tr>
<tr>
<td>Collect Data</td>
<td>1</td>
<td>Image-positioning task</td>
<td>An instruction to position images on a blank screen UI with no criteria was added.</td>
</tr>
<tr>
<td>Collect Data</td>
<td>1</td>
<td>Writing down adjectives at image-positioning task</td>
<td>An instruction to write down some adjectives describing the images was added.</td>
</tr>
<tr>
<td>2D map</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>1</td>
<td>Registration for a new account</td>
<td>Participants were informed that they could create their own email address, username and password to register.</td>
</tr>
<tr>
<td>Run Analyses</td>
<td>1</td>
<td>Running smallest space analysis</td>
<td>Participants were informed how ‘smallest space analysis’ works.</td>
</tr>
</tbody>
</table>

Table 28: Summary of errors made by participants during the test

<table>
<thead>
<tr>
<th>Task</th>
<th>n</th>
<th>Screen</th>
<th>Description of error</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Study</td>
<td>1</td>
<td>Number of groups</td>
<td>Participants entered the number of groups as 20, instead of the number of participants for each group</td>
</tr>
<tr>
<td>New Study</td>
<td>2</td>
<td>Import images</td>
<td>Import images from database instead of from files</td>
</tr>
<tr>
<td>Run Analyses</td>
<td>1</td>
<td>Analyses Menu</td>
<td>A participant had selected a statistical analysis that was not in the task</td>
</tr>
</tbody>
</table>
Tutorial of DACADE

- As attached in a disk
- Filename: page235TUTORIAL.pdf
Enhanced DACADE prototypes

- As attached in a disk
- Filename: page236DACADE_PROTOTYPES.pdf

1. New Study
2. Edit Study
3. Run Analyses
4. Collect Data
The Mean, Median and Mode illustrations in the DACADE tutorial

An example of the Mean:

If we took the scores of five design students obtained out of a possible 100 each in their information design final examination, we might find the following data:

80 75 62 72 87

To find the mean of the final examination results, add the five values and then divide it by the number of student scores:

\[ 80 + 75 + 62 + 72 + 87 = 376 \]
\[ \frac{376}{5} \text{ (five design students)} = 75.2 \]

The Mean score of the five design students in their final examination for an information design course is 75.2.
An example of the Median (the same graphics were used to show Median and Mode):

The median of a set of data values is the middle value of the data set, which must first be arranged in ascending order from the lowest to the highest value.

Example: The marks of five students in a history test that had a maximum possible mark of 50 are given below:

Find the median of this set of data values

Answer: Arrange the data values in order from the lowest value to the highest value:

Answer: The third data value, 37, is the middle value in this arrangement.

Median = 37

An example of the Mode:

The mode of a set of data values is the value(s) that occurs most often.
The tutorial was tested with a professor in communication design at the Faculty of Design, Swinburne University of Technology, who suggested using only one type of object to show the differences and avoid confusion. He suggested choosing images of bananas that can be obtained from the Internet and edited it in Adobe Illustrator to show the values by varying the length of these. He also suggested demonstrating the differences between Mode, Frequency and Relative Frequency.

A picture of bananas varying in size was then produced as shown in Figure 56. To the researcher’s surprise, the students perceived this as having sexual connotations, which was just as inappropriate as it was embarrassing for the researcher conducting the test. This finding corroborates with a comment made by one participant during the interview (Chapter 3) conducted earlier, who said, “Designers are sometimes very lazy to find for answers and normally look at the obvious not deeper.” Likewise, the finding mirrors those of the previous studies that have examined the use of graphs and graphical representations to foster learning, suggesting novices with limited knowledge of the underlying concepts tend to be attracted to the salient features of the graphics rather than understanding the underlying concepts presented (Stern, Aprea, & Ebner, 2003; Westelinck et al., 2005). Upon deliberation, the illustration was therefore changed to depict a set of books as shown in Figure 57. The completed tutorial of DACADE is attached in Appendix B, (p. 235).
**Figure 56**: The original illustration of Mean, Median and Mode

**Figure 57**: The illustration of Frequency and Relative Frequency
Hints and Errors for the Second Formative usability testing

Table 29: Summary of *hints given* and *errors made* during the second iteration of usability test

<table>
<thead>
<tr>
<th>UI/ Task</th>
<th>Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hint</strong></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>Study Details - Participants were informed that they can enter some information such as aim or details of the study</td>
</tr>
<tr>
<td>New Study</td>
<td>Importing images – a participant was trying to edit the images instead of proceeding to the next screen. A hint was given to inform that they could click ‘Next’ button to proceed to the next screen, not editing the images. DACADE does not provide image editing.</td>
</tr>
<tr>
<td><strong>Error</strong></td>
<td></td>
</tr>
<tr>
<td>New Study</td>
<td>A participant did not specify the number of participant and group</td>
</tr>
<tr>
<td>New Study</td>
<td>A participant had chosen the wrong demographic question by assigning adjectives on the occupation category.</td>
</tr>
<tr>
<td>New Study</td>
<td>A participant decided not to assign adjectives when asked even though she was given a 2D map task that requires adjectives</td>
</tr>
<tr>
<td>Edit Study</td>
<td>Instead of adding a new map, participants changed the adjectives on the existing map</td>
</tr>
</tbody>
</table>
Appendix C – User Acceptance Test

Ethics certificate of UAT

To: Prof Allan Whitfield/Design; Ms Madihah Binti Sheikh Abdul Aziz
Dear Allan and Madihah,

SUHREC Project 2012/006: An investigation of quantitative data collection and data analysis methods in design curricula at higher educational institutions
Prof Allan Whitfield/Ms Madihah Binti Sheikh Abdul Aziz, Design
Approved Duration: 07/02/2012 To 31/12/2013 [Adjusted] [Modified December, 05 August 2013]

I refer to the e-mail received on 1st August 2013 in which you requested a modification to your project by allowing for two more tests to be carried out and for an extension of duration of the project to 31/12/2013. The request was reviewed by a SHESC delegate.

I am pleased to advise that, as submitted to date, the modified project/protocol may continue in line with standard ethics clearance conditions previously communicated and reprinted below.

Please contact me if you have any queries about on-going ethics clearance, citing the SUHREC project number. Copies of clearance e-mails should be retained as part of project recordkeeping.

Best wishes for the project.

Kind regards,

Sally

Secretary, SHESC1 & SHESC3

Sally Fried
Research Administration Officer (Ethics)/EA to Pro Vice-Chancellor (Research)
Swinburne Research
Swinburne University of Technology
SPS Level 1
PO Box 218
Hawthorn VIC 3122
Tel: +61 3 9214 8145
Fax: +61 3 9214 5267
Internal mail code: H68
### Summary of performance data

**Table 30: Summary of New Study issues found in the UAT**

<table>
<thead>
<tr>
<th>New Study</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>He Sign in - I have to stop him and asked to Sign Up first as a new user</td>
<td>Sign In/Sign Up</td>
</tr>
<tr>
<td>Not sure of what to do based on the task - I need to guide him how to do the task - probably related to language. He is non-native English speaker</td>
<td>Did Not Understand The Task</td>
</tr>
<tr>
<td>Not sure of the group - he thought he needs to include all variables of the study such as age range, gender. I explained to him that the group is to define group name such as group A etc., he was suggesting to add what is the purpose of naming the group. (Although we already put that on the tutorial). He was saying, “first impression I thought that I have to put variables of the group. Then, the next page will be asking me to specify the categories of the variables selected in the previous page, such as age range”.</td>
<td>Group &amp; Concept</td>
</tr>
<tr>
<td>Demographic questions - he suggested to add instructions that you can tick more than one question</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>Group - he thought that there is no group because he was the only participant, did not understand the concept of group - need to explain again the concept of groups in DACADE. He wasn't sure that it was according to the task; he tried to put his own information on the study.</td>
<td>Group &amp; Concept</td>
</tr>
<tr>
<td>Sign Up - confused with signing up - she put her email address on the First Name section - she said she hasn’t had enough sleep last night.</td>
<td>Sign In/Sign Up</td>
</tr>
<tr>
<td>Did not fill in the form completely (Step 1), was reminded to</td>
<td>Did Not Pay</td>
</tr>
<tr>
<td>Issue</td>
<td>Category</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Go back to the previous screen, and complete the form then proceed.</td>
<td>Attention</td>
</tr>
<tr>
<td>Was unsure of what to do with the task, then asked to refer to the</td>
<td>Did Not Understand The Task</td>
</tr>
<tr>
<td>task again and reminded that she is to explore the tool based on the</td>
<td></td>
</tr>
<tr>
<td>task.</td>
<td></td>
</tr>
<tr>
<td>Stuck with group - I have explained to her the function of groups -</td>
<td>Group &amp; Concept</td>
</tr>
<tr>
<td>and she used the terms 'fickle person', 'quirky style', 'hipster'</td>
<td></td>
</tr>
<tr>
<td>for the group names. She missed the number of participants. Then i</td>
<td></td>
</tr>
<tr>
<td>asked her to assign the number of participants per group before</td>
<td></td>
</tr>
<tr>
<td>proceeding. She said she wanted to look at the demographic of these</td>
<td></td>
</tr>
<tr>
<td>groups.</td>
<td></td>
</tr>
<tr>
<td>Unsure of Step 3: questions - gender/age range etc.</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>Not sure of the participants' number and number of groups, when</td>
<td>Group &amp; Concept</td>
</tr>
<tr>
<td>asked to read the task again, he managed to do it.</td>
<td></td>
</tr>
<tr>
<td>Asked about Demographics - he thought that by choosing the list of</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>demo Questions - the next screen will ask him to define the</td>
<td></td>
</tr>
<tr>
<td>Questions' further like the age range etc.</td>
<td></td>
</tr>
<tr>
<td>Selected display all items in a study (This is to display all</td>
<td>Did Not Understand The Task</td>
</tr>
<tr>
<td>images at once for image positioning). A step that was not required</td>
<td></td>
</tr>
<tr>
<td>in the task.</td>
<td></td>
</tr>
<tr>
<td>She total up all participants that was wrong. Doesn't really like</td>
<td>Group &amp; Concept</td>
</tr>
<tr>
<td>the participant’s number. Asked what if I want different</td>
<td></td>
</tr>
<tr>
<td>participants for each groups?</td>
<td></td>
</tr>
<tr>
<td>Demographic Questions - was unsure which one to tick.</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>She doesn't want to read the instructions on Step 4. i have to</td>
<td>Refused To Read The</td>
</tr>
</tbody>
</table>
techniques - or put the 2D MAP and BLANK SCREEN - bigger or in different color. Not sure of which one to choose, then read the task again.

Nearly give up to proceed; I have to guide her to add images. She didn't want to read the cover story and tasks. She didn't even want to click on the screen. But I asked her to do it. She deleted the wrong images. Then, only she understood the task that was replacing images.

<table>
<thead>
<tr>
<th>Not a MAC user - having trouble to use the keyboard</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsure what to put on a Summary - Step 1</td>
<td>Step 1 – Summary</td>
</tr>
<tr>
<td>Missed to add one more group - and to rename the group.</td>
<td>Group</td>
</tr>
<tr>
<td>Selected Education Background - not needed in the task</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>Instruction template - need to tell her what it was for.</td>
<td>Did Not Understand The Tutorial</td>
</tr>
<tr>
<td>Image - where to find the files - looked again on the task - then she did it.</td>
<td>Did Not Understand The Task</td>
</tr>
<tr>
<td>Thought a separate number could be assigned into groups</td>
<td>Group &amp; Concept</td>
</tr>
<tr>
<td>Confused about education background</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>Not a MAC user</td>
<td>Not A Mac User</td>
</tr>
<tr>
<td>Unsure of adding the second group</td>
<td>Group</td>
</tr>
<tr>
<td>Unsure of how to add a group - clicked on Name twice, then</td>
<td>Group</td>
</tr>
<tr>
<td>Clicked twice on the Name - then click ADD button to add adjectives</td>
<td>Adjectives Button</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Problem to sign up - existing email address used - he had to use his other email address. It probably because he clicked twice on a Sign Up button.</td>
<td>Sign In/Sign Up – Clicked Twice – technical issue</td>
</tr>
<tr>
<td>Problem with Start Date - could not clicked on the 31st Oct (the date of the testing day), but when i tried, it works. He clicked twice on the button.</td>
<td>Start Date - Clicked Twice – technical issue</td>
</tr>
<tr>
<td>He ticked all for demo Questions – not required in the task</td>
<td>Demo Questions &amp; Task</td>
</tr>
<tr>
<td>Sign up - password &lt; 7 characters</td>
<td>Sign In/Sign Up</td>
</tr>
<tr>
<td>Step 2 - clicked twice on Name, then clicked ADD group</td>
<td>Group</td>
</tr>
<tr>
<td>Step 5 - not sure where the folder was</td>
<td>Not A Mac User</td>
</tr>
</tbody>
</table>
Table 31: Summary of Edit Study issues found in the UAT

<table>
<thead>
<tr>
<th>Edit Study</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adding new adjectives - was editing the existing adjectives -</td>
<td>Error - Edited Existing Adjectives</td>
</tr>
<tr>
<td>not adding a new term - needed to guide him to add new adjectives</td>
<td></td>
</tr>
<tr>
<td>First, she created a new study - not editing. Stopped her, and asked to</td>
<td>Created A New Study Instead Of Editing and</td>
</tr>
<tr>
<td>go back.</td>
<td>existing study</td>
</tr>
<tr>
<td>Accidentally deleted the wrong images</td>
<td>Deleted Wrong Images</td>
</tr>
<tr>
<td>Not reading the cover story and task 2. She then followed my instruction</td>
<td>Refused To Read The Task</td>
</tr>
<tr>
<td>of how to do it to get the answers.</td>
<td></td>
</tr>
<tr>
<td>Edited the start date instead of end date</td>
<td>Error – start and end date</td>
</tr>
<tr>
<td>Unsure of how to replace images - thinking whether to click import images</td>
<td>Did Not Understand The Concept Of The Tool /</td>
</tr>
<tr>
<td>or what. Reminded to delete images first or import the cars first, then</td>
<td>Deleted Wrong Images</td>
</tr>
<tr>
<td>delete. But, he deleted the wrong images according to the task.</td>
<td></td>
</tr>
<tr>
<td>Done the first part, to do the second part, she went back to Main, and</td>
<td>Did Not Understand The Concept Of The Tool</td>
</tr>
<tr>
<td>edit again. (She could edit both parts at one time, no need to exit)</td>
<td></td>
</tr>
<tr>
<td>Collect Data</td>
<td>Remarks</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Image positioning - he was trying to move images at the bottom instead of the one on the top</td>
<td>Image positioning</td>
</tr>
<tr>
<td>Was asking about strong and weak of the cars. What does it means?</td>
<td>Adjectives</td>
</tr>
<tr>
<td>Unsure of what to do with the blank screen - stuck here. (Positioning images). After explanation, I need to explain on how to add adjectives, then move the adjective anywhere on the images (or clusters) then she managed to drag and drop and entered some adjectives related to the products.</td>
<td>Image positioning</td>
</tr>
<tr>
<td>For task 3 - I asked her to read both Cover story and task – she refused.</td>
<td>Image positioning</td>
</tr>
<tr>
<td>i asked her to perform the task, without reading the text.</td>
<td></td>
</tr>
<tr>
<td>When she tried to move the image, then only she understand how to position.</td>
<td></td>
</tr>
<tr>
<td>The image is too small.</td>
<td>Images too small</td>
</tr>
<tr>
<td>Unsure that she can move the adjectives</td>
<td>Image positioning</td>
</tr>
<tr>
<td>Adjectives can't be deleted</td>
<td>Adjectives deletion</td>
</tr>
<tr>
<td>Not sure of what to do when positioning images. Reminded to click on the +adjective button after entering the text, and can move the text.</td>
<td>Image positioning</td>
</tr>
<tr>
<td>Unsure of how to use the blank screen - stuck for 1 minute - needed explanation</td>
<td>Image positioning</td>
</tr>
<tr>
<td>I cannot see in front of the cars, but it is okay.</td>
<td>Images too small</td>
</tr>
<tr>
<td>Strong in terms of mechanic or in terms of long lasting?</td>
<td>Adjectives / the concept of the tool</td>
</tr>
</tbody>
</table>
Table 33: Summary of Run Analyses issues found in UAT

<table>
<thead>
<tr>
<th>Run Analyses</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confused with the Frequency - selected Product Select instead. - He counts</td>
<td>Frequency</td>
</tr>
<tr>
<td>the frequency manually though have been told to click on the quadrant</td>
<td></td>
</tr>
<tr>
<td>To get the mean, he clicked the frequency Quadrant 2 instead, and count</td>
<td>Mean</td>
</tr>
<tr>
<td>the number of cars, and divide by the number of participants</td>
<td></td>
</tr>
<tr>
<td>Product selection - stuck - was confused with frequency, kept clicking on</td>
<td>Product selection</td>
</tr>
<tr>
<td>the quadrant and counting the product on each quadrant to count products</td>
<td></td>
</tr>
<tr>
<td>manually. Couldn’t find the button to Product Select.</td>
<td></td>
</tr>
<tr>
<td>Need to guide him on understanding the analysis</td>
<td>Understanding the map</td>
</tr>
<tr>
<td>He was unsure of the frequency, need to remind him to read the instruction</td>
<td>Frequency</td>
</tr>
<tr>
<td>on the screen to get the frequency, because he was trying to count them</td>
<td>Clicked twice</td>
</tr>
<tr>
<td>manually. Clicked on quadrant twice - went hang!</td>
<td></td>
</tr>
<tr>
<td>Taught him how to read the map and also see other maps.</td>
<td>Understanding the map</td>
</tr>
<tr>
<td>Frequency- he wanted to count the products manually. Was asked to read the</td>
<td>Frequency</td>
</tr>
<tr>
<td>instruction on the screen, then he clicked on the quadrant and get the f.</td>
<td></td>
</tr>
<tr>
<td>Mean - he tried to calculate manually by double clicking on the quadrants.</td>
<td>Mean</td>
</tr>
</tbody>
</table>
The screen hangs again and I have to go back to Analysis section to continue. He was then taught how to get Mean on DACADE.

| Action                                                                 | Error                                      
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clicked twice</td>
<td>Confused with menu</td>
</tr>
<tr>
<td>Clicked the wrong button - Run button instead of Analysis.</td>
<td></td>
</tr>
<tr>
<td>She didn't understand the concept of 'frequent' adjectives mentioned by participants. After looking at the tutorial again for two times, then she can answer. Was spending a long time on the adjectives tutorial - then not sure to move from tutorial to the Analysis again. (5 minutes on searching for the information). I have to assist her again of what to do on that particular screen. She then, answered me - i look at the frequency number, which are two and three. After explanation, she then answered them correctly.</td>
<td>Confused with menu</td>
</tr>
<tr>
<td>Not sure of which study to click on the Main Menu - was supposed to click on the Cars Study - blank screen.</td>
<td></td>
</tr>
<tr>
<td>He was referring to how many times the participant no 5 appears on the list of adjectives, then realized he did it wrongly and suggested the right answer without having to explain more details by a researcher.</td>
<td>Frequency</td>
</tr>
<tr>
<td>'To go to Map - clicked twice – error - return to Main Menu</td>
<td>Clicked twice</td>
</tr>
<tr>
<td>Not sure where to click on the screen after Main Menu - could not see the link to &quot;map&quot;.</td>
<td>Confused with menu</td>
</tr>
<tr>
<td>Found the 2D map - unsure where to look at - need assistance. Reminded to read the instruction on the screen to find</td>
<td>Understanding the map</td>
</tr>
<tr>
<td>Frequency - click on a quadrant once. Couldn’t tell which is which for the image files on the</td>
<td>Frequency</td>
</tr>
<tr>
<td>Frequency - maybe images can be bigger.</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Couldn’t find Mean on the screen - shown to her.</td>
<td>Mean</td>
</tr>
<tr>
<td>Frequency - forgotten what frequency meant - explained and asked to read instruction on the screen. Clicked on the quadrant twice.</td>
<td>Frequency</td>
</tr>
<tr>
<td>Overall positions - need explanation - 'there is strong tendency of likeness to the red and white cars, and also the red cars is more related to expensive cars&quot;. Showed him there was another map.</td>
<td>Understanding the map</td>
</tr>
<tr>
<td>Frequency - reminded to read instructions on the screen</td>
<td>Frequency</td>
</tr>
<tr>
<td>Clicked twice – quadrant</td>
<td>Technical error</td>
</tr>
<tr>
<td>Could not see Mean on the screen. Gave a hint to look at the button on the screen to get Mean. Unsure of which button to click to Analyse - stuck here. Guided her to go to Map, and showed her the map.</td>
<td>Mean</td>
</tr>
<tr>
<td>Guided her to read the instruction on the screen, but she clicked on the instruction without even reading it. Then she read, and clicked on the quadrant to get the frequency.</td>
<td></td>
</tr>
<tr>
<td>Was confused with the cars pictures - not clear to her.</td>
<td>Cars not clear</td>
</tr>
</tbody>
</table>
### Summary of all issues found in UAT

Table 34: Summary of issues found in User Acceptance Test

<table>
<thead>
<tr>
<th>Type of issue</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure/ refusal to read the instructions</td>
<td>2</td>
</tr>
<tr>
<td>Totally lost on tasks</td>
<td>4</td>
</tr>
<tr>
<td>Sign up</td>
<td>3</td>
</tr>
<tr>
<td>Demographics</td>
<td>3</td>
</tr>
<tr>
<td>Groups</td>
<td>8</td>
</tr>
<tr>
<td>Summary/instructions to participants</td>
<td>2</td>
</tr>
<tr>
<td>Frequency</td>
<td>7</td>
</tr>
<tr>
<td>Finding/calculating the mean</td>
<td>4</td>
</tr>
<tr>
<td>Blank screen/adjectives</td>
<td>9</td>
</tr>
<tr>
<td>Images</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43</strong></td>
</tr>
<tr>
<td>Goes beyond task requirements</td>
<td>4</td>
</tr>
<tr>
<td>MAC issues</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>
Summary of SUS score

Table 35: Mean scores of each item for the SUS scale

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Std Dev. S</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>4.23</td>
<td>0.93</td>
<td>84.62</td>
</tr>
<tr>
<td>Q2</td>
<td>2.46</td>
<td>1.33</td>
<td>49.23</td>
</tr>
<tr>
<td>Q3</td>
<td>4.15</td>
<td>0.69</td>
<td>83.08</td>
</tr>
<tr>
<td>Q4</td>
<td>1.85</td>
<td>1.07</td>
<td>36.92</td>
</tr>
<tr>
<td>Q5</td>
<td>3.69</td>
<td>0.95</td>
<td>73.85</td>
</tr>
<tr>
<td>Q6</td>
<td>1.85</td>
<td>0.90</td>
<td>36.92</td>
</tr>
<tr>
<td>Q7</td>
<td>4.08</td>
<td>1.19</td>
<td>81.54</td>
</tr>
<tr>
<td>Q8</td>
<td>2.08</td>
<td>1.12</td>
<td>41.54</td>
</tr>
<tr>
<td>Q9</td>
<td>4.08</td>
<td>0.76</td>
<td>81.54</td>
</tr>
<tr>
<td>Q10</td>
<td>2.46</td>
<td>1.13</td>
<td>49.23</td>
</tr>
</tbody>
</table>
Table 36: List of questions asked in SUS

<table>
<thead>
<tr>
<th>Item</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>I think that I would like to use DACADE frequently</td>
</tr>
<tr>
<td>Q2</td>
<td>I found DACADE unnecessarily complex</td>
</tr>
<tr>
<td>Q3</td>
<td>I thought DACADE was easy to use</td>
</tr>
<tr>
<td>Q4</td>
<td>I think that I would need the support of a technical person to be able to use DACADE</td>
</tr>
<tr>
<td>Q5</td>
<td>I found the various functions in DACADE were well integrated</td>
</tr>
<tr>
<td>Q6</td>
<td>I thought there was too much inconsistency in DACADE</td>
</tr>
<tr>
<td>Q7</td>
<td>I would imagine that most people would learn to use DACADE very quickly</td>
</tr>
<tr>
<td>Q8</td>
<td>I found DACADE very cumbersome to use</td>
</tr>
<tr>
<td>Q9</td>
<td>I felt very confident using DACADE</td>
</tr>
<tr>
<td>Q10</td>
<td>I needed to learn a lot of things before I could get going with this system</td>
</tr>
</tbody>
</table>