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Designing a technology mash-up to support remote physical-digital fashion design collaboration

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Abstract

Due to high labour costs, most companies have changed their business strategy by outsourcing their manufacturing process to manufacturers in China instead of manufacturing locally. Therefore there is an increase in need to support remote collaboration in the fashion industry. The achievement of a shared understanding of the design problem, the shared design artefacts and the solutions is vital for any remote collaboration to happen successfully. One of the problems the fashion design industry faces, in the context of distributed collaboration, is that there is a barrier between the physical artefacts associated with the process of fashion design, and the digital version of artefacts or the representation of those artefacts through technology. From the Human-Computer Interaction point of view, the physical and digital barrier can be seen as a 'social technical intersection'.

To explore this problem from an interaction design perspective, this thesis describes the design and evaluation of a prototype to support remote collaboration in fashion design—TVTM prototype. The TVTM prototype is designed to provide the translation mechanism between actual physical artefacts and the digital representation of those artefacts. The prototype takes advantage of the increasing sophistication of off-the-shelf technologies in order to explore the use of a mash-up approach to designing collaboration technology. The thesis later presents a principled way of dealing with the problem associated with the achievement of shared understanding that is caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for remote collaboration.

This thesis contributes to the field of interaction design and communication theory by presenting the link between the translation mechanism of physical to digital fashion design collaboration and the social technical intersection. The thesis also contributes to the novel use of the Video Card Game methodology as an evaluative tool to understand the design process as part of the iterative design process. The themes generated from the Video Card Game study allowed triangulation of the data that has been collected using three different methodologies as a new approach to ensure robustness of research findings.

Declaration By Author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly authored works that I have included in my thesis.

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Publications During Candidature

Yang, J., Dekker, A., Muhlberger, R., & Viller, S. (2009, November). Exploring virtual representations of physical artefacts in a multi-touch clothing design collaboration system. In Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7 (pp. 353-356). ACM.

Yang, J., Viller, S., & Rintel, S. (2012). Outsourcing: Mashing up design methods and technologies in the fashion industry. In: *PIN-C 2012: Participatory Innovation Conference*, Melbourne, Australia, (1-4). 12-14 January 2012.

Yang, J., Rintel, S., & Viller, S. (2013). Principled ways of finding, analysing and planning for communicative overhead in interaction technology for fashion industry. In Human-Computer Interaction. Users and Contexts of Use (pp. 484-491). Springer Berlin Heidelberg.

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Contributor	Statement of contribution
Jason Yang	Conception, literature survey, hardware and software design, experimental design, writing (75%)
Andrew Dekker	Software development, experimental design, writing (20%)
Ralf Muhlberger Stephen Viller	Conceptual input and editorial comments (5%)

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Jason Yang	Conception, literature survey, experimental design, analysis, interpretation and writing (75%)
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Stephen Viller	Conceptual input and editorial comments (5%)

Contributions By Others To The Thesis

The software for the first iteration and the improvements for the second iteration of the TVTM prototype were developed by Andrew Dekker.

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Keywords

Fashion industry, outsourcing, remote collaboration, physical-digital, interaction design, mashed-up technology, multimodal system, social technical intersection, asymmetrical access, novelty, overhead.

Australian And New Zealand Standard Research Classifications (ANZSRC)

120304 Digital and Interaction Design 70%
080602 Computer-Human Interaction 30%

Fields Of Research (FOR) Classification

1203 Design Practice and Management 70%
0806 Information Systems 30%

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Abbreviations

CAD	Computer-Aided Design
CMC	Computer Mediated Communication
CSCW	Computer Supported Cooperative Work
CVE	Collaborative Virtual Environment
DI	Diffused Illumination
DSI	Diffused Surface Illumination
FLOSC	Flash Open Sound Control
FTF	Face-To-Face
FTIR	Frustrated Total Internal Reflection
GUI	Graphic User Interface
HCI	Human Computer Interaction
ICT	Information And Communication Technologies
LAN	Local Area Network
LCD	Liquid-Crystal Display
LLP	Laser Light Plane
NUI	Natural User Interface
OSC	Open Sound Control
POS	Point Of Sale
QR	Quick Response
SMCR	Source Message Channel Receiver
SMD	Surface Mount Device
STS	Socio-Technical System
TUI	Tangible User Interfaces
TUIO	Table-Top Tangible User Interfaces protocol
TVTM	Textual Visual Tangible Multi-Touch
UPS	Unit Product System
VR	Virtual Reality
WIMP	Windows-Icons-Menus-Pointers
WYSIWIS	What-You-See-Is-What-I-See

Chapter 1: Introduction

In this chapter, I present background information, my research aims and conclude the chapter with the outline structure of this thesis.

1.1 PROBLEM OVERVIEW AND MOTIVATION

In a distributed manufacturing process such as the fashion industry, fashion designers have to give clear and concise instructions, and pass prototype garments back and forth between factories to ensure fashion designers and manufacturer have common expectations of the final product. It is therefore vital that there is minimal error in communications. It can take up to nine months to design an entire new season's range of clothing before they appear on the retailer's shelves. From the design collaboration process to the manufacturing of the garments (outlined in red in Figure 1 below), fashion designers need to collaborate with various other departments, including the graphic design department, the clothing pattern-making department and the manufacturing department.

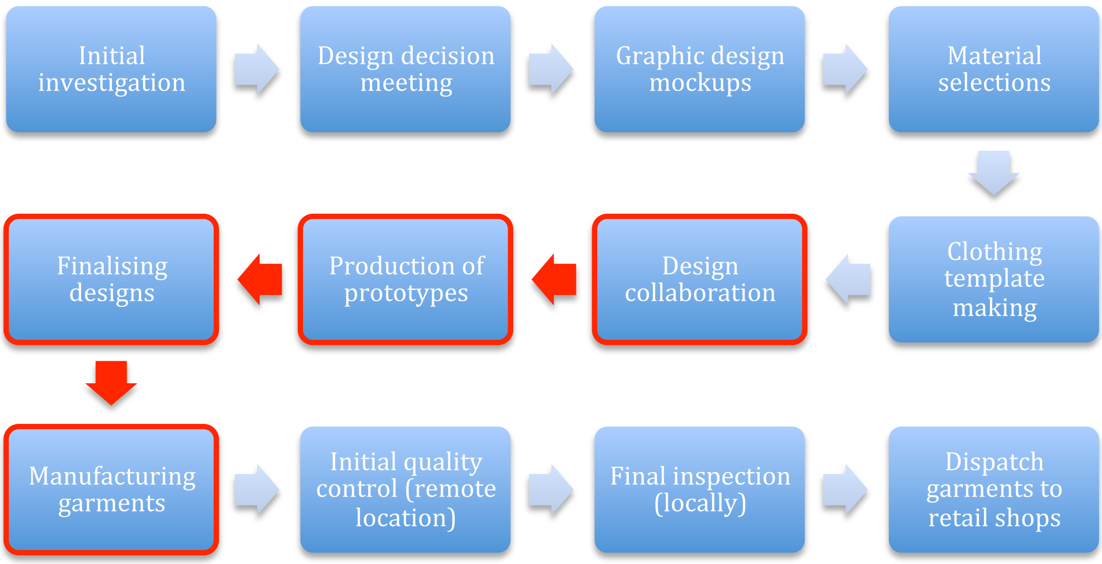


Figure 1: Overview of typical clothing design and manufacturing process

Due to high labour costs, most companies have changed their business strategy by outsourcing their manufacturing process to manufacturers in China instead of manufacturing their own locally (Gereffi, 2002; Hong, Chin, & Liu, 2004; Tokatli, 2008; Ukoha, 2013). During the development cycle, manufacturing issues and miscommunication between the design department and the remote located manufacturer frequently arise.

The fashion industry may present itself as glamorous and trendy, but behind the scenes the technology used in the clothing industry has not kept pace with recent trends in Information and Communication Technologies (ICT). Competition forces all firms to transform, and as Sheehan has pointed out, the new ICT and the processes of globalisation have already changed the face of manufacturing (Sheehan, 2000). The current workspace systems do not involve high-tech computerised programs, but instead rely purely on calendar or diary based scheduling systems for each department.

There is no doubt that computing demands have increased dramatically in the last few years, and these demands have led to the development of new computing technologies. Users now have the option to utilize a variety of new tools such as gestural input to navigate, access and manipulate data displayed on tablet PCs and smartphones. A primary example is the touch screen technology that allows users to operate a computer by simply touching the liquid-crystal display (LCD) screen. It is therefore important to examine and understand how these new technologies and existing technology can be combined, and how the resulting mash-up of these technologies may be adopted by the fashion industry.

Fashion designers often use physical manipulation to compare various design ideas, trying out different fabrics and colours to suit a particular design. One of the problems the fashion design industry faces, in the context of distributed collaboration, is that there is a barrier between the physical artefacts associated with the process of fashion design, and the digital version of artefacts or the representation of those artefacts through technology. Therefore designers and developers need to have a clear understanding of how fashion designers work with their physical fashion design artefacts and how they can be represented and shared as digital artefacts. For any remote collaboration to happen successfully, it is important for the collaborative participants to achieve a shared understanding of the fashion design problem, and the solutions.

This understanding of how fashion designers work is a pre-requisite for the design and development of a solution that could potentially increase the efficiency of the shared workspace experience, allowing the participants in the collaborative process to function as effectively and efficiently as if they were collocated.

Therefore it is important not to have a negative impact on fashion designers' work practice when introducing a new system. By creating a shared workspace collaborative design tool that can draw upon a database of fashion design information from various departments (such as graphics, fabrics, costs, colours, and patterns of past designs), together with product life cycle management software, it may be possible to cut down the production cycle time, while keeping interaction and manipulation methods with which fashion designers are already familiar.

There has already been considerable research in interpersonal distance communication, using acoustic communications (Masoodian, Apperley, & Frederickson, 1995; Monk & Gale, 2002; Ochsman & Chapanis, 1974; J. S. Olson, Olson, & Meader, 1995), visual communications (Argyle & Cook, 1976; Monk & Gale, 2002; Williams, 1977), conferencing systems, shared workspace systems (Kraut, Fish, Root, & Chalfonte, 1990; Stefik, Bobrow, Foster, Lanning, & Tatar, 1987; J. C. Tang, 1991; Whittaker, Geelhoed, & Robinson, 1993) and groupware systems (Bullen & Johansen, 1988; Johansen et al., 1991; Johnson-Lenz & Johnson-Lenz, 1981; A. Tang, Boyle, & Greenberg, 2004). However there has been less well established research (Gidney & Robertson, 1994; MJ Perry, Fruchter, & Rosenberg, 1999) in the area of engaging with physical artefacts through virtual representation especially for the distributed industry.   My research seeks to target this area by focusing on the development of a new approach to the design of a system for remote collaboration. My research is primarily concerned with engaging with physical artefacts, and the hurdles that this presents. These hurdles currently stand in the way of designing a computer system that will potentially allow businesses that have manufacturing departments located remotely to function as effectively and efficiently as if they are in the same location. When working virtually with a complex physical artefact in a system, the artefact itself needs to be represented within the information space.

I have chosen to carry out my research within the fashion industry because this industry is a good example of a distributed manufacturing process. Fashion designers traditionally employ more tactile and physical processes during the design and manufacture of fashion garments. In the fashion design industry, fashion designers need to work with multiple design concepts such as basic outlines of the garment, graphic designs and fabric selections. In order to explore the challenges of remote collaboration in the fashion design process, I have developed a Textual Visual Tangible Multi-touch (TVTM) remote collaborative prototype that would assist fashion designers to work in an environment that simulates the existing work setting, and also would be able to enhance remote collaboration with offshore manufacturers.

1.2 RESEARCH QUESTIONS

The basis of this thesis has been empirically driven and has had a design-oriented (Fallman, Kruzeniski, & Andersson, 2005) approach to Computer Supported Cooperative Work (CSCW). This *research in and through design approach* (Dalsgaard, 2010) is built and extends upon design research by Frayling (1993) and Ludvigsen (2006) and it is widely use by researchers within the field of Human Computer Interaction (HCI). My research question is: **How can the design of a technological mash-up overcome the barrier between physical artefacts and the digital representation of those artefacts to enhance and support remote fashion design collaboration?**

To improve the engagement with physical artefacts through virtual representation for the fashion industry, the process of the design of this technology mash-up using off-the-shelf technologies needs to first address real practical problems of the translation of physical artefacts associated with the process of fashion design to the digital version or representation of these artefacts through technology (physical-digital gap), within the context of remote collaboration in the fashion industry. This research question will be addressed through the exploration of the problems of developing an interactive prototype that can be combined or 'mashed up' to allow collaboration around physical and digital artefacts, facilitate meaningful communications around these fashion design 'working materials', and to evaluate the needs for technological support within the context of remote collaboration in the fashion industry.

My attempt to answer the research question is exemplified through a design process that consists of a series of activities such as an *observational study* and *contextual interviews* and followed by *prototyping*, *user testin*g and ultimately the *evaluation* of the interactive remote collaborative prototype. This *research in and through* design and evaluation process of mashing up current technologies could potentially resolve an existing workplace problem in a distributed collaborative environment. The findings reported in this thesis have had a qualitative approach. I have chosen to use qualitative data collection techniques such as contextual interviews, observational study and video-assisted recall interview (Larsen & Stege, 2012) as the primary techniques used to collect the data. In order to verify and increase validity of the qualitative data from the initial observational study, multiple validation processes were undertaken within the same setting (fashion teaching environment), and subsequently verified against an alternative setting (fashion design firm) (Figure 2). The use of the multiple validation processes also ensures the extrapolation and informed speculation of my findings from fashion design-teaching environment to future user testing and evaluation at the fashion design firm.

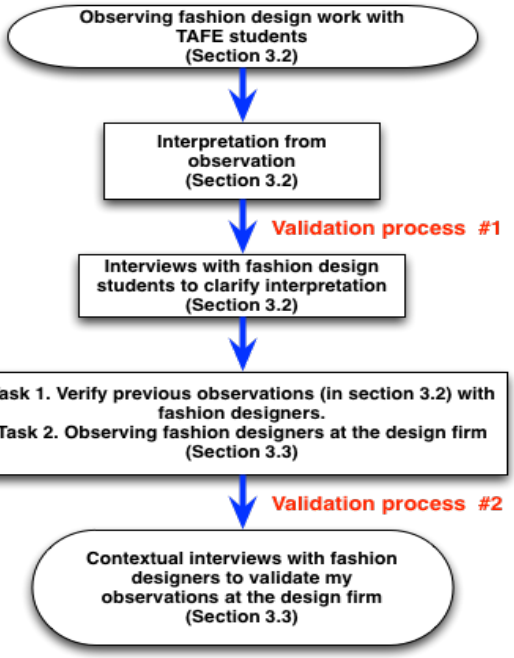


Figure 2: Multiple validation processes to verify and to increase validity of data.

The evaluation process involves identifying various interactions, such as users interacting and communicating with each other, users trying to work through the prototype to collaborate their fashion design work, users trying to create shared understanding during remote collaboration, and also to determine *when* and *where* users focus on the mashed-up technology as a relevant tool to assist their remote collaboration.

The evaluation process also examines whether the various aspects of the fashion design and remote collaborative work can be supported by the combination of mashed-up technology in terms of *assisting* or *hindering* with the use of the TVTM prototype. Below are two typical scenarios:

(a) Remote collaboration assisted by the use of the TVTM prototype in using the prototype to answer questions, as well as giving instructions to, or following instructions from a collaborative partner.

(b) Remote collaboration hindered by the use of the TVTM prototype in using the prototype to answer questions, as well as giving instructions to, or following instructions from a collaborative partner.

During the evaluation stage, I also use the Video Card Game (Buur & Soendergaard, 2000) with a participatory approach at the later stage to evaluate the TVTM prototype with two very diverse group of participants; one from the same group of fashion design students who participated earlier in the user testing of the TVTM prototype, and the other; a group of interaction designers at The University of Queensland. I was particularly interested to see the fashion design students' reaction to 'watching' their fellow students using the TVTM prototype during the Video Card Game's video clip viewing stage, to allow me to gain a better understanding of the requirements for technological support for remote collaboration in design. It was also interesting to observe the differences between the dynamic themes that the students have generated, compared to the themes that the interaction designers had identified.

This thesis makes the methodological contribution of the novel use of the Video Card Game at the evaluation stage to validate the data collected from different methodologies (observational study, contextual interviews, video interactive analysis, video-assisted recall interviews) and to allow the triangulation of the results, which subsequently increases the robustness of the results, and greater confidence in the findings. Interaction design researchers could potentially conduct similar Video Card Games in the later stage to validate a combination of other methods to confirm their analysis and also to identify what kinds of impact their 'decision on design' methodology have on their research outcome, and improve their subsequent design based on their Video Card Game analysis.

It is important to be aware of the barrier between the physical artefacts associated with the process of fashion design, and the digital version of artefacts, as well as how to represent these artefacts through technology. Of particular interest is an awareness of the importance of the novelty aspect of the mash-up technology on users. Furthermore, for any communication medium, there is a potential for asymmetrical access (Rintel, 2013b), due to technological distortion, and this asymmetrical access is an issue which needs to be resolved .

I used my evaluation data to determine whether the social-technical intersection between the challenges that participants faced due to asymmetrical access and the novelty of the mash-up technology is a potential problem for achieving shared understanding during remote collaboration. The evaluation data also confirmed that this social-technical intersection created overheads that take the form of design-intended constraints and design-unintended constraints, as well as operational problems. As a result, users were required to make extra effort in order to achieve shared understanding by 'switching channels' between the different modalities of the TVTM prototype, and also communicating in different levels of meta talk.

The theoretical contribution of this thesis is the discovery of the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of a remote collaborative system. This social-technical intersection is built upon an extension with a variation to the social-technical gap theory by Ackerman (2000). The development of a principled way of dealing with the overheads associated with achieving shared understanding that are caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype could potentially enable designers and the developers to overcome the physical-digital gap.

1.3 THESIS OUTLINE

Chapter 2 begins with a discussion on the nature of the manufacturing strategy and the business problems that the fashion industry is currently facing due to outsourcing, as well as the need to adopt technologies to facilitate their manufacturing strategy. The chapter also highlights some of the historical communication models, and the importance of shared understanding in interpersonal communications. The literature review also covers areas from Computer Mediated Communication (CMC) and CSCW, collaborative workspace/shared workspace systems and tangible/gestural user interfaces in order to have a better understanding of how to best support remote collaboration for the fashion industry.

Chapter 3 begins with the description of an iteration design process that I have taken in an attempt to answer my research question. This chapter focuses on presenting the methods and findings of the first stage of the design process; a requirements study, which was conducted at a children's clothing design firm to develop a better understanding of the problem space. The chapter concludes with a focus on exploring further issues with regards to the representation and manipulation of physical artefacts.

Chapter 4 covers the iterative design process of data collection, device design, prototyping and evaluation through several research studies. The chapter first explores issues regarding the representation and manipulation of physical artefacts, specifically addressing different users' modes of engagement, the progression of information representation, and the implications for the design of the technology. The chapter later examines and identifies various types of information that are exchanged during remote collaboration within the fashion design TAFE College. Subsequently, the chapter explains the steps that I have taken to build the hardware part of the TVTM prototype, including examining some aspects of the fashion design work through observations and contextual interviews at a fashion design firm to determine what types of information are being exchanged (textual/visual/tangible), and also what types of current technology can be mashed together to support remote collaboration and communication, to allow the remote collaboration to function as effectively and efficiently as if the participants are in the same location. The chapter later discusses whether 'richness' affects the outcome in terms of the effectiveness of the collaboration, quality of the design and the overall experience of the TVTM prototype through a quantitative efficiency experiment. The experiment also determines if there is any improvement in efficiency between the current method that is being used at the design firm, and through the use of the TVTM prototype. The chapter concludes with a discussion on the analysis of the efficiency experiment, and the need for further qualitative evaluation of the TVTM prototype due to the limitations of the experimental setup, and the effect of these limitations on the outcome of the experiment.

Chapter 5 begins with a description of the multi-stage evaluation study, the methods that were used including observations, video-assisted recall interview and a Video Card Game, followed by the evaluation of the results in terms of where and when the participants focus on the technology as a relevant communication tool during the remote collaboration, and also whether the remote collaboration can be assisted or hindered by the use of the TVTM prototype. The chapter describes the analytical process that was used to investigate whether or not the notion of social technical intersection exists in the TVTM prototype by identifying issues regarding asymmetrical access and novelty of the technology. The chapter later introduces the use of Video Card Game as an evaluative tool to understand the design process as part of the iterative design process. The themes generated from the Video Card Game study allowed triangulation of the data that has been collected using three different methodologies as a new approach to ensure robustness of research findings.

Chapter 6 discusses the findings from my evaluation study. The chapter discusses the social-technical intersection between asymmetrical access and the novelty of the mash-up technology and the potential problems in achieving shared understanding that can be found as the result of this intersection. The chapter also discusses different types of overheads, which required users to put in extra work in order to achieve a shared understanding during remote collaboration and ways users resolved the overheads problem.

Chapter 7 concludes the thesis by revisiting the research questions introduced in this current chapter, stating some of the limitations of the research studies that were conducted, and the contributions of this thesis. The chapter concludes with potential future work.

Chapter 2: Literature review

There is a wide range of literature on the subject of virtual collaboration within the field of HCI. This chapter first briefly discusses the manufacturing strategy of the fashion industry in section 2.1, followed by a quick overview of the current technologies available to, and in use by the fashion industry in section 2.2. Section 2.3 focuses on interpersonal communication, starting with discussions of various models of communication and the mechanisms involved in interpersonal communication, followed by a brief overview of different types of media in the context of social presence and media richness theory. Section 2.4 focuses on supporting collaborative work over distance; the section begins with related work aimed at studying and understanding current work practices in the fashion industry and distributed collaboration, followed by an overview of related work into collaborative technologies, collaboration and gesturing in shared workspaces, virtual representations of physical artefacts, and gestural and multi-touch user interfaces that support collaboration based on empirical studies by other researchers. Section 2.5 focuses on understanding the design approach for a socio-technical system and design challenges such as the social-technical gap. Section 2.6 focuses on multimodal systems, and understanding how different communication channels within the multimodal system could ultimately provide a translation mechanism to bridge the physical-digital gap. Section 2.7 focuses on the importance of acknowledging affordances in terms of enablements and constraints when designing a system.

2.1 MANUFACTURING STRATEGY

Clothing manufacturing in the fashion industry is a labour intensive process (Djelic & Ainamo, 1999); human labour accounts for around two-thirds of the cost of manufacturing and selling products (Cooper, 2004). Complex garments such as winter coats (Figure 3) often require component parts to be sourced from different continents around the world. There are many different kinds of manufacturing strategies, for example, automation by machines (Satchell, 1998) and outsourcing that companies can adopt to improve manufacturing efficiencies such as cost, quality, delivery and flexibility (Wheel Wright, 1984). In the fashion industry however, human labour cannot be fully replaced by automation, therefore *outsourcing* has become one of the manufacturing strategies and common practices adopted by companies within the fashion industry (Kumar & Arbi, 2007), to move their manufacturing processes from developed to developing countries since the era of globalisation (Dicken, 1998).

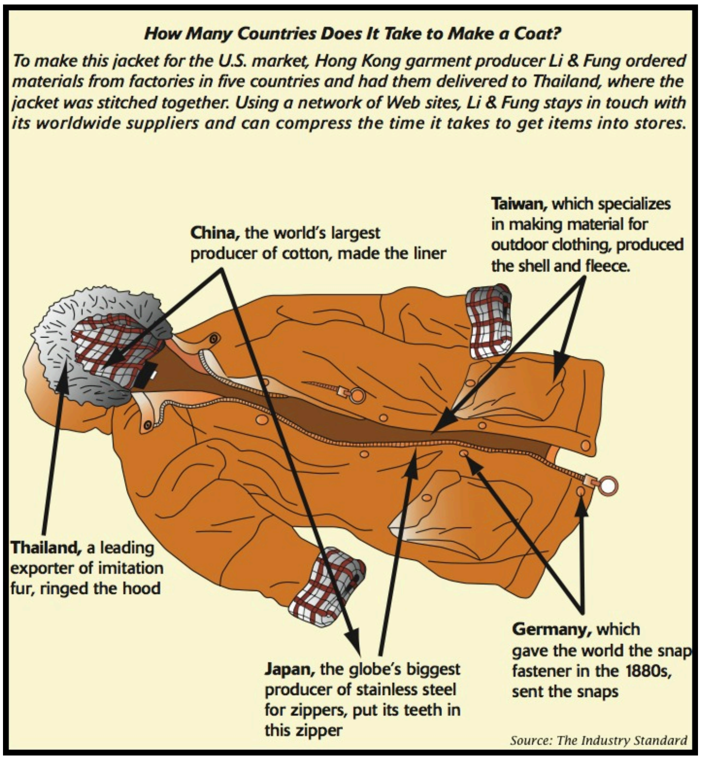


Figure 3: The global fashion industry (M. Johnson, 2002).

Mihm (2010) pointed out that there can be different variations of *sourcing* based on the three basic models below:

1. Fully integrated - the clothing firm uses vertical integration and controls all parts of design and their own manufacturer and distribution centre.
2. Home brand – the clothing firm is responsible for direct contact with their contracted manufacturing plant and supervising their design and manufacturing processes in order to meet their internal quality standards.
3. Fully outsourced – the clothing firm partners with an outsourcing expert company to handle all parts of the process from initial design to manufacturing and finally handles the logistics to have the apparel item onto the retailer's floor.

Factors such as labour cost, price of goods sold, use of technology, market responsiveness and involvement in the supply chain can influence retailers' decisions on the outsourcing model (Mihm, 2010). There are many benefits of outsourcing, one of which is to take the advantage of emerging technology without having to invest significant amounts of capital in that technology and to be able to switch to various different suppliers according to a company's operational strategy and market demand (Gilley & Rasheed, 2000).

In the next section, I focus on the adoption of technologies for a specific business strategy within the fashion industry, the advantage of using these technologies, and the factors that affect the acceptance of these technologies.

2.2 TECHNOLOGY FOR THE FASHION INDUSTRY

Within the fashion industry, the adoption of technology still remains an issue for firms that are trying to gain competitive advantage in an increasingly dynamic market. Prior research shows that using information technology enhances internal communication support, as well as a decentralised decision structure within the firm (Andersen & Segars, 2001; Huber, 1990). A variety of technologies is required to facilitate an outsourcing manufacturing strategy, as part of a *quick response* (QR) business strategy that most fashion design companies have adopted. QR is defined as "*a business strategy that attempts to identify and meet the demands of the customer by moving merchandise from raw material suppliers to customers in the most efficient way, and at the same time reducing the amount of inventory in the merchandise pipeline*" (Askelson, 1994). The following technologies for outsourcing manufacturing strategy, as part of QR, have been identified by industry sources and academic research: automated sewing operations, electronic reordering, shared product information with trading partners, bar coding, product planning with customers, short cycle cut planning, computer-aided design (CAD), receiving point of sale (POS) data, short cycle sewing, computer-aided manufacturing (CAM), reduced inventory size; small lot orders, computer-aided pattern making, scanning fabric rolls, unit product system (UPS), computerized inventory systems, and shade sorting (Ko, Kincade, & Brown, 2000).

There are many advantages in using technology to assist the design and production cycle of clothing, including reduced cycle time, reduced faxing and express mail costs, faster time to volume production, reduced scrap costs and mistakes, fewer markdowns due to late arrivals, a more secure environment with less paper and emailed documents floating around the supply chain, more reuse of standard design elements saving time in the design process and archived product history and product change information leading to better accountability (M. Johnson, 2002).

However, some firms are concerned with the cost of the QR technologies, as well as the trust involved with technology adoption (M. Johnson, 2002). For example, an expensive modern spectrophotometer can measure colour of a fabric very accurately, but most fashion designers still prefer to determine the colour of the fabric with their own eyes. In some cases, the technology itself is not the limiting factor in the use and acceptance of that technology. Olson and Olson (2000) state in their paper that while some organisations may be good candidates for successful adoption of newly emerged technologies for distant collaborative work, their work habits and infrastructure may not be. For example, Internet infrastructures of developing countries may limit the effectiveness of some QR technologies; it may take several hours for a contracted manufacturer in a developing country to download a complex CAD file attached to an email, using a slow dialup Internet connection. As a consequence, this may hinder the collaboration between the fashion designer and the manufacturer.

Interpersonal communication also plays an important role in collaboration, and in the next section, I explain the fundamental mechanisms involved in interpersonal communication and collaboration based on Shannon and Weaver's (1948) Transmission model of communication, and the importance of shared understanding. The section then addresses different types of media in the context of media richness theory, and how these different types of media support the achievement of common ground during interpersonal communication.

2.3 INTERPERSONAL COMMUNICATION

Early communication models such as Shannon-Weaver's model (Shannon & Weaver, 1948) and Lasswell's model (Lasswell, 1948) focus on the technical aspects of communication, however they do not deal with *meaning*. Effective face-to-face (FTF) human communication is not just about decoding signals, but carries the additional requirement to *interpret* the message and the *meanings* correctly.

2.3.1 The importance of shared understanding

Interpersonal communication is found to be effective when there is a substantial sharing of common ground such as *mutual knowledge*, culture, language, attitudes, beliefs, values and experience within a close *physical proximity* to each other (Clark & Brennan, 1991; S R Fussell, Kraut, & Siegel, 2000; Schramm, 1954**).** Wilbur Schramm (1954) introduced a model that focused on the *relationship* of the senders and receivers (Duncan & Moriarty, 1998), Schramm's revised model added *field of experience* (Figure 4) became one of the widely known theories of communication.

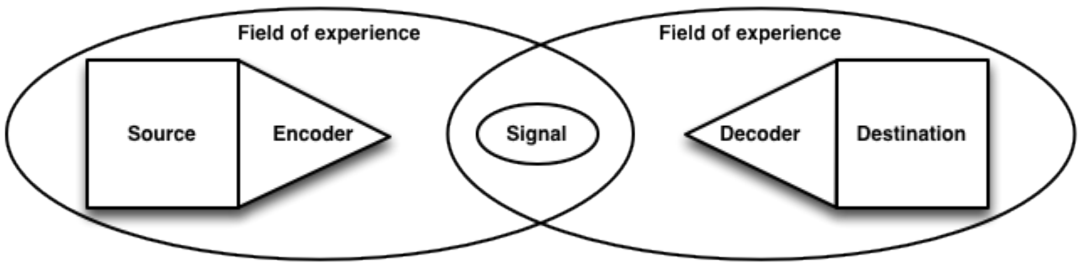


Figure 4: Schramm's "field of experience" model.

Schramm (1954) believes that the overlapping of the *field of experience* increases the probability of *mutual understanding* during communication (Hill, Watson, Rivers, & Joyce, 2007). However with the modern view of interpersonal communication, there are additional factors that could potentially further increase the ability to achieve shared understanding. I will explain later why this is the case.

Berlo's Source Message Channel Receiver (SMCR) model (1960) is a more straightforward model that places emphasis on *dyadic* communication (Figure 5).

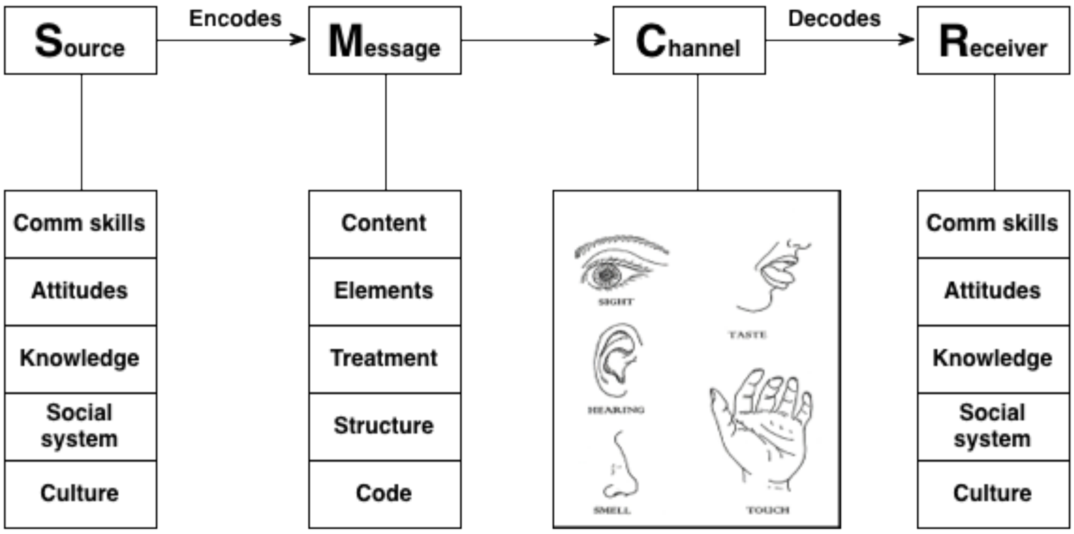


Figure 5: Berlo's SMCR model.

The SMCR model focuses on the individual characteristics of communication and stresses the role of the *relationship* between the source and the receiver through various elements of the message, and the use of channels during the interpersonal communication. Berlo believed the *relationship* between the skill level of the receiver and the source needs to be taken into consideration (Berlo, 1960) as it may affect the *mutual understanding* during the communication process. During communication, the source also has to decide and choose a best channel or a combination of channels to convey the message. It may depend on what channels are available, what the source's preferences are, and which channels most people receive and have the most impact.

There has been a paradigm shift from the predominant classic linear communication model to non-linear communication models. For example, the convergence model by Rogers and Kincaid (1981) defines communication in a different way. Instead of describing it in terms of source and receiver like previous communication researchers, they described it in terms of participants or partners who engaged in a meaningful *relationship;* to create or to share information with one another in order to reach a *mutual understanding*. This kind of mutual understanding or shared understanding is one of the outcomes of a successful collaboration and can be visualised by Kincaid's convergence model (1981). Deshpande et al. (2005) define shared understanding as 'an objected state achieved through interactive processes by which a common ground between individuals is constructed and maintained.' Slater and Anderson (1994) further described the conditions needed for convergence based on adaptation of Kincaid's model (1981). Slater and Anderson (1994) stated that: 'Mutual understanding consists of shared psychological interpretations of information, and mutual agreement is a shared belief in the validity of those interpretations. Both conditions - mutual understanding and mutual agreement - are necessary for convergence (uniting in common interest or collective action) to occur' (Slater & Anderson, 1994).

2.3.2 Computer mediated communication

The choice of communication channel can be determined by both social presence theory and media richness theory. Short, Williams and Christie first used the term 'social presence' (Short, Williams, & Christie, 1976) to describe the concept of awareness of other interaction users, and the medium's social effects are directly caused by the degree of social presence that it affords to its users. Therefore, the absence of nonverbal communication reduced social presence in mediated communication. As CMC has evolved, the social presence is said to become a way for the individuals to represent themselves and exchange messages, and how those messages are interpreted by others in an online environment (Lowenthal, 2009). Media richness theory suggests that the effectiveness of the communication is dependent on the selection of an appropriate medium (Neale, Carroll, & Rosson, 2004), based on the degree of ambiguity users are willing to accept in any given communication situation (Daft & Lengel, 1986). It is a channel-based approach to the selection of an appropriate technology for a given situation.

Figure 6 shows a selection of communication media; FTF is at the richest end of the communication medium selection, and is invariably considered to be the most effective form of communication, followed by less rich video conferencing medium, constrained by limited visual cues, causing some of the body language to be filtered out. The telephone communication medium is less rich than video conferencing because visual cues have been completely removed, which means the communication is relying solely on language content and audio cues. Telephone communications are considered to have fast mutual feedback and communications are personal. Written addressed documents such as notes, memos and letters rely on limited visual cues on the paper. Although written addressed documents are personal, they are classified as low in richness due to the absence of audio cues, hence they are not able to allow rapid mutual feedback. Furthermore, unaddressed written documents such as fliers, bulletin sand standard reports are the least rich communication, as they do not support any levels of personalisation.

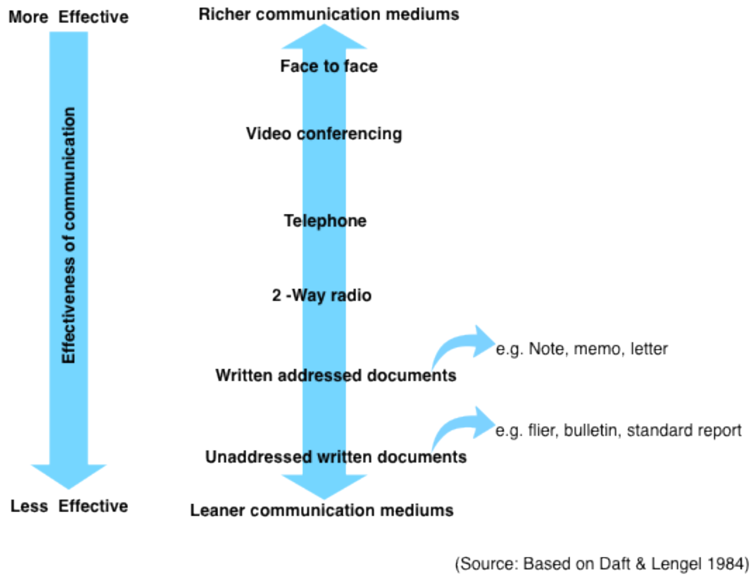


Figure 6: Richness of different communication media

However, it is not always the case that the richest communication media afford the most effective communication, and leaner communication media are less effective. In some circumstances, there is a need and desire for a leaner communication medium. For example, people would use a form of document to present some sales figures, in order to reduce ambiguity. Conversely, it would be wise to use richer communication media, such as FTF, to discuss the meaning of these sales figures and avoid any potential ambiguity. Such factors had to be taken into consideration during the selection of current technologies to be mashed into the TVTM prototype, to prevent ambiguity during remote collaboration.

Burgoon (2006) proposed the principle of interactivity framework that offers understanding of the interrelationships of verbal and nonverbal cues within CMC. The principle of interactivity assumes that the degree of interdependent, contingent, participative, and synchronous interaction provided by a communication interface or experienced by interlocutors, or both, will affect the social judgements and task performance. (Burgoon et al., 2006; Walther, Gay, & Hancock, 2006). This is an important consideration in the design of a technological mash-up to overcome physical-digital gap.

According to the 3C collaboration model (communication, coordination and cooperation) (Ellis, Gibbs, & Rein, 1991), individuals need to communicate and negotiate with others in order to make decisions and exchange information. They also need to minimise conflict to prevent loss of communication while they are coordinating and organising themselves to work together. "*The need for renegotiating and for making decisions about unexpected situations that appear during cooperation may demand a new round of communication, which will require coordination to* *reorganize the tasks to be executed during cooperation.*" (Fuks, Raposo, & Gerosa, 2005). Neale and Carroll interpreted that coordination can sometimes be viewed as overhead or operating cost while completing interactive group activities (Neale et al., 2004). The TVTM prototype exhibited some overheads issues, which will be discussed further in chapter 4 and 5.

As mentioned previously in section 2.3.2, achieving common ground is vital to interpersonal communication especially during remote collaborative activities. The choice and use of the communication medium has significant impact on the establishment of the common ground. Clark and Brennan (1991) proposed a framework in which common ground can be established and achieved, based on their identification of eight constraints on grounding across various communicative media (Table 1).

	Face to face	Telephone	Video conference	SMS	Answering	Email	Letter
Copresence	✔						
Visibility	✔		✔				
Audibility	✔	✔	✔		✔		
Contemporality	✔	✔	✔	✔			
Simultaneity	✔	✔	✔	✔			
Sequentiality	✔		✔	✔			
Reviewability				✔	✔	✔	✔
Revisability				✔		✔	✔

Table 1: Constraints that may affect the establishment and achievement of common ground in various communication media (adapted from G. Olson & Olson, 2000)

Clark and Brennan (1991) further outlined the dimensions that affect grounding and the cues associated with the media during communication between two people:

- Copresence: sharing the same physical environment
- Visibility: the ability to see each other
- Audibility: the of use speech to communicate
- Contemporality: messages received immediately after they are sent
- Simultaneity: both speakers can send and receive messages
- Sequentiality: turns cannot get out of sequence
- Reviewability: messages can be reviewed by others

- Revisability: messages can be revised before they sent

In this thesis, I am proposing a mash-up of different communication media into an integrated system. It is therefore important to have a clear understanding of the effectiveness and limitations of different types of communication media, and to be able to distinguish the ways in which different types of communication media allow procuration of common ground.

Previous research into how individuals used media space showed some unusual features during interpersonal interactions. In particular, Heath and Luff (2000) discovered that some methods of interaction within the media space became less effective and introduced asymmetries into the interpersonal communication. These asymmetries can also occur during remote collaboration, and will be discussed later.

In the next section, I focus on the importance of understanding the current work practices and distributed collaboration before designing and developing a prototype to support any remote collaboration. I then review a selection of relevant groupware systems that support shared workspaces, and also those that support gesturing during co-located and remote collaboration. The section later focuses on the tangible aspects of the groupware studies that support virtual representation of physical artefacts, and gesture and multi-touch user interfaces.

2.4 SUPPORTING REMOTE COLLABORATIVE DESIGN WORKS

2.4.1 Related work aimed at studying and understanding current work practices in fashion industry and distributed collaboration

In order to support any remote collaborative design work, it is important to first understand current work practices. The ethnographic work conducted by Pycock and Bowers (1996) in the context of the fashion design work produced a detailed report of the activities of fashion designers that could be instrumental in the development of innovative CSCW systems, rather than blindly designing and developing inappropriate or ineffective technologies, (such as the virtual reality catwalk), for the fashion industry. Perry and Sanderson (1998) also suggest that a richer understanding of current practices and a closer examination of the social and interactional dimensions of their designer work is required, in order to determine which technologies may support productive work. Based on their case studies, they pointed out that technological ‘solutions’ are unlikely to be a simple remedy to improve design efficiency. However, adding ‘simple’ computer technologies designed to facilitate the design process, as well as linking design artefacts to their role in communication and co-ordination, may achieve efficient design work (Mark Perry & Sanderson, 1998).

Early research studies on distributed collaboration assumed that people were dedicated to work at their desks such as sending emails (Sproull & Kiesler, 1986) or distributed co-authoring

(Beck & Bellotti, 1993). Other research studies were more focused towards developing new technologies to support collaboration from the desktop, such as video conferencing, multimedia emails and shared authoring tools (Baecker, Nastos, Posner, & Mawby, 1993; Maltz & Ehrlich, 1995; G. M. Olson & Atkins, 1990; Streitz, Geißler, Haake, & Hol, 1994; J. C. Tang, Isaacs, & Rua, 1994) as well as workflow systems and semi-structured collaboration systems (Abbott & Sarin, 1994; Jintae Lee, 1990). On the contrary, Bellotti and Bly (1996) believe that in order for a CSCW system to support remote collaboration, the system must be able to achieve two goals: " *(1) To replicate for remote colleagues some of the opportunities for building awareness and for informal communication and coordination that local mobility enables. (2) To reduce the penalties for distributed colleagues of trying to communicate, collaborate and coordinate with others who are away from their desks.*" (Bellotti & Bly, 1996, p. 216).

Collaborative Virtual Environment (CVE) is a distributed, virtual reality that is designed to support collaborative activities (Churchill & Snowdon, 1998). The development of CVE not only provides users with a wide range of rich representational environments, it also forms a new way to undertake distributed collaborations. The interactions with early CVE were mostly achieved by using keyboard and mouse (Gabriel, 2000; Redfern & Galway, 2002). However, other researchers such as Kim and Maher (2008) were experimenting with new kinds of interaction with the CVE by adding tangible interactions to tabletop systems to provide alternative collaborations within the virtual environment. They conducted a study to compare the differences in design processes, where designers used a traditional keyboard and mouse inputs compared to using 3D virtual blocks as a form of tangible input devices. Their results revealed that designers using 3D blocks identified more spatial relationships with multiple objects and spaces, and were able to uncover new visuo-spatial features when revisiting their initial design configurations. The conclusion from their study showed that changes of spatial cognition are directly associated with creative design processes. Additionally, this thesis shows that some users experienced cognitive overload causing communication overheads during remote collaboration.

2.4.2 Related work into collaborative technologies

Cooperative design work often takes place in a workspace that allows visualisation and direct manipulation of the physical artefacts. However, with remote cooperative design work, designers at each remote location will need to be in a shared workspace in order to collaborate on their design work. Visualising and manipulating artefacts in a shared workspace poses significant challenges to researchers. In order to support as many facilities as those in FTF collaboration, Stefik (1987) proposed an idea of shared workspace model called what-you-see-is-what-I-see (WYSIWIS). There are four key dimensions; space, time, population and congruence, each with corresponding constraint in the 'strict' WYSIWIS principle. Stefik (1987) later proposed a 'relaxed' version of the WYSIWIS to overcome the inflexibility of the strict implementation model. One of the advantages of the relaxed implementation is that the space constraint is relaxed, which enables private windows to be displayed beside the share workspace. For example, the private windows allow one of the users to lookup additional information without disturbing other users from working in the shared workspace. There are many examples of systems and projects that support relaxed WYSIWIS model (Benford et al., 2000; Carstensen & Schmidt, 1999; Chang et al., 1995; Greenberg, Gutwin, & Cockburn, 1995; Marsic, 2001). However both 'relaxed' and 'strict' WYSIWIS models apply to shared workspace and its artefacts only, and not to workspace awareness information such as live webcam images, which can also be visualised by users in the share workspace. Therefore, neither WYSIWIS models can be applied to both physical and electronic workspaces for individual and shared workspaces.

In late 1980s and early 1990s, Ishii and Ohkubo (1990) at NTT Human Interaction Laboratories created a system that provides physical and electronic workspaces for individual and shared workspaces called TeamWorkStation (Ishii & Ohkubo, 1990). The TeamWorkStation project (Figure 7) improved on real-time shared workspaces projects such as CRUISER (Root, 1988) and VideoDraw (J. C. Tang & Minneman, 1991).

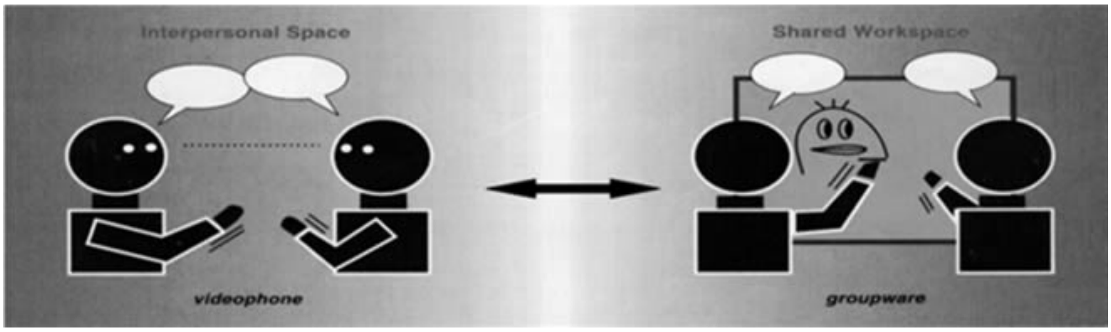


Figure 7: Integrating 'interpersonal space' to 'shared workspace' by Hiroshi Ishii (Ishii & Ohkubo, 1990).

These were video and audio communication-based virtual shared workspaces. According to Ishii, both CRUISER and VideoDraw projects only allowed the data within computers to be processed. Information outside the computer could not be processed together with data within computers. Due to this limitation, users were faced with a discontinuity between computer data and information outside the computer (Ishii, 1990). In his TeamWorkStation project, he adopted the concept of the "*overlay of individual workspace image*" (Ishii, 1990, p. 16) as a new methodology in his design (Figure 8). Users can choose the most suitable mode of overlays for their needs such as Screen-Overlay, Desk-Overlay and Screen and Desktop-overlay.

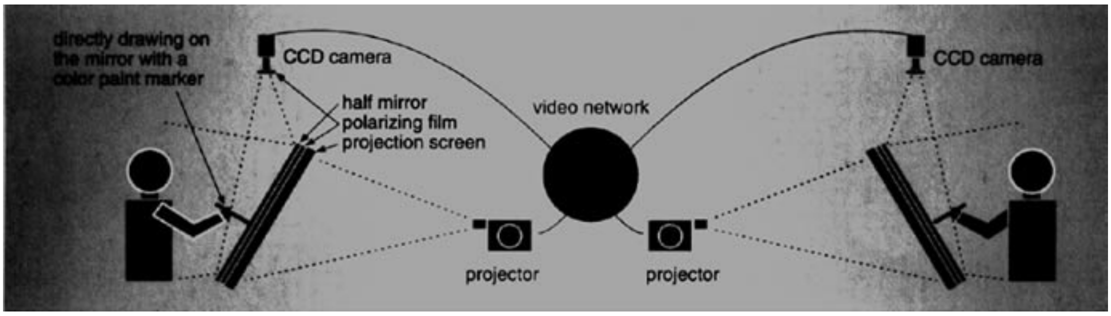


Figure 8: Screen overlay technique (Ishii, 1990).

The Overlay technique was also used in the VideoDraw project by Tang and Minneman (J. C. Tang & Minneman, 1991). They created a shared drawing space by using overlaying images of individual drawing surfaces with video cameras. However, VideoDraw was constrained by hand-drawn images and hand gestures that needed to be shared on a special transparent sheet attached to the surface of a TV monitor (J. C. Tang & Minneman, 1991).

Ishii improved upon VideoDraw by fusing the computer screen and actual desktop image approach in TeamWorkStation thus bridging the gap between the personal computer and desktop and communication.

The goal of the TeamWorkStation was to provide distributed users with a real time shared workspace "*that every member can see, point to and draw on simultaneously*" (Ishii, 1990, p. 15). It is possible that TeamWorkStation could be easily adopted and deployed throughout the design departments in the fashion design industry with high-resolution webcams and broadband Internet. For example, a garment designer could simply overlay the images of icons or company logos prepared by the graphic designer on to the screen where both designers can discuss the size and colour scheme of the images. TeamWorkStation could also act as a problem solving tool when it comes to the manufacturing stage as most of the problems occur during the assembly of the garments at the remote location. For example, the quality control manager in the remote manufacturing facility could simply overlay the faulty garment on the screen to try to resolve the problem with the fashion designers in the main offices.

Ishii and Arita further improved their TeamWorkStation by modifying the size of the shared screen space as well as implementing a new multi-user interface design technique called ClearFace (Ishii & Arita, 1991) which allow users to move and resize the translucent face windows (Figure 9).


Figure 9: Demonstrations of ClearFace (Ishii & Arita, 1991).

Ishii and Arita realized the TeamWorkStation had significant limitations, specifically, not being able to share the results of collaboration directly. In order to achieve a more seamless integration of inter-personal space and shared workspace, Ishii and Kobayashi designed the ClearBoard (Ishii & Kobayashi, 1992). They considered two different metaphors at the early stage of the design; the whiteboard metaphor, and over-the-table metaphor. For the whiteboard metaphor, "*the advantage of this metaphor is that all the participants can share the common board orientation*" (Ishii & Kobayashi, 1992, p. 527). But they discovered that this metaphor required the use of virtual reality technology, which imposes on users the need to wear awkward head-mounted displays, special gloves and suits in order to share their drawings. Ishii and Kobayashi point out that the over-the-table metaphor is not really suitable as the orientation of the drawing is upside-down for the other participants, "*if we could develop an 'L-shaped display', this metaphor could be realized to some extent, however, it is hard to give users a natural sense of sharing the same space over the table*" (Ishii & Kobayashi, 1992, p. 527). Ishii then developed a third metaphor: the through-a-glass-window metaphor or 'clear board', it is based on the advantages of the whiteboard metaphor and over-a-table metaphor. The team later discovered that the participants could not share the common orientation for the right and left of the drawing space. However, the problem was easily solved by mirror reversing the video image.

ClearBoard-2 (Ishii, Kobayashi, & Grudin, 1993) offered some new functions, such as recording of working results, easy manipulation of marks and the use of data in computer files. While Clearboard or Clearboard-2 are feasible for 2D drawing applications, they are limited in its potential application to the fashion design industry because many of the over-the-table discussions that occur during the design process require handling of artefacts (actual physical objects) such as retailed garments.

In recent years, sophisticated video conferencing technologies have emerged like Cisco Telepresence, Polycom TPX, as well as the HP Halo's "*blending*" distributed physical locations into one system (Gorzynski, Derocher, & Mitchell, 2009) and BISi blended workspace system (Broughton et al., 2009), which have all set out to improve the user experience of distributed meetings by supporting the feeling of distributed collaborators "*being here*". Recent research by Ou, Tang and Ishii (2013) went a step further to create a remote pointing system prototype called synchroLight (Jifei Ou et al., 2013), which allows users to use synthetic light to seamlessly point to remote objects or space on a workbench between two distributed networked locations during a remote urban planning meeting. The remote pointing system could be a useful tool for fashion designers and manufactures to participate in collaborative work or problem solving meeting, within the fashion industry. However, the synchroLight system currently only allows one-way pointing, which may potentially limit the effectiveness of this system during the collaboration.

Yarosh et al. (2013) developed the ShareTable system (Yarosh et al., 2013), with the intention of connecting divorced parents and children living in different households or families. The system is built into a cabinet, with live video images and a shared drawing table surface that is automatically connected when the cabinet doors are opened. The ShareTable is able to provide both FTF video and also a shared workspace to support a number of joint activities; "*(1) creating a playful context for conversation, (2) providing instrumental care, and (3) using the ShareTable as a meeting place for sharing the objects and moments*" (Yarosh et al., 2013, p. 185). According to their results, the ShareTable system was easy to initiate because there was no login screen and no contact list as the system was dedicated for two specific households families. The ShareTable supports emotional interaction by presenting overlapping video of the local and remote spaces to create a sense of closeness and a metaphor for physical touch (Yarosh et al., 2013). The shared drawing table surface of the ShareTable system is similar in concept to elements of the remote collaborative system that I have developed as part of my research, which allows users to interact with shared objects (both digitally created objects and physical objects that have been captured as digital images), during remote collaborative meetings.

Overall these previous researchers looked at how to provide users with a shared workspace, in which they can work on their collaborative tasks. This research focused on developing support for a distributed FTF interaction, rather than allowing remote users to discuss objects that they are collaborating on within the respective setting. Conversely, the TVTM prototype not only emphasises the ability to discuss the shared objects, it also allows users to access and manipulate shared objects using gestures. Next, I will discuss the significance of gesturing during collaboration.

2.4.3 Collaboration and gesturing in shared workspaces

With regards to collaboration in shared workspaces, Tang (1991) conducted observational studies of collaborative work in a shared workspace and identified five features of collaborative work activities: (1) collaborators use hand gestures and their relationship to uniquely communicate significant information; (2) the process of creating and using drawings conveys much information not contained in the resulting drawings; (3) proximity and concurrent access to the drawing space is an important resource for the group in mediating their collaboration; (4) collaborators fluently intermix activity in the drawing space (J. C. Tang, 1991). Tang (1991) further discussed the importance of the gestures by the remote collaborators in relation to the artefacts in the shared workspace; (5) "*The spatial relationship between hand gestures and their referents is a resource used in interpreting collaborative drawing activity.*" (J. C. Tang, 1991, p. 151). Bekker at al. (1995) catalogued four types of gestures that people use during design meetings to clarify or enhance their messages; (1) a sequence of kinetic gestures used to describe an action; (2) a spatial gesture performed by two fingers or both hands to represent physical distance/location/size between two objects; (3) using fingers to point at someone/object/place; (4) other gestures that have purpose but do not fall into the other three categories. Bekker at al. (1995) observed an average of nine gestures per minute of gestures used by the groups during the design meeting. "*Gestures in design have a broad range of temporal and spatial richness*" (Bekker et al., 1995, p. 162). However their experiment did not have enough evidence to support the requirement of gestures to perform effective collaborative design tasks.

Kirk et al. (2005) explored the use of gestures in collaborative physical tasks in a laboratory based experiment. He proposed that the users formed 'gestural phrases' as part of their interactions. These gestural phrases were sequential patterns of gestural actions during the collaborative tasks. Kirk additionally speculated that these gestural phrases improved collaborative awareness and the coordination of tasks. Kirk et al. (2007) further presented evidence that gestures from the use of remote gesturing technology smooth interaction and facilitate clear turn-taking, but more importantly, gestures support conversational grounding that improves remote collaborative task performance. Corrie and Storey (2007) studied the importance of gestures in artefact-focused distributed scientific collaboration, and observed that almost all of the observed artefact gestures were in fact gesture or utterance pairs. Corrie and Storey (2007) discovered that an artefact together with the accompanying gesture is only meaningful if the utterance of a gesture or utterance pair is of a deictic nature. Corrie and Storey (2007) also noted the importance of supporting the communication of both utterance and gestural communication channels in groupware applications for artefact-focused remote collaboration.

Recent research by Huang and Alem (2013) has led to the development of a real-time collaborative wearable system called HandsInAir (Huang & Alem, 2013). While similar in concept to previous designs, it additionally supports the mobility of both the worker and the remote helper conducting physical tasks. The remote helper demonstrates the solution to the problem associated with the physical task, by using hand gestures to simulate the manipulation of the physical artefact.

The head mounted camera on the helper's helmet then captures the hand gestures as live video images, and transmits it to the near-eye devices on the worker's helmet as unmediated hand gestures. However usability test results for this system show low scores for the perception of interaction by the participants. This could imply the possibility that the participants may have experienced confusion or difficulties with the perception of the hand gestures due to the hand being digitally extracted from the background, and combined with the scene video. While the HandsInAir system would certainly be a particularly useful tool for remote collaborative design work within the fashion industry, it is unfortunately still in the early developmental stage.

2.4.4 Virtual representations of physical artefacts

Research related to the use of physical artefacts as representations and controls for digital information has been conducted by Fitzmaurice, Ishii and Buxton's Graspable User Interfaces (Fitzmaurice, Ishii, & Buxton, 1995). Ishii and Ullmer took another step in the field of augmented reality in their 'Tangible Bits' project (Ishii & Ullmer, 1997) at the MIT Media Lab, and introduced the term 'tangible user interfaces' (TUI). Ishii and his team point out that the approach in 'Tangible Bits' is different from other augmented reality projects due to its strong focus on graspable physical objects as input rather than relying on visual augmentation alone. The goal of the 'Tangible Bits' project was "*to bridge the gap between cyberspace and the physical environment by making digital information (bits) tangible*" (Ishii & Ullmer, 1997, p. 235). There are many application domains for TUI; the largest class is in the use of the tangible as information storage, retrieval and manipulation. Examples include: mediaBlocks (Ullmer, Ishii, & Glas, 1998); musicBottles (Ishii et al., 1999); Triangles (Gorbet, Orth, & Ishii, 1998); marble answering machine by Durell Bishop, student at the Royal College of Art (Ishii & Ullmer, 1997); InteractiveDesk (Arai, Machii, Kuzunuki, & Shojima, 1995) and, metaDESK (Ullmer & Ishii, 1997) (Figure 10). The majority of these applications use video cameras and computer vision techniques to compute a touch image that permit simultaneous video projection and surface sensing with diffusion screen. Other classes include information visualization, modelling or simulation, system management, configuration and control co-located collaborative work. There has been a steady and continuing trend from a more traditional static (passive) TUI towards kinetic (active) TUI. Ishii and his colleagues have been working from the static TUI towards the kinetic TUI.

Static TUI research includes Illuminating Clay (Piper, Ratti, & Ishii, 2002) for a landscape design tool using augmented clay, Sandscape (Ishii et al., 2004) landscape design tool using augmented sand, as well as 2D tabletop discrete tangibles such as the metaDESK (Ullmer & Ishii, 1997), URp (Underkoffler & Ishii, 1999) for urban planning and Sensetable (Patten, Ishii, Hines, & Pangaro, 2001) tabletop TUI platform.

Kinetic TUI research that has focused on transformable tangibles include Relief (Leithinger & Ishii, 2010), a 2.5D transformable interactive shape display and Recompose (Blackshaw, DeVincenzi, Lakatos, Leithinger, & Ishii, 2011), a gesture-controllable 2.5D shape display. Kinetic TUI research that has focused on translation of discrete objects include research such as PSyBench (Brave, Ishii, & Dahley, 1998), which synchronised actuated workbenches, Actuated Workbench (Pangaro, Maynes-Aminzade, & Ishii, 2002) that utilises computer-actuated pucks as display and control, which leads to ZeroN (Jinha Lee, Post, & Ishii, 2011), an antigravity tangibles TUI project.

Ishii and his colleagues also worked on embodied kinetic tangibles such as Intouch (Brave & Dahley, 1997); a distributed synchronized haptic phone, Curlybot (Frei, Su, Mikhak, & Ishii, 2000); a record and play toy and Topobo (Raffle, Parkes, & Ishii, 2004); a constructive assembly that also allows record and play to more recent projects that focused on kinetic tangible motion prototyping toolkits with physical transformability such as the Kinetic Sketchup (Parkes & Ishii, 2009). From these TUI literatures, for the context of remote collaboration in the fashion industry, the traditional static TUI is considered to be the most appropriate design requirement to achieve virtual representation of physical artefacts rather than using the newer kinetic TUI as the fashion designers rely heavily on objects such as visual graphic images.

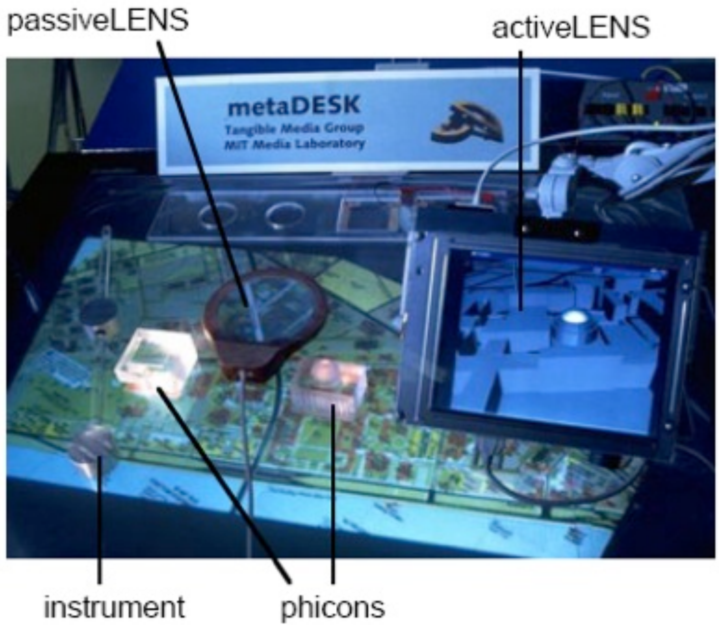


Figure 10: metaDESK (Ullmer & Ishii, 1997).

2.4.5 Gesture and multi-touch user interface

Gesture is another tool to enhance communication, and is widely used in the fashion design industry to illustrate required behaviour, for example gestures are used to demonstrate sewing directions, or moving/rotating graphical objects etc. There has been long evolution of multi-touch technology, and growing interest in gesture technologies and applications research.

Multi-touch technology began with the emergence of single touch screen technology in the 1960s. Johnson (1965) was the first to publish his work on a capacitive touch screen. By the beginning of the 1980s, researchers began to investigate multi-touch sensor design for robotics, to enable sensing of shapes and orientation (Buxton, 2007). The first true multi-touch input computer system was developed by Metha (1982). It used simple image processing to allow multi-touch input picture drawings (Metha, 1982). Minsky (1984) also developed a similar gesture painting system. Another innovative multi-touch system was the vision sensing VIDEOPLACE system (Krueger, Gionfriddo, & Hinrichsen, 1985), which allowed for unencumbered full-body participation in computer mediated telecommunication, including both hands and fingers for multi-touch interaction. In the early 1990s, more advanced multi-touch systems began to incorporate the use of a projector to table top setup, classic examples of which would be the DigitalDesk system (Wellner, 1991) by Wellner in 19991 (Figure 11) and ActiveDesk system (Buxton, 1997) .

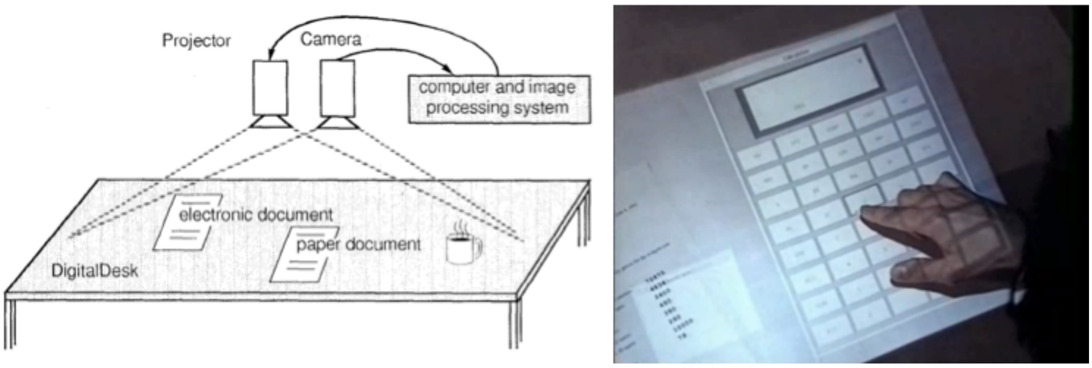


Figure 11: DigitalDesk system by Wellner (1991).

Smaller scale multi-touch pressure sensor technology, such as Flip Keyboard by Tactex, uses a Kinotex pressure sensing controller pad together with a normal keyboard on the reverse side to control various applications (Buxton, 2007). More recent projects on multi-finger and whole hand gesture interaction techniques include the Diamond Touch table developed by Mitsubishi Electronic Research Laboratory (Figure 12) (Wu & Balakrishnan, 2003), and also gesture communication over video stream (Susan R Fussell et al., 2004). In this thesis, I have developed four iterations of multi-touch table top prototypes, one of which is based on Han's (2005) multi-touch sensing technique called frustrated total internal reflection, (FTIR) together with the use of rear projection on a table-top surface.

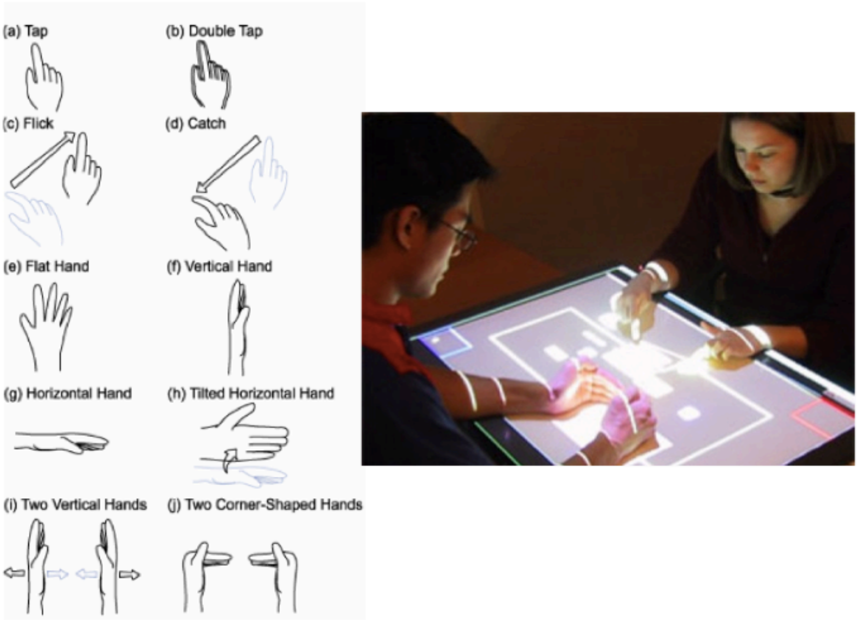


Figure 12: Categories of actions represented using hand gestures Wu and Balakrishnan (2003).

Fussell presented a cursor pointer and a pen based gesturing tool for their DOVE system (Jiazhi Ou, Fussell, Chen, Setlock, & Yang, 2003) with live video feed. The DOVE system is potentially more powerful than Ishii's video overlay system because of the additional pointing tools that allow representation of gestures, however Kirk and Stanton Fraser (Kirk & Stanton Fraser, 2006) found that gesturing using hands perform quicker than pen-based gesturing.

Despite the increasingly popular multi-touch enabled devices in the market, and research focused on multi-touch user interfaces (Benko, Wilson, & Baudisch, 2006; Dietz & Leigh, 2001; Rekimoto, 2002; Wigdor, Fletcher, & Morrison, 2009b) and multi-touch technologies, at this time there is no consensus on standardised gestures for multi-touch user interfaces (Wigdor et al., 2009b). Nonetheless, the multi-touch user interface is an interesting and novel interaction technique for remote collaboration (Buxton, Hill, & Rowley, 1985; Han, 2005). Oviatt et al. (2000) believe users have a strong preference to interact using a multimodal interface design to improve performance, and also to improve error handling in terms of error avoidance and graceful recovery from errors (Oviatt, 2003). My research will take into consideration the use of gestural and multitouch user interfaces as part of a multimodal interface design, to support more flexible and robust means of human-computer interactions for remote fashion collaboration.

2.5 MULTIMODAL SYSTEM AND MULTIMODAL USER INTERFACE DESIGN

There has been much early research conducted on multimodal systems including Bolt's 'Put-That-There' system (Bolt, 1980) which allowed users to move objects on screen by pointing and speaking. CUBRICON (Neal, Thielman, Funke, & Byoun, 1989) is another system that used a mouse pointing and speech. In the 1990s, researchers began to study multimodal interfaces that recognised both speech and pen-based input such as the original QuickSet system that was built in 1994 (Cohen et al., 1997). Other relatively mature system types exist within the multimodal interface research area including speech and lip movements and multibiometric input. These multimodal systems can process two or more recognition technologies to either help identify users or to assist in interpreting users' communication intent (Oviatt, 2003).

Multimodal systems process a combination of natural input modes in a coordinated manner with multimedia system output, for example, Oviatt's multimodal interfaces for dynamic interactive maps supported speech, pen-based writing inputs (Oviatt, 1996). Multimodal systems move away from traditional windows-icons-menus-pointers (WIMP) interfaces, as keyboard and mouse inputs are relatively limited especially when interacting with virtual environments (Oviatt, 1999). "Multimodal interfaces should integrate complementary modalities to yield a highly synergistic blend in which the system capitalises on the strengths of each mode to overcome weaknesses in the other" (Oviatt, 2003, p. 66). Oviatt identified several key design strategies for optimizing robustness for multimodal interfaces based on previous research, and believed that a well designed multimodal interface with two or more rich input modes can support disambiguation of partial or conflicting information, which effectively reduces recognition uncertainty and stabilises system performance (Oviatt, 2003). She believes that in order to achieve optimal disambiguation of meaning, *"a multimodal interface ideally should include complementary input modes, and each mode should provide duplicate functionality so users can accomplish their goals using either one*" (Oviatt, 2003, p. 64).

However, there is very little research on multimodal systems that specifically target remote collaborative issues in the fashion industry. In order to create and develop different modes of representation in a virtual environment through technology, as well as to facilitate human-centred multimodal communication for the fashion industry, it is important to first understand the nature of the remote collaborative system from both the system-centred perspective and the user-centred point of view.

Nigay and Coutaz (1993) defined multimodality from a system-centred view as "*the capacity of the system to communicate with a user along different types of communication channels and to extract and convey meaning automatically*" (Nigay & Coutaz, 1993, p. 172). Coutaz (1993) believes these communication channels can be used to convey or acquire information. On the other hand, from the user-centred point of view, modality refers to the way an idea is expressed or perceived, or the manner an action is performed.

In order to define the criteria for evaluating the multimodal remote collaborative system for the fashion industry, it is important to first understand how the introduction of a new system will affect the social interactions of the users as well as technical implications.

2.6 SOCIO-TECHNICAL SYSTEM (STS) AND SOCIAL-TECHNICAL GAP

The socio-technical phenomenon was first discovered as a result of studies on coal-mining methods at London's Tavistock Institute of Human Relations in the late 1940s. Through action research, Trist (1981) and his colleagues investigated ways to improve productivity and morale in organizations and they believed that:

> "*... a work system depends on the social and technical components becoming directly correlated to produce a given goal state. They are co-producers of the outcome. The distinctive characteristics of each must be respected else their contradictions will intrude and their complementarities will remain unrealized*" *(Trist, 1981, p. 24)*

Socio-technical theorists described STS as a method of viewing organisations, which accentuates the interrelatedness of the social and technical subsystems of the organisation, and the relation of the organisation itself to the social and economic environments in which it operates (Fox, 1995; Pava, 1986; Scarbrough, 1995; Taylor & Felten, 1993).

"Technology alone does not improve social structures and human behavior, making the design of socio-technical systems (STSs) a necessity rather than an academic luxury" (Fischer & Herrmann, 2011, p. 2). They believe that the STS design approach must take into account both social and technical factors that influence the functionality and usage of computer-based systems. Therefore, it is not simply a matter of installing new technology to solve performance issues within the organisation, rather, this design approach seeks to improve the group interactions in a two-way relationship between people and machine rather than focusing on individual performances.

Other researchers, however, suggest that "*STS is a social system built upon a technical system.*" (Whitworth, Bañuls, Sylla, & Mahinda, 2008, p. 3). They believe that the term 'social system' describes the 'social' as a system identifiable by its own operational mode, which is communication. "One can define a social system neither by formal rules or rigidly structured workflows nor as a means to an end. In this understanding a social system is the whole communication context." (Wulf, 1999, p. 60). Winograd and Flores (1986) consider technical systems as allopoietic systems and believe that once the technical systems have been put in place within an organization, they are fixed. As the requirements of these technical systems change, user intervention is required (Wulf, 1999). Whitworth et al. (2008) diagrammatically illustrated (Figure 13) how social levels affect technology design.

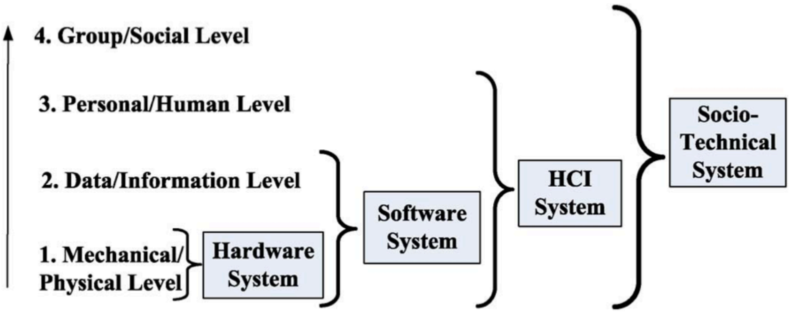


Figure 13: Four systems levels by Whitworth et al. (2008).

In this thesis, I have presented a small but relevant selection from a large body of on-going research and literature on STS since the early 1980s. Many researchers have identified a wide range of relationships and perspectives on STS, and how the social and technical intersect. It is not the aim of this thesis to be engaged in the debates surrounding the STS literature; rather the acknowledgement that in the design and deployment of a technical system there are social implications for any technology.

Baxter and Sommerville (2011) believe the field of CSCW has implicit roots in socio-technical thinking. However, CSCW and social computing systems can be affected by many challenges (Grudin, 1994b), such as critical mass issues for people to participate (Markus, 1987), restrictions by hierarchical organisations (Katz & Kahn, 1978) and the need for technical support to achieve fluidly in collaboration between individual and co-workers (Maguire, 2013) as well as the social-technical gap (Ackerman, 2000).

The social technical gap is "*the divide between what we know we must support socially and what we can support technically*" (Ackerman, 2000, p. 179). Ackerman (2000) believes the gap is one of the fundamental intellectual challenges in CSCW research, especially design-oriented research, because technical solutions cannot be separated from social and organisational issues. Although Ackerman (2000) classifies the gap as a technical problem, he stresses the need for fundamental understanding of the social aspect; "*HCI and CSCW systems need to have at their core a fundamental understanding of how people really work and live in groups, organizations, communities, and other forms of collective life. Otherwise, we will produce unusable systems, badly mechanizing and distorting collaboration and other social activity*" (Ackerman, 2000, p. 199).

However, other researchers have different views about the gap; for example, Dourish believes that seeking to minimise the gap is counterproductive as he believes the gap is "*where all the interesting stuff happens, a natural consequence of human experience*" (Dourish, 2006, p. 546).

In Ackerman's opinion, the gap is a result of an inadequate HCI mechanism for the automation of human social behaviour in a technical system. Conversely, De Souze, Nicolaci-da-Costa, da Silva, and Prates (2004) argue that the automation of human social behaviour can cause major problems, as computer systems designers cannot be expected to master a wide variety of interconnected disciplinary knowledge such as psychological, sociological, cultural and computational knowledge. Furthermore, Dourish (2004) believes social contexts are dynamic constructs with different behaviour among instances of organisational settings, activities and participants.

Li and Chandra (2008) on the other hand suggest that the *users adapt to the system* and at the same time *adapt the system to their needs*. Similarly, Tan and Kondoz (2008) believe it is justifiably important to understand *what people can cope with* and their *level of tolerance* for various types of inadequacies in a collaborative system, such as reduced visual fidelity that masks facial cues and body language, audio and video delays and a reduction in environmental ambience. Later in the thesis, I will exemplify that the degree of novelty is directly associated with the need for users to adopt and adapt the technology.

From the business context point of view, Zacarias, Marques, Pinto and Tribolet (2005) suggest that the gap can be reduced with the provision of context models enabling 'context-informed' collaboration services that act according to the specific knowledge and behaviour of each business context. Löfgren (2005) is of the opinion that when introducing any collaborative systems into any existing business work practices to support the existing knowledge formation, to develop and enhance organisational capabilities and improve collaboration and project communication, it is critical to *understand the environment*, *the needs* and *social behaviours* of the intended users, especially focusing on how they collaborate in groups in order to prevent deterioration and distortion between users' collaboration and other social activities within the organisation.

Ackerman's social-technical 'gap' is a different metaphor to the physical-digital 'gap' that I have used earlier in this thesis to describe the barrier between physical artefacts and digital representation of those arefacts. Later in the thesis, I establish that there is an intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype, which I will refer to as the 'social-technical intersection'. This is not to be confused with Ackerman's social-technical gap. The TVTM prototype is built upon multimodal system, designed and developed to provide the 'translation mechanism' to potentially bridge the 'physical-digital' gap, rather than as a mechanism to solve the social-technical gap.

2.7 ACKNOWLEDGING AFFORDANCES IN TERMS OF ENABLEMENTS AND CONSTRAINTS

Gibson coined the term *affordance* and described it as a concept that relates to the perception of a person to its action (Gibson, 1977). In his book, he defined affordances as what the environment "offers the animal, what it provides or furnishes, either for good or ill" (Gibson, 1979, p. 127). Gibson further explained the relationship between matter and affordances that "*what we perceive when we look at objects are their affordances, not their qualities. We can discriminate the dimensions of difference if required to do so in an experiment, but what the object affords us is what we normally pay attention to*" (Gibson, 1986, p. 134). Therefore the theory of affordances is concerned with how affordances are perceived and not affordances per se.

The term affordances has been used in many ways in the HCI community, for example, Norman has a different view on affordance, he argues that designers must make affordances easy to perceive as "*the designer cares more about what actions the user perceives to be possible than what is true*" (Norman, 1999, p. 39). Other researchers such as McGrenere & Ho (2000) describe affordances as the "*design aspect of an object which suggests how the object should be used*" (McGrenere & Ho, 2000, p. 1).

Affordances can conceptually have both enabling and limiting properties. Hutchby (2001) treats the term 'affordances' as a term within which there can be both 'enablements' and 'constraints' at each end of a scale of how aspects of a given technology relate to human activities. Rintel (2013a) proposed that the terms 'technical affordances' describes 'material aspects' of a technology. Within that, he proposed the use of the term "enablements" to refer to possible actions and "constraints" to refer to limits on action. This leads to the possibility of 'technical enablements' – "*what the technology actually allows you to do physically, materially, or virtually"* and 'technical constraints' – "*what the technology actually limits you to from doing physically, materially, or virtually.*" (Rintel, 2013a) Furthermore, Rintel (2013a) proposed that purposive enablements can be considered to be what the technology 'encourages' the user to do, socially, culturally and in accordance with logic conventions, conversely, purposive constraints can be considered to be what the technology 'discourages' the user from doing in the same context. This thesis later addresses these issues in terms of 'design-intended enablement', 'design-unintended enablement', 'design-intended constraints' and 'design-unintended constraints'.

2.8 CHAPTER SUMMARY

An outsourcing manufacturing strategy as part of QR, is one of the common practices adopted by companies within the textile industry, and this strategy influences the fashion industry in different ways. While design firms gain benefit from outsourcing their manufacturing process, outsourcing brings with it a number of problems, such as the adoption of technologies to facilitate the manufacturing strategy, and the inability to collaborate efficiently with the remote manufacturers. In the absence of an effective system to support remote collaborative work for the fashion industry, there is a need to develop a system to fully support collaborative work as part of a QR strategy for the fashion industry.

Before a system can be designed and developed to support remote collaborative work there is a requirement to understand the fundamental mechanisms involved in interpersonal communication, especially the establishment of shared understanding. Effective communication is not just about decoding signals, but carries the additional requirement to interpret the message and the meanings correctly especially during remote collaboration. Interpersonal communication is found to be effective when there is a substantial sharing of common ground such as mutual knowledge. However, literature suggests that the choice and use of the communication medium has a significant impact on the establishment of the common ground.

The literature review covers areas from CMC and CSCW, collaborative workspace/shared workspace systems and tangible/gestural user interfaces. Literature additionally shows the importance of understanding current work practices. There is currently no groupware to support remote collaboration in the fashion industry, previous research in groupware being unsuitable for application to the fashion industry. Since a significant component of fashion design work is artefact-focused (fabric colour and texture, thread, accessories, print patterns etc.), there is a need to use hand gestures to manipulate those artefacts, or digitally represent the physical artefacts in a virtual space during the remote collaboration. It is crucial to determine how a multimodal interface will benefit remote collaboration for the fashion industry. It is also important to acknowledge any technical enablements and technical constraints. This knowledge formed the framework from which the TVTM prototype was designed and developed.

In the next chapter, I will describe methods that I have chosen in finding and *understanding the environment*, *the needs* and *social behaviours* in the context of remote collaborative fashion design processes. The design and development of remote collaborative systems not only needs to account for the existence of the social-technical gap, it is also important to pay particular attention to the role of asymmetry in the design and appropriation of the CSCSW system These asymmetries were originally discovered during video-conferencing; however, I subsequently found that these asymmetries also occurred during remote collaboration in which the participants were using mash-up technology such as the TVTM prototype. This thesis acknowledges that the content that users share through the multimodal system creates asymmetrical access for achieving shared understanding, and attempts to develop a principled way of dealing with the problem of creating shared understanding caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for remote collaboration.

Chapter 3: Requirements study relating to understanding design challenges

Since my thesis is empirically driven, and has had a design-oriented (Fallman et al., 2005) approach to CSCW, I have adopted the *research in and through* design approach (Dalsgaard, 2010), which builds and extends upon design research by Frayling (1993) and Ludvigsen (2006). I have exemplified the design process in an attempt to answer the research question through a series of field studies. Based on the suggestion from Perry and Sanderson's (1998) research that conducting a richer understanding of current practices and a closer examination of how fashion designers collaborate with others are crucial, in order to determine which technologies may support productive fashion design remote collaborative work, the first step of the design process was to conduct an initial requirements study to understand the problem space within the business context of the fashion industry, followed by observing the social interactions, and understanding the nature of the collaboration in the fashion design domain, particularly focusing on different modes of representations (textual/visual/tangible) that fashion designers required during their (fashion) design process. In my research, I am using an iterative design process (Figure 14) of data collection, device design, prototyping and evaluation.

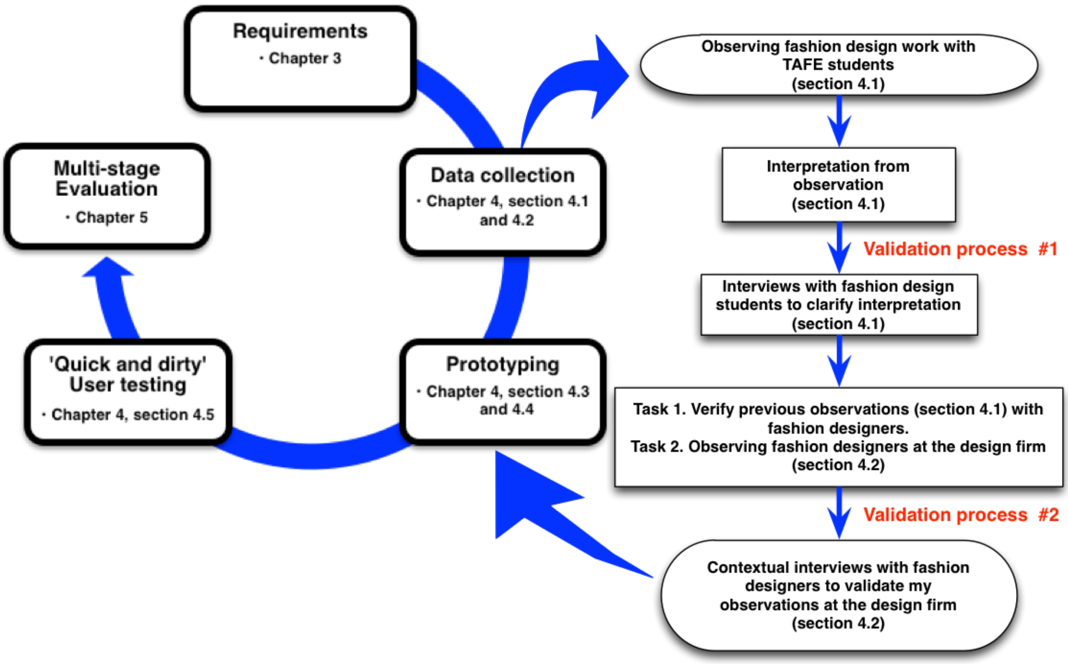


Figure 14: Iterative design process

My research work is focused on the fashion industry. I initially conducted a requirements study at a children's clothing design firm to develop a better understanding of the problem space. This requirements study included interviewing the staff and general manager of the design firm to get a sense of the overall structure, and the production cycle of the design firm. I also interviewed the head of the fashion department to identify the collaboration methods that were in use, and also to identify any problems that may exist in the existing collaborative environment between departments and production line. The requirements study is covered in this chapter. Subsequently, I have conducted several data collection studies that are described later in chapter 4, section 4.1 and 4.2 through to device design and prototyping studies and 'quick and dirty' user testing from section 4.3 to 4.5. Multi-stage evaluation study is covered in chapter 5.

3.1 COMPANY DESCRIPTION

The requirements study was conducted at a children's clothing design firm in Taiwan. The design firm was first established over 40 years ago, with a local brand selling only boys' clothing in local shops in Taiwan. The current owner (second generation) took over the design firm and started to expand the design firm's retail locations to department stores. Over the last decade there has been a large increase in market demand for brand and franchised or licensed clothing in Taiwan. In order to meet the increased market demand, the design firm now manufactures and retails a Japanese children's fashion brand under license in Taiwan, and specialises in boys' and girls' (from ages three to twelve) fashion clothing. The design firm mainly retails via department stores in major cities around Taiwan. Due to high labour costs, the design firm stopped manufacturing clothing itself about two years ago. The design firm changed its strategy and contracted the manufacturing of the clothing to manufacturers in China. The design of the clothing is still carried out in Taiwan. The design firm has since grown to become one of the top children's clothing manufacturing companies in Taiwan. Today, the design firm's products are sold in eighteen department stores in Taiwan.

The design firm consists of five departments, each department having its own tasks and responsibilities. The Design Department is responsible for functions from gathering fashion information and forecasting upcoming trends to the actual design of boys and girls clothing for each season. The fashion designers' tasks include material selection and material usage calculations, preparing all relevant design notes, graphics and logo design, and clothing patterns for the Manufacturing Department (of which the majority of their work is now subcontracted to manufacturers in China).

3.2 TYPICAL PRODUCTION CYCLE

The following are the typical steps taken from resource gathering to putting the design into production to delivery of the final product, in a children's fashion design firm in Taiwan:

Step 1: The head of the Design Department goes overseas to determine the latest fashion trends for the upcoming season from industry sources such as fashion shows and the current season goods in retail shops.

Step 2: Decision making for next season involves meetings with the general manager, the head of the Design Department, and team leaders from the appropriate department store sales staff in major cities. The meeting maps out the direction and styles of the following season's products according to the information gathered from overseas.

Step 3: Organise all relevant graphic work that needs to be created or modified or reproduced, and pass this on to the Graphic Department.

Step 4: The selection of textiles and fasteners for the entire following season, and the ordering of these materials in advance of the production run.

Step 5: The making of the clothing patterns for the following season's products. (e.g. Shirts, pants or jackets etc.)

Step 6: Because the graphic work takes longer to finish, the Graphic Department will pass on the finished graphic and logo back to the Design Department for the next step.

Step 7: Produce prototypes of each design in various sizes to confirm the assembly process and expose any potential manufacturing difficulties that may be experienced by the manufacturer. Any necessary modification will be done at this stage. At this time, detailed notes and specific instructions are prepared, relevant graphics and logos finalised, and these together with the completed prototype, are sent to the manufacturer.

Step 8: The general manager and head of Design Department will decide which style of clothing will go on sale in the department stores first. For example: in autumn and winter, the thin long sleeved t-shirt, polo shirt and pants will go on sale first, then some sweaters and jackets.

Step 9: Once the subcontracted manufacturer in China has received all of the pre-production information and prototypes, it will add the task into its current production. (i.e. the factory might also manufacture clothes for another design firm). The factory may also have to order materials and accessories from local suppliers if the textiles are not sent directly from Taiwan.

Step 10: Quality control people from Taiwan are responsible for inspecting the final products in the factory before they are sent back to the Packaging Department in Taiwan. Faulty or sub-standard goods are reported back to the Design and Accounts Departments in Taiwan. The Design Department will initially try to resolve any issues. If a resolution is not possible the Accounts Department will make a note and apply appropriate penalties. The quantities of finished products will be reconciled before shipping to Taiwan for packaging.

Step 11: Once the Packaging Department has received the goods they are counted again to make sure there are no goods lost in the delivery.

Step 12: The completed garments will then be ironed and company tags added before being individually packed in a plastic bag. Clothes are sorted according to design, size and model number into boxes. The boxes will then be sent to the Warehouse & Delivery Department for storage.

It is clear that the current production cycle and workspace do not involve high-tech computerised programs. Instead, they use calendar or diary based scheduling systems for each department. The technology that has already been deployed in the design firm within the Design Department and Graphic Department includes a CAD system for producing patterns. There are two multimedia PCs set up for the fashion designers and the graphic designers. There are also telephones with inter-com functions and fax machines available.

For my requirements study, I focused on the design collaboration stage through to the manufacturing of clothes (Figure 15) within the normal clothing production cycle.

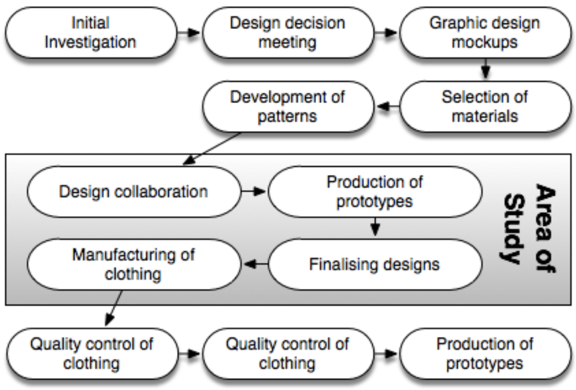


Figure 15: Area of study focusing on the design collaboration stage through to manufacturing of clothing stage.

3.3 EXPLORING THE PROBLEM SPACE

The main purpose of the requirements study was to investigate the situated description of the problems that the design firm was experiencing, as well as focusing on establishing whether the various collaboration issues between the departments could be resolved by the application of different modes of symbolic representation such as textual, visual and tangible representation during the collaborative process.

I have selected the following three examples to show some typical problems that the design firm had experienced, and the existing solutions that were implemented during collaboration between departments in a children's fashion design firm at the time.

1. Problem: The Design Department may have omitted a particular note or did not explain the assembly process clearly or correctly in the notes for the production line, which can cause serious problems at the quality assurance phase.

   Current solution: The subcontracted manufacturer can initially contact the Design Department via email or telephone. Usually, the fashion designers can resolve the problem by adding more design notes, or clarify a particular design instruction on the database that subcontracted manufacturers have access to.

For simple problems, text can be an efficient and expedient method of solving the problem. During the interviews with the manager, it was revealed that a simple textual reply via facsimile or email was efficient, but only when solving basic fashion design problems. For more challenging fashion design problems, the solution would require visual representation such as drawings to match an appropriate symbolic representation to the problem.

2. Problem: Sometimes not all fabrics are sent directly to China from Taiwan, resulting in the need for the manufacturers to order these materials themselves. It may not be possible to get an exact colour or a matching pattern fabric to the one that the Design Department specified.

   Current solution: Subcontracted manufacturers can scan the fabric themselves and send it back to the Design Department for verification via the Internet.

In this case, textual encoded data is clearly going to be an ineffective method of data representation. While it is currently relatively easy to represent colours as digital values, patterns of colours are not as easy to represent in a textual encoded form. Clearly fashion designers would be unable to work with data representation at this level. In the above case the problem may be resolved by using different modes of symbolic representation.

Visual encoded representation of the fabric would allow fashion designers to evaluate the colour and pattern of the material, in a form with which they are completely familiar, as the interpretation of colour is a predominantly visual activity. Current technologies can allow accurate representation of colour, with the potential for greater accuracy than the human eye. According to Poynton (1993), "*the RGB components of each pixel in a 24-bit system can represent one of 16.7 million codes, but the number of colours that can be distinguished is considerably less than this*" (Poynton, 1993, p. 1107). Poynton stated that the colour management systems for PCs and workstations will one day allow device independent specification of colour and "*this will make it easy to obtain colour matching across different graphics libraries, and different hardware.*" (Poynton, 1993, p. 1108).

Human visual perception can change given different lighting conditions, such as artificial light or daylight. "*The same scene viewed under two different illuminants induces two different colour images.*" (Finlayson, Schiele, & Crowley, 1998, p. 1). Using visual encoded representation of colour may potentially allow colour to be more tightly controlled through the use of colour correction technologies and controlled lighting conditions; "*It is well known that the image dependencies due to lighting geometry and illuminant colour can be respectively removed by normalizing the magnitude of the RGB pixel triplets (e.g. by calculating chromaticities) and by normalizing the lengths of each colour channel (by running the* '*grey-world*' *colour constancy algorithm).*" (Finlayson et al., 1998, p. 1).

Visual encoded representation may be able to provide the fashion designer with enough information regarding the texture of the fabric. However if the texture of the fabric was a requirement for the fashion designer, providing the data in a tactile form may make the resolution of the problem more efficient.

3. Problem: One of the subcontracted manufacturers in China discovers a problem with the assembly of a particular garment, such as the alignment of the zip fastener, which is causing difficulty with closing the fastener. The manufacturer has devised a possible solution to the problem, but due to the limitations associated with verbal communication via telephone, the original fashion designer still cannot visualise what effect the proposed solution will have on the finished product.

   Current solution: A live video link is established between subcontracted manufacturer and the Design Department, where the subcontracted manufacturer can point out the problem and demonstrate the proposed solution.

This particular problem is considered to be a visual motor (eye-hand coordination) issue, therefore by presenting the data using a live or recorded visual representation is potentially the most effective mode of representation to resolve the problem.

3.4 CHAPTER SUMMARY

After the preliminary investigation, I have set out to explore issues with regards to the representation and manipulation of physical artefacts as part of the requirements study, specifically focusing on:

- Different users' modes of interaction.
- Textual representation as opposed to visual or tangible encoded representation and the progression from information representation to visual or tangible presentation. ((Ishii & Ullmer, 1997))
- Communication issues, in terms of classification of context in a fashion design environment.

It is important to consider the implications of technology and design methods within the clothing design environment. It is also important to identify what the various design and collaboration processes within the fashion industry are, and from that, determine which processes can (and cannot) be enhanced or augmented with technology. In order to achieve that, I have conducted a series of observational studies and interviews to identify any design directions that industry workers might or should follow, examining what (if any) suitable technologies currently exist that can be mashed into a system, and how the system might support problems encountered in the current design process when dealing with physical artefacts. In the next chapter, I will describe the observational study that I have carried out at the fashion department of the Metropolitan South Institute of TAFE (MSIT) College in Brisbane (it was previously known as Moreton TAFE Institute).

Chapter 4: Technical research studies

This chapter covers the technical research studies to address the remote collaborative issues within a business context and how different data collection methods are used to gain different perspectives on the fashion design process. The first two technical studies described in this chapter use research methods that are in-situ, engaging with both fashion design students and fashion designers in their respective natural working environments.

The chapter begins with a discussion of an observation study (section 4.1) conducted to gain a basic understanding of how fashion designers design garments, since fashion design practices are particularly difficult to accurately articulate or describe in detail verbally to conceptualise fashion design processes. Additionally, the master and apprentice method was conducted to gain insight of the fashion design process from the viewpoint of a fashion designer.

Following this is a discussion on a contextual interview study (section 4.2) conducted at a fashion design firm. In addition to observing how fashion designers work in their natural work environment, the contextual interviews also involve interviews with the fashion designers to discuss and reflect upon their own actions, by actively asking questions that could potentially reveal tacit aspects of fashion designers' work practices.

The findings from these two studies suggest three modes of interactions; textual, visual and tangible**,** which are considered essential for any effective remote collaboration. These three modes of interactions are subsequently implemented as a multimodal system during the prototyping studies (section 4.3 and 4.4). The chapter concludes with a final technical study; a quick and dirty user study (section 4.5) to explore which forms of interaction (textual, visual, gesture/tangible) are relevant when collaborating remotely through a multi-touch screen based interface.

4.1 OBSERVATIONAL STUDY

Previously I have identified some of the collaboration methods currently used in relation to specific problems and the current collaborative environment between departments and production line as well as exploring the problem space within the children's clothing design firm through interviews with key stakeholders. However, due to the constraints imposed by geographical restrictions, I have had to attempt to locate alternative firms in the Brisbane area that were potentially willing to participate. Unfortunately, I was unable to find any local clothing design firm that was willing to participate. Therefore, I have chosen to conduct the observational study at the MSIT College with a class of fashion design students in their final semester. I have made this selection based on the fact that the fashion design students were in the advanced stages of acquiring the skills of the professional fashion designers.

4.1.1 Method

In order to have a basic understanding of how fashion designers design garments, I have conducted an observational study at the fashion department of the MSIT College. I have chosen to conduct this in a teaching environment because: (1) the designing work settings are closely related to the real work environment, (2) the location is local and accessible as opposed to flying overseas to conduct field work at the same design firm where I had conducted my previous preliminary study, (3) all the current teaching staff members have had several years of experience working at various clothing companies.

I have chosen to use the observational method as a primary means of data collection, because fashion designing practices are skills that are very difficult to accurately articulate or describe in detail verbally in order to easily understand or conceptualise the fashion design process. When the observations require further explanation, or when the observational data from the study reveal some particularly interesting aspect of the fashion design process or interaction between the fashion designers, these observations are supported by interviews with these participants.

The observational method of qualitative data collection also provides the best way to obtain the data for this particular study, the 'data' in this case being an overview of the fashion design process. This includes individual fashion design work, interactions between teacher and students during design critique sessions and also interaction between fellow fashion design students regarding their design work in their natural setting (the classroom). In order to minimise observation-selectiveness during the field study, I elected to observe all participating students from the back of their classroom, rather than focusing on a particular student's work since the subjective bias of the observer may affect data reporting.

During the observation study, I followed eight participating students preparing their design work for an upcoming fashion parade, as part of the requirements for their advanced fashion diploma degree. I observed the design process from beginning to the final product during six observation sessions from 10th May 2006 to 21st June 2006. Each session took approximately 2 hours. Figure 16 shows the floor plan of the classroom in which the observational study was conducted, at the MSIT College.

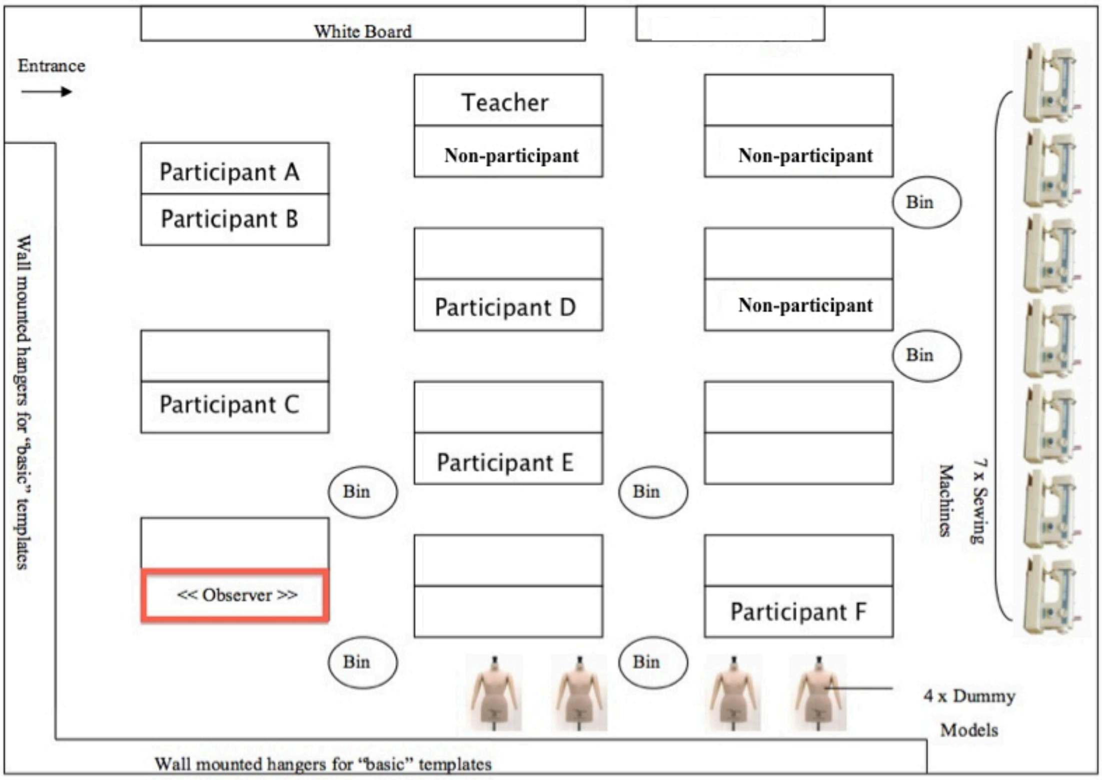


Figure 16: Floor plan of the classroom.

As the observational study progressed, I developed an understanding of the fashion design process, and consequently restructured the observations and focused attention on certain characteristics and events; for example, the gestures and the social interactions between participating students to potentially provide enhanced and increased validity (Newman & Benz, 1998)

I have also interviewed the participating students, and asked a number of questions about the students' activities during the study. The proceedings were audio recorded and a digital still camera was used to capture hand gesture movements of students while they were carrying out their design work.

Interviewing the participants after my interpretation of the observations was part of the multiple validation processes. The multiple validation processes were based on the original triangulation method broadly defined by Denzin (1978) as "*the combination of methodologies in the study of the same phenomenon*" (Denzin, 1978, p. 291), and the term was originally regarded as an 'instrument of validation' (Denzin, 1978). In order to accomplish the multiple validation processes, I have used interviews as a validation support technique to validate the interpretation and the assumptions that I have made, based on previous observational data obtained in this particular observational study. Later on, I will use the data that I have collected to verify different aspects of the fashion design method used by the fashion design students against the fashion designers at the design firm (section 4.2).

The goal of the observational study was to observe the fashion design processes that the fashion design students had undertaken, and how they communicate and interact with other students or their teacher. During the first session of the observational study at the MSIT College, I used pen and paper to note what I observed, sketching any gesture movements and making statements based on my observations, plus recording any conversation going on at the time between the participating students. I realised there was too much information to note down, while simultaneously analysing all the interesting interactions that I had observed from the participating students. I subsequently used multiple validation processes (Figure 17) to validate my observational data by re-confirming the interpretation statement that I have made from the observation with the participating students. The validation process involved the assumptions that I had made initially from the observation about 'what was going on there', and had also made an assumption of what the observation meant. The observational data was subsequently validated with the participants that I had observed, to verify that 'what they said matched what I observed'.

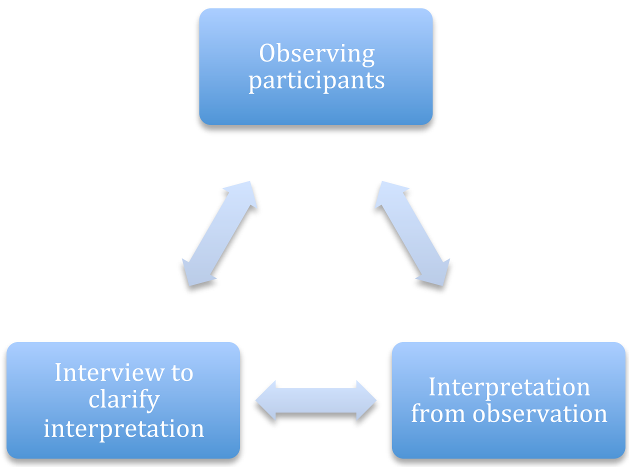


Figure 17: Example of a validation process used in observation session 1 based on the triangulation method by Denzin (1978).

In order to concentrate on the observations rather than spending too much time drawing somewhat inaccurate sketches, I decided to use a digital still camera for capturing the gesture movements instead (see Figure 15 and Figure 16). I captured gesture movements by the students while they were undertaking design work. These still photos were used to assist the students to recall what was occurring during the design process. As a result of this assisted recall, the students were able to remember not only *what* they did, but were also to explain in more detail *why* they did what they did during their design work.

Figure 18: Example of photo illustrating hand measurement gestures used by student.

Figure 19: Example of photo illustrating folding gestures used by student.

During one of the observation sessions at the MSIT College, I had a chance to perform two small design tasks (see Figure 20 and Figure 21) following the master and apprentice approach from contextual inquiry (Beyer & Holtzblatt, 1997), where the TAFE students (the master) taught me (the apprentice), what they do and how they do their design work.

The first master and apprentice task involved helping Participant F cut the paper pattern. She taught me how and what to cut. This task involved cutting the shape of the pocket, which was pre-drawn using a pencil. For the second master and apprentice task, Participant F wanted to fold some fabric, and pin it together to prevent the fabric from moving while it was being sewn. I was experiencing difficulties trying to follow the instructions as well as accomplishing the task. After I put the first pin into the fabric, Participant F corrected me, and told me not to pin it too close to the area where the sewing will occur. I then repeated it the correct way.

The study participants acting as the master, and observer acting as the apprentice in accordance with the master/apprentice relationship model, is a useful and effective way of collecting data (Beyer & Holtzblatt, 1997). It is also one way to learn how users work in their workplace, and to understand the work practices and why certain tasks are performed.

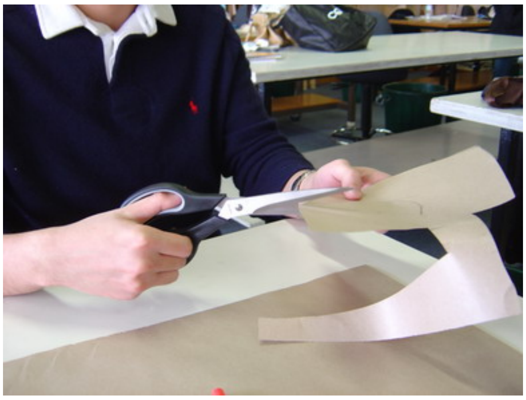


Figure 20: Master and Apprentice Task 1.

Figure 21: Master and Apprentice Task 2.

4.1.2 Findings

It was noticed during the observational study that gestures formed a significant part of interactions between the participants in numerous FTF collaborations, and warranted further investigation. The observational data from the interaction between two participants is presented below, followed by my interpretation of this data, and an interview with the participants to confirm the validity of the interpretation. The data was deliberately kept in raw form to illustrate the multiple validation processes used.. The raw data below shows a short conversation between two participating students; Participant A and Participant B were having a discussion about Participant A's design work.

> <u>Participant A:</u> *"I am having trouble with the size of this one, Participant B what do you think?"*
> <u>Participant B:</u> *"Let me have a look"*

My interpretation from observation:

Based on the drawing (Figure 22) that I have made at the time of the observation, Participant A and Participant B were discussing a particular size problem with one of Participant A's pattern (paper). Participant A used thumb and index fingers to measure top and bottom of that particular pattern she was working on.

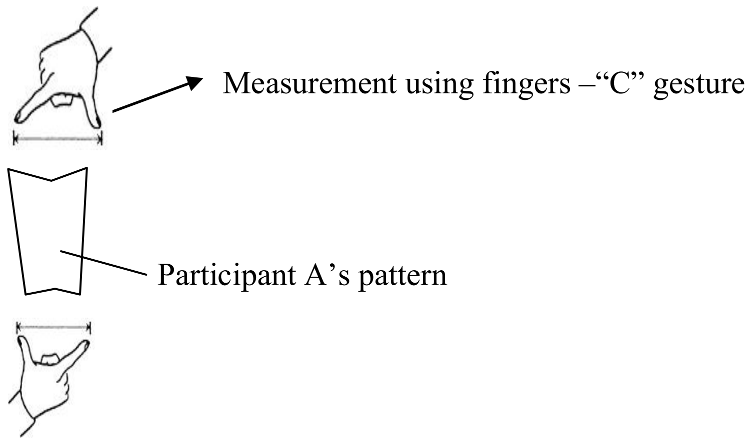


Figure 22: Drawing representing gesture movements by TAFE student Participant A.

Interview data to verify my interpretation:

> <u>Participant A:</u> *"I was showing to participant B earlier that the top and the bottom opening doesn't match using my fingers because I wasn't sure if I should reduce the size of the top opening to match the bottom, so I wanted her opinion about it."*
> <u>Participant B:</u> *"Yes as soon as she pointed out the size differences with her fingers, I could see the problem myself and later I told her to change it so the top and the bottom matched.*

My interpretation of the data in this case was somewhat accurate. It is interesting to note that participant A was *using finger gestures to demonstrate the design problem* to participant B in order to receive feedback. I have also observed many other cases where students had used hand and finger gestures while they were talking about their design with other students or their teacher in the classroom. As an example (Table 2 - Observation 1), the teacher initially showed a student how to quickly draw a curved line by using finger gestures over student's paper pattern design. However, the student appeared confused and asked if the teacher could show her again. The teacher acknowledged, and began the demonstration, verbalising each step in the process. She used a tape measure and a chalk to draw a dotted line in the middle of the fabric, creating a centre point for the curve. The teacher subsequently used a piece of string, holding down one end on the top point of the dotted line that she had drawn. She then wrapped the chalk with the other end of the string and used it to mark an initial point on the left hand side. She then swung the string and the chalk to the right hand side and marked another equidistant point on the right hand side, joining the two points in the form of an arc, by swinging and drawing with the chalk.

This example shows the importance of every individual exchange of information during FTF collaboration, using both verbal communications and gestures during the communication. In this case, the collaborative participants were able to see, touch and manipulate the physical artifact, as well as using gestures to demonstrate design methods and techniques to maximize the transmission of information during the FTF collaboration. There were other examples of gesturing including the use of hand gestures to imply movement (Table 2 – Observation 3), or to move objects (Table 2 – Observation 3 and 5), as well as hand gestures to represent 'bright red' colour (Table 2 – Observation 4).

The design and the development of a remote collaborative system will need to take into consideration the transition of physical to digital artifacts, the ability of the remote participants to see the artifact in the same detail as the local participants, and the ability to see the gesturing of both participants, in order to provide a similar collaborative experience to a FTF collaboration.

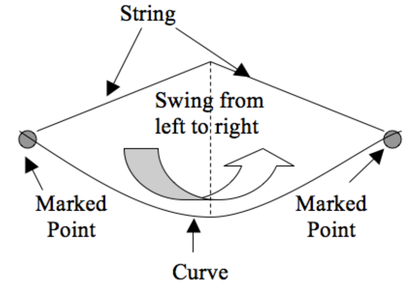
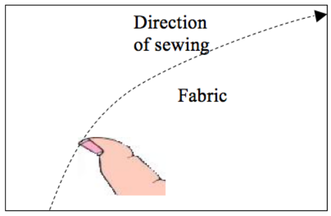
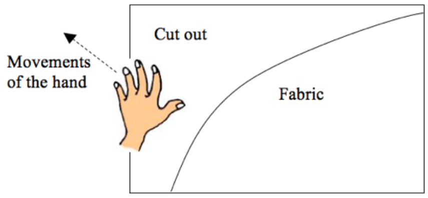
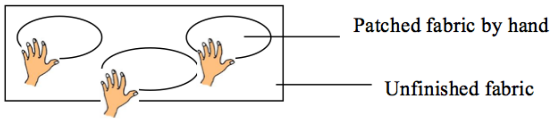
<table>
<tr><th>Observations</th><th>Sketches</th></tr>
<tr><td>Observation 1:
The Teacher helped a student with her design, using a tape measure and a chalk to draw lines/curves, also using a string to measure one point and mark another point symmetrically on the fabric, and then join up the dots to form a curve.</td><td>
</td></tr>
<tr><td>Observation 2:
Teacher showed Participant C how to sew the fabrics. Hand gestures: using thumb and thumb nail to draw a curved line mimicking the direction of sewing.</td><td>
</td></tr>
<tr><td>Observation 3:
Participant C used hand gestures to show the teacher (or re-confirm) what needed to be cut out before sewing.</td><td>
</td></tr>
<tr><td>Observation 4:
Teacher went to help Participant D with her design. Participant D wanted to change the colour of the fabric that she wanted to use for her design. She then told the teacher that she decided to use ‘bright red’ (hand gestures of ‘sparking’)</td><td></td></tr>
<tr><td>Observation 5:
Participant D used hand gestures movement across her chest and told the teacher she was having trouble with part of her design. She started to lay out a few round-shaped fabrics to her unfinished garment that she made; she was trying to show the teacher her idea of ‘patching’ another fabric to her unfinished garment.</td><td>
</td></tr>
</table>

Table 2: Hand and finger gestures used during the conversation between students and teacher.

As previously mentioned in 4.1.1, during one of the observation sessions at the MSIT College a participating student enquired whether I was interested in undertaking some basic fashion design work, with the aim of improving of my understanding of the fashion design process.

The role of the apprentice allowed me to experience some of the interactions and basic design processes from the viewpoint of a novice fashion designer, and additionally improved my understanding of the fashion design process. The observations showed that, in order to correctly manipulate physical artefacts during the master and apprentice tasks, giving out clear ‘step-by-step’ instructions while both parties were able to see the entire 'action' was extremely important. Therefore the ability of the remote participants to be able to see the same things as the local participants during collaboration, is considered to be extremely important and should be considered an essential design element in any remote collaborative system 'for them to be able to see what I see' was considered as implication for designs.

4.1.3 Summary

In order to get a deeper understanding of how fashion designers work, an observational study was conducted based on the literature within clothing related CSCW research (Pycock & Bowers, 1996). The study was carried out with a group of fashion school students at the MSIT College preparing for their fashion parade project. During the observation, multiple validation processes were utilised. Early observations captured the collaborative nature of the fashion design work as well as gestures used during communications. The observations and the *master and apprentice* tasks both explained the intricacies and processes of fashion designers' day-to-day design work. These findings provided me with some insights to the fashion design process within the teaching environment, understanding some of the work practices that are similar to the real world environment, and why certain design tasks are performed. Observational data from the study showed that the fashion designers relied on both ***visual*** and ***tangible*** elements of the communication during the fashion design process. The implications for design of the TVTM prototype were that the prototype required incorporation of both visual and tangible modalities, as part of the multimodal system.

Next, I will describe some aspects of actual design work practices at the children's clothing design firm based on my observations and interviews.

4.2 CONTEXTUAL INTERVIEW STUDY – FASHION CLOTHING DESIGN FIRM IN TAIWAN

I had an opportunity to revisit the clothing design firm in Taiwan in December 2008, for in-depth contextual interviews for three days with various employees working across design, pattern and prototyping departments. I had chosen to conduct contextual interviews to not only observe how fashion designers work in their natural work environment, but also to involve the fashion designers in discussions and reflections on their own actions by actively asking questions that could potentially reveal tacit aspects (Beyer & Holtzblatt, 1999) of fashion designers' work practice.

The main objective of this study was to investigate the interactivity of the actual design processes carried out in a normal clothing design firm, and to focus on content creation during the design process. The secondary objective was to check the real world validity of some of the observations arising from the observational study at the MSIT College.

4.2.1 Work practices at a fashion design firm

The design team was working on the spring and summer collections; most of the team members were working at a relatively fast pace to finalise their summer collections ready to be manufactured by the contracted manufacturer in mainland China. The entire conversations during the contextual interviews happened in my native language (Chinese), which were subsequently translated into English. During the observation, digital snap shots were taken and interview conversations were written down.

The head of the design team first introduced me to her team. Present that day were head designer herself (Designer A), one of the design assistants (Designer Assistant B), one of the paper pattern developers (Pattern Developer C), one of the digital pattern developers (Pattern Developer D) and one of the graphic designers (Graphic Designer E).

Over a period of three days, I observed these different people at their workstations carrying out their design work according to their work schedule. Each team member was working on his/her own dedicated design task at the time of the observation. I started at Designer A's workstation on the first day to observe the design task that she was working on, which was reconfirming measurements for the design specifications that she needed to send to the offshore manufacturer. Later that day, I followed Designer A around and noticed some interesting interactions between Designer A and the Graphic Designer E about converting Designer A's physical drawings into digital drawings at the graphic department. On the second day, I followed Design Assistant B around the fashion department. She was working on a prototype for a shirt based on the new design from Designer A. Observing the prototyping process was an interesting experience as fashion designers manipulated different kinds of artefacts (such as paper patterns, design tools and fabrics). On the final day, I went to the pattern-making department to observe the transformation of paper patterns into digital patterns.

There was a total of five different tasks (Table 3) that I had observed. During the observation, some relevant questions were asked regarding the design team members' current task. In the next section, I will present the findings from my observation and contextual interviews in accordance with the five tasks.

Task	Design team member(s)	Principal topic derived from observation and interviews
(a) Prototyping a white shirt pocket using a stock shirt pocket paper pattern from archive	Design Assistant B	Prototyping process
(b) Preparing design notes for the manufacturer	Design Assistant B	Design specification notes
(c) Transforming paper patterns into digital patterns	Paper Pattern Developer C, Digital Pattern Developer D	Physical manipulation with physical artefacts during the pattern making process
(d) Adding decorative crystals to a graphic embroidery	Designer A, Graphic Designer E	Adding physical elements to an existing graphic design
(e) Transforming hand drawn design sketches to digital graphic image	Designer A, Graphic Designer E	Converting design sketches into digital format for cataloguing

Table 3: Principal topic derived from observing and interviewing various design team members performing five design related tasks.

4.2.2 Findings

The following findings are presented as a brief description of each fashion design related task, with my observations, followed by the contextual interviews to clarify or explain any observation of interest and concluded with a short analysis of the interaction.

<u>Prototyping process</u>

I followed Design Assistant B to her workbench to conduct my initial observation. She overlapped two different sizes of paper pocket patterns to check if she had selected the correct ones for the particular design (Figure 23 - Right). She then laid out a few shirt pocket paper patterns over a white fabric (Figure 23 - Left) on a workbench and then used a special black chalk to mark the outline of the pattern, which was subsequently cut out and sewn onto a shirt.

Figure 23: Design Assistant B was working on some design pattern patterns

While I was observing, I had noticed that the design firm had a semi-automatic fabric-cutting machine on a bigger workbench not too far away from where I was observing. When I asked Designer Assistant B why she didn't use the semi-automatic machine to cut out the fabric, she responded:

> *"In this case, it is quicker to cut this out by hand for a prototype garment that I am making as I am trying out the new pocket size and to examine the overall look of the design. As for the final production line, we overlay multiple layers of fabric and use the semi-automatic cutting machine with a laser guide to cut though thick layers of fabric. The end result of that is a large amount of precisely cut-out fabric patterns within a very short period of time."*

Her response confirmed that this was the same reason for fashion design students only cutting fabrics by hand as opposed to using the automatic cutting machine. Also, from the observation and interviews with the design assistant, the fashion designers still used the paper patterns as an efficient way of constructing prototype garments instead of using the digital patterns. The main reason for using the paper patterns was that fashion designers are more comfortable with the traditional method of having to trim off the fabric by hand with the paper patterns in order to produce a prototype garment. Again, the use of the paper patterns was also confirmed to be the same as what fashion design students used at the time when I conduced the observational study at the TAFE collage. In terms of modes of interaction and representation, both visual and tangible representations are required in this situation.

<u>Design specification notes</u>

While Design Assistant B was gathering all the patterns for the prototype garment that she was making, she wrote some notes on the back of the fabric (Figure 24 - Left) with a pencil and (Figure 24 - Right) also wrote down a design specification that will be sent to the manufacturer in China. When I asked Design Assistant B about the purpose of writing down the notes, she responded:

> *I am writing down the pattern part numbers on the back of the fabric for a particular style of the garment, so it is easier to organise later on. It is very important for me to write down additional design specification notes for our manufacturer in China, and I will be sending this together with some fabric samples and the prototype via international mail.*

Figure 24: Design Assistant B wrote down some design specifications for manufacturer.

Part of the design process from design to manufacturing was to ensure the manufacturer receives every possible detail of the design of the garment. Providing detailed specification notes to the offshore manufacturer potentially limits the occurrence of major manufacturing errors during the production of garments. In terms of modes of interaction and representation, both textual and visual are required in this situation.

Physical manipulation of physical artefacts during pattern making process

I went to observe the Pattern Department. Paper Pattern Developer C was working on new pattern sizes. He laid out existing patterns for a particular shirt design on to a previous season shirt design. He subsequently picked up the existing pattern (Figure 25 - Left) and used a ruler to measure the extra length he needed in order to make a new set of enlarged patterns based on the existing patterns. Digital Pattern Developer D later received the new paper pattern from Paper Pattern Developer C and started converting the new set of patterns into digital patterns using a small handheld digital point-capturing device (Figure 25 - Right). Digital Pattern Developer D used the device to select a number of points that needed to be captured, she then pressed a button on the device to preselect a setting to capture a straight line and later pressed another button to preselect a setting to capture a curve. Once the Digital Pattern Developer D finished scanning all the points, she went back to her computer to make minor adjustments to the new digital pattern. The new digital pattern was stored securely on the design firm's server. The new digital pattern was later sent via email to the contracted manufacturer.

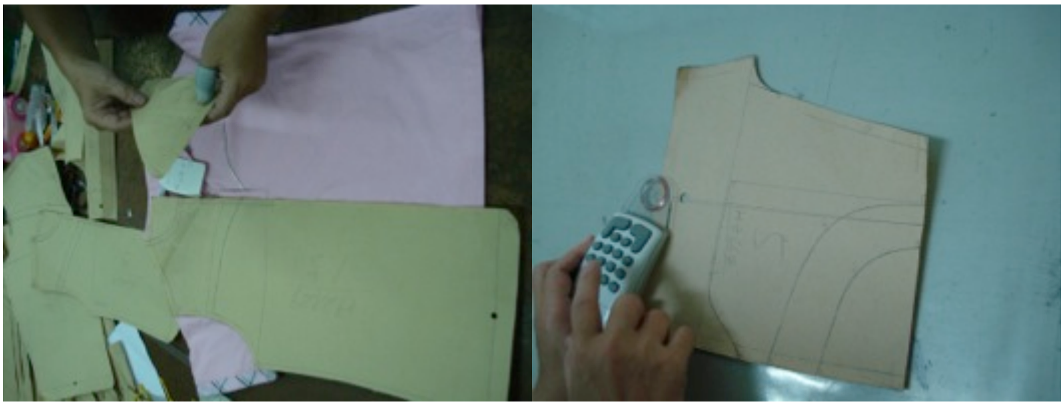


Figure 25: Paper Pattern Developer C compared the existing paper patterns against a sample garment (Left). The new paper pattern was later transformed into a digital pattern by Digital Pattern Developer D (Right).

I was curious as to why the design firm uses two different types of patterns, so I asked Paper Pattern Developer C to explain the differences between paper patterns versus the digital format and how they stored them. He replied:

> *The paper patterns allow us to quickly assemble the prototype garment. Also, they are easier to handle and manipulate, therefore making any sizing adjustment a lot easier before the final production. As for the digital format, some of our sub-contracted manufacturers in China require digital formats for the final production of the garments. All paper patterns are held together using cotton strings and they are stored in our storage room. They are categorized by seasons such as spring/summer and autumn/winter followed by years. The digital patterns are named in exactly the same format as the paper patterns, and are then similarly categorized into either spring/summer or autumn/winter folder for the current year. The files are saved on our secure server and they can be emailed to our sub-contracted manufacturers in China.*

From the observation and the interview, the traditional paper patterns appeared to be significantly easier for fashion designers and pattern developers to manipulate along with other physical artefacts, including fabric, rules, tape measures etc. However, due to the streamlining process that was happening within the design firm, it was essential to convert all paper patterns into digital patterns for the offshore manufacturing even though it was a slow and time consuming process. The benefit of the conversion was that the digital patterns were easier to catalogue and store on the design firm's server. In terms of modes of interaction and representation, both visual and tangible are required in this situation.

Adding physical elements to an existing graphic design

During my observation at the design department, Designer A received an urgent phone call from the contracted manufacturer with regards to a missing beading graphic pattern design. Meanwhile, Designer A requested the latest version of the logo design from Graphic Designer E (Figure 26 - Top Left). She subsequently opened a bag of crystal beads and started to place some of the colour crystals onto the fabric by hand with a pair of tweezers (Figure 26 - Top Right), in accordance with the logo design by Graphic Designer E. After Designer A finished placing the crystals, the next step was to make a pattern by laying down a special sticky transparent plastic over the fabric and crystals to capture the positions of the crystals (Figure 26 - Bottom Left). She then compared the crystal pattern carefully against the physical prototype of the design (Figure 26 - Bottom Right) before sending the crystal layout pattern to the clothing manufacturer.

I asked Designer A whether it would be easier to view the graphic design on a computer monitor or on paper to complete the same job that she was working on. She responded:

> *It all depends on the work really, if it is the 'work-in-progress' graphic designs then I will look at them on the computer monitor but in most cases the graphic designer will print them out for convenience as I would need to double check my crystal beading patterns on the sticky transparent sheet against the graphic design. This will probably take me roughly 10 minutes to do and I am only doing one as a sample copy for our manufacturer. However they have a special machine that puts a batch of crystals onto a sticky transparent sheet, which they can later iron it onto the fabric.*

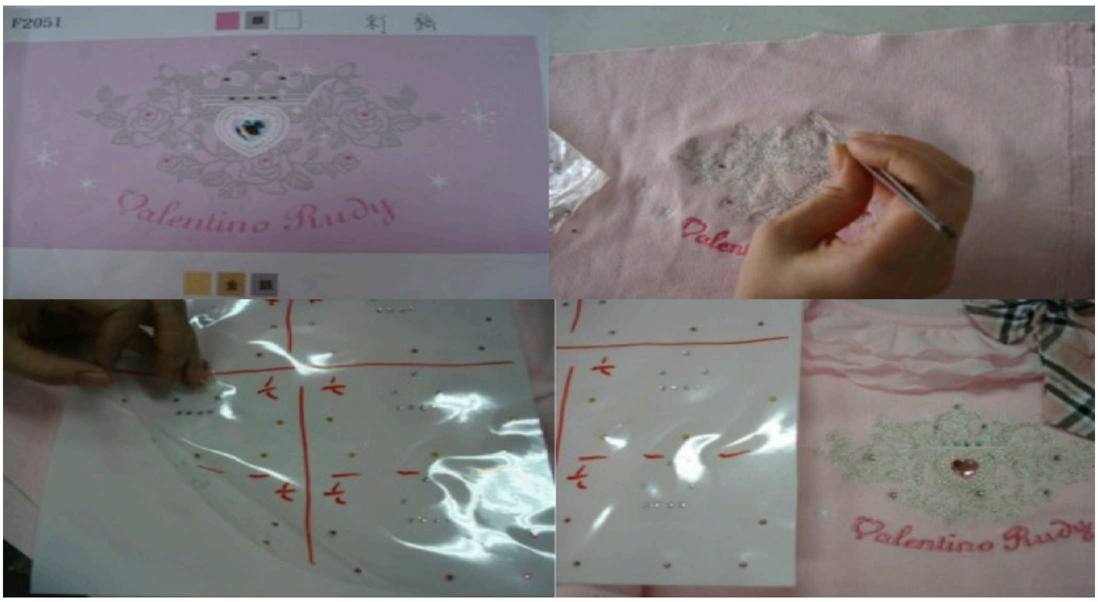


Figure 26: Designer A was in the process of creating a pattern for crystals laying for a design.

Adding physical elements manually to an existing graphic design can be time consuming but the fashion designer is able to view the result of the final design instantly and also is able to make any adjustment during this process. In terms of modes of interaction and representation, both visual and tangible are required in this situation.

Converting design sketches into digital format for cataloguing

I visited the Graphic Department and noticed Graphic Designer E was working on converting several hand-drawn design sketches by Designer A into digital images for easy cataloguing (Figure 27). During this process, the graphic designers also applied appropriate colours and graphic images to the corresponding designs to enhance the visibility and easy recognition of the style of the designs. I asked why she needed to convert them, she responded:

> *We use these design sketches repeatedly in many places, from season collection overview to manufacturing of the garment calendar. Once the design sketches are in digital format, we can use them anywhere. For example, we can list them in our workflow chart and design specification sheet like this one here. At this stage the current season design specification sheets are used for fashion designers to jot down notes with pen and pencil. They are then stored in folders and the previous season's specifications are transferred and stored in our storage room.*

Figure 27: Graphic Designer E converted design sketch by Designer A into digital images.

Converting hand-drawn designs into digital format was part of the workflow, as the digital format can be used on multiple occasions throughout different stages; from season collection overview to the manufacturing of the garment, and production priority. It was not only a time saving step but also provided a visual reference, (as opposed to the specific design style ID), to everyone who was involved with the production of the garment. In terms of modes of interaction and representation, both textual and visual are required in this situation.

4.2.3 Summary

Fashion designers still prefer to use the traditional method of constructing a prototype garment with the paper patterns. The traditional paper patterns allow the fashion designers and pattern developer to easily manipulate paper patterns and other physical artefacts including fabric, rules, tape measures etc. Digital patterns, however, are required for mass production at the offshore subcontracted manufacturing firm. It is always time consuming to complete any manual design work such as adding crystal beadings to an existing graphic design, however fashion designers are able to view the results instantly. Similarly, while converting hand-drawn designs into digital format manually is not cost effective, the end result provides better workflow, as the digital format can be reused on other occasions throughout different design stages; from season collection overview to manufacturing of the garment and production priority. Design specification notes are considered to be part of the design process, from design to manufacturing, to ensure that the offshore manufacturer is aware of every possible detail of the design of the garment, to minimise any final production errors.

By observing and interviewing the fashion designers at the design firm, I identified many varied interactions, and subsequently identified five key topics from the observations made during that study. These five topics guided the initial design process of the TVTM prototype, which I would then be able to evaluate in more detail.

Based on my observations and interviews at the TAFE College and the design firm, I have observed three modes of interactions; ***textual***, ***visual*** and ***tangible*** (Table 4), which I consider essential for any effective remote collaboration.

Observed interactions with objects (TAFE College)	**Required Modality**
Hand gestures to move objects	Tangible
Hand gestures to draw	Tangible + Visual
Hand gestures to represent show/describe	Tangible + Visual
Observed interactions with objects (Design firm)	**Required Modality**
Physical manipulation (Overlapping and tracing objects)	Tangible + Visual
Jotting down design specification notes	Textual
Converting physical objects to digital objects (e.g. paper patterns, hand drawn graphic images)	Tangible + Visual
Adding physical objects (e.g. beadings) to physical objects	Tangible + Visual

Table 4: Proposed modalities based from observed interactions from the TAFE college and the design firm.

4.3 ORIGINAL PROOF OF CONCEPT FOR A MULTIMEDIA AND MULTIMODAL PROTOTYPE

4.3.1 Why multimodal system?

There are many challenges in the fashion industry including issues with collaboration and communication (Masson, Iosif, MacKerron, & Fernie, 2007). Information such as the technical specifications of the garment is very complex. One of the biggest challenges is to ensure everyone in the remote-located manufacturing supply chain receives the most accurate and up-to-date description and design specifications.

> *"Like all products, once designed, garments are subject to many design changes in the pre- production phases. Typical products see more than 50 changes or enhancements before production is complete. And often changes made by brand designers are slow to reach the production floor of a contract manufacturer." (M. Johnson, 2002, p. 6)*

From the qualitative studies that I have previously conduced at the fashion design firm, I have learnt that the physical collaborative tasks involve communications with a combination of speech, gestures, and physical actions such as manipulation of artefacts (fabrics/garments). These actions can be classified as human-centred multimodal communication.

Based on the observational study in a FTF setting, with the findings backed up by the contextual interviews, the qualitative data enabled me to make reasonable assumptions about how users would potentially interact socially in a remote collaborative exchange (e.g. requesting help with a particular design problem of a garment verbally, or offering an alternative design idea), and what kinds of modality the designer and the developer of a collaborative system would need to provide (e.g. annotating with text description or pointing with a finger to a problem with the design of a garment using a webcam, or drawing an alternative design on the computer screen) in order for users to successfully collaborate remotely.

These assumptions formed the basis of the design requirements of a remote collaborative system, with the findings from the contextual interviews confirming some of the major modalities that are required for collaboration to bridge the barrier between physical artefacts and the digital representation of those artefacts.

I have proposed the design and development of a multimodal system, specifically an inexpensive mash-up of technologies to support communication with the users through different input modalities such as speech, pen, touch, gestures and a live (webcam) video feed during remote collaborative physical tasks. The prototype has different modes of virtual representation such as *Textual*, *Visual* and *Tangible* with a *Multi-touch* screen technology; hence it is called a TVTM prototype. Therefore the multimodal component of the TVTM prototype can be characterised by exchanging and handling information acquired by different modalities through multiple (digital) input and output communication channels and presenting that information in the multimedia context (Coutaz et al., 1993; Nigay & Coutaz, 1993).

Multimedia means information can be represented, stored, transmitted and processed digitally as an integration of multiple forms of media, which includes traditional media such as text, graphics drawings and images to audio, video and animations etc. The TVTM prototype offers users easy access to earlier work and archived multimedia content, as well as the current collaborative design work. My vision was to incorporate the TVTM prototype into the fashion designer's workbench, to allow fashion designers to work on their desk as envisioned in Figure 28.

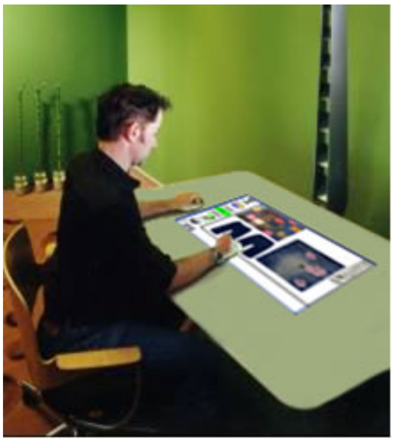


Figure 28: Photo illustrated fashion designer working on the TVTM prototype.

4.3.2 Initial design concept

My original design concept was to allow users to be able to switch between different interfaces, according to their need for design work during any remote collaboration. Each level would have unique tools, such as tools for text editing (textual), tools for importing media (visual), and tools for manipulating digital artefacts. The initial design that I had proposed features a green highlighted box to indicate to users that the corresponding feature they had selected was currently active. The illustration below shows the original proof-of-concept design (Figure 29) for the TVTM prototype, with a set of features that focused on textual, visual and tangible representation, that were selected based on the observations and interviews conducted in the earlier study at the design firm.

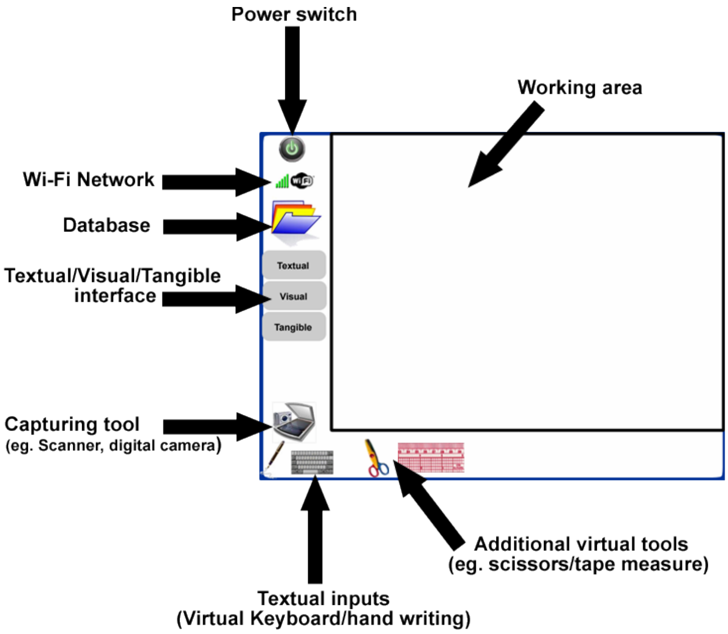


Figure 29: Details of initial interface prototype.

From the observations at the fashion design firm, I saw that fashion designers constantly need to check measurements against previous designs or improve a new sizing pattern from the previous design pattern etc. This proof of concept prototype would allow users to be able to search or browse the entire company's database (Figure 30). Typical elements of the database would include all previous designs (including all design notes and sewing instructions), standard basic patterns, and samples and specifications for available fabrics and colour choices.

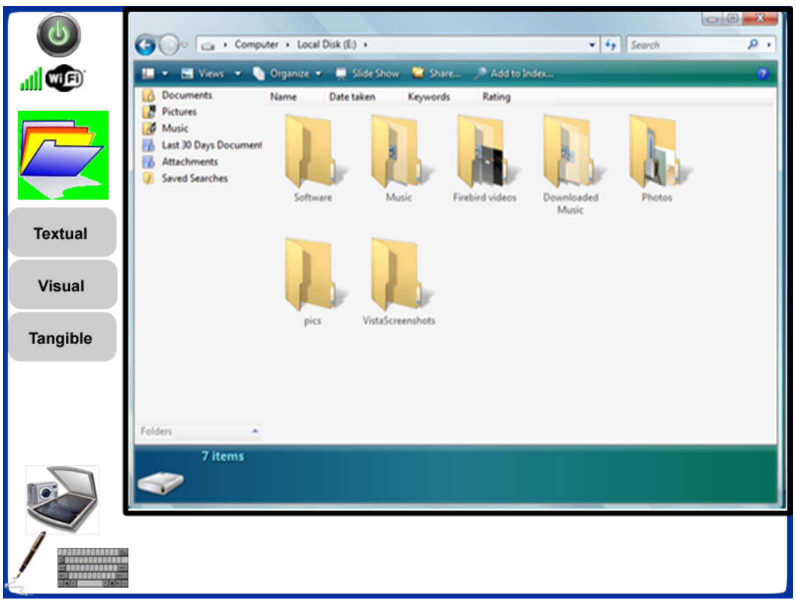


Figure 30: Typical elements of the database include all previous designs, including all design drawings, design specification notes, digital patterns and sewing instructions.

As observed from the TAFE College and also the fashion design firm, fashion designers require textual, visual and tangible modalities to be able to draw design sketches, annotate design drawings, and write down design specifications, as well as comparing colours of fabrics, physical manipulation of fabrics and design patterns etc. This proof of concept prototype would enable users to be able to switch between different interfaces according to their need for design work; each modality would have its unique tools such as instant fabric wrapping tool, virtual cutting and measuring tools etc. For example, for the textual modality, the system would offer both virtual keyboard and virtual pen for basic textual editing (Figure 31).

Figure 31: Textual - User can edit design notes through either virtual keyboard or virtual pen

For the visual modality, the user would be able to view the available suitable fabric samples from a range selected from the database, or scanned at that time. Different patterns and embroidered features would be available (Figure 32), either from the database of stored designs, or created from the range of suitable tools offered by the interface. The user would be able to view the effects of any design change instantly through a virtual 'finished' garment available in a 3D view using an instant 'fabric wrapping' tool as portrayed in Figure 33.

Figure 32: Visual –importing various virtual fabrics.

Figure 33: Textual – adding annotations.

For the tangible modality, users have the option of using appropriate tools to manipulate the design including the use of virtual tools to perform the required task - for example to use hand gestures to move a digital artefact around or use virtual scissors to 'trim' the digital artefact (Figure 34) or to select a virtual ruler to perform digital measurements of length or area between selected points.

Figure 34: Trimming off flowery pattern and applying it to the jean's fabric.

4.3.3 TVTM software development

The software interface was developed using Adobe Integrated Runtime (Adobe Air); cross-platform software built upon HTML, Ajax, Adobe Flash and Flex technologies, which runs on Windows, Mac OS and Linux computers. In the initial software prototype, only Adobe Flash/Actionscript language was chosen due to its flexibility, open source and modular nature (Yang, Dekker, Muhlberger, & Viller, 2009).

The first version of the multi-touch software prototype interface (Figure 35) was based on my initial concept, which I have previously discussed (in 4.3.2). The interface prototype consists of a main design work area and a two level navigation interface. The main design work area allows for a workspace where objects such as clothing design mock-up, graphic design/icon, photos etc. can be added, manipulated and collaborated on by fashion designers and also the manufacturers in the remote locations. (Yang et al., 2009) Users can create and store any design work, design problems and solutions locally in the design firm's database or cloud based online storage such as *Dropbox*[1].

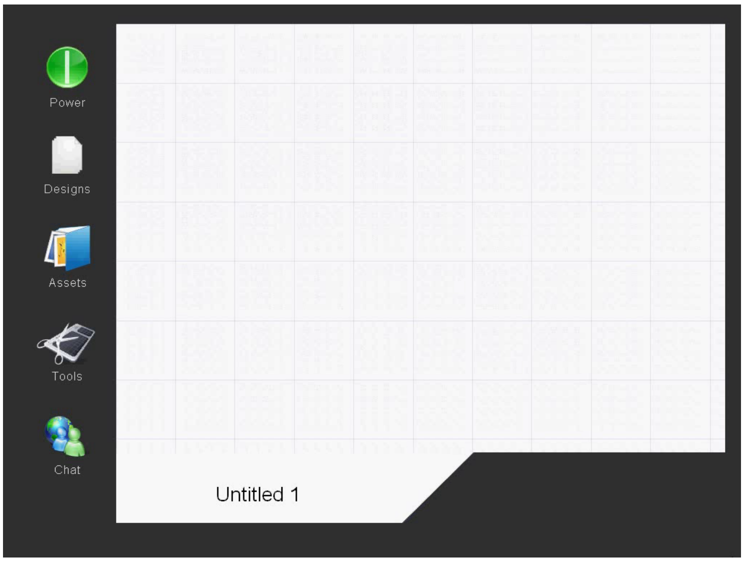


Figure 35: TVTM software prototype.

Objects brought into this area allow for traditional multi-touch gestures, including scaling, panning and rotating (Wigdor, Fletcher, & Morrison, 2009a) simply by using two finger points gestures. The navigation interface consists of two tiers. The main navigation on the left-hand side of the interface allows the user to switch modes easily based on the task that needs to be performed, e.g. object manipulation, communication, design management and 'helper tools' such as scissors or a ruler. The second level navigation (Figure 36) appears on the bottom right of the screen, providing direct access to actions related to the specific mode (Yang et al., 2009).

[1] Dropbox is a free service that lets you bring your photos, documents, and videos anywhere and share them easily. (source: www.dropbox.com)

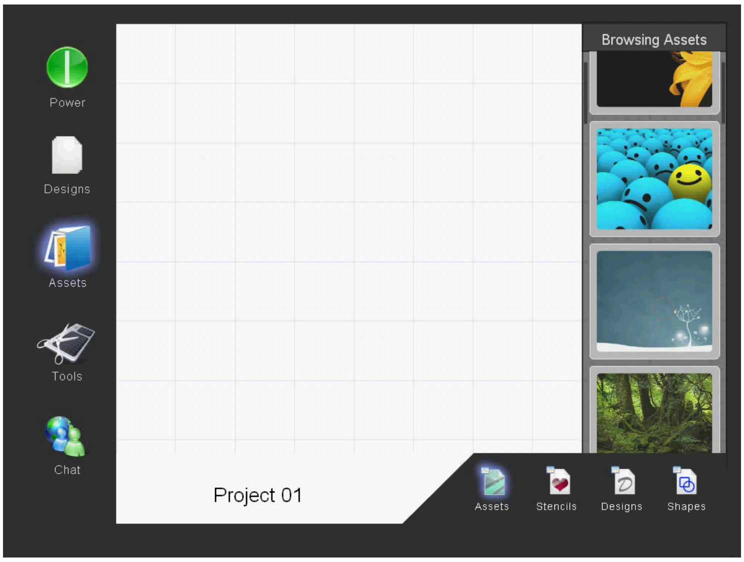


Figure 36: Second level navigation.

Within the TVTM prototype, there are technical enablements and technical constraints that were 'design-intended', therefore I will refer to them as 'design-intended enablements' and 'design-intended constraints' from this point onwards. I will use the terms 'design-unintended enablements' and 'design-unintended constraints' instead of purposive affordances to describe design-unintended encouragement and discouragement.

4.3.4 Modalities within TVTM prototype

From my literature review, it was determined that a well designed multimodal interface with two or more input methods can effectively reduce recognition uncertainty and stabilise system performance (Oviatt, 2003). Therefore, I have proposed a multimodal system that specifically targets remote collaborative issues in the fashion industry by offering multiple inputs modalities. The TVTM prototype has multiple input modalities; each type of modality carries its own set of information to be exchanged with other modalities in the same interactional cycle (Figure 37).

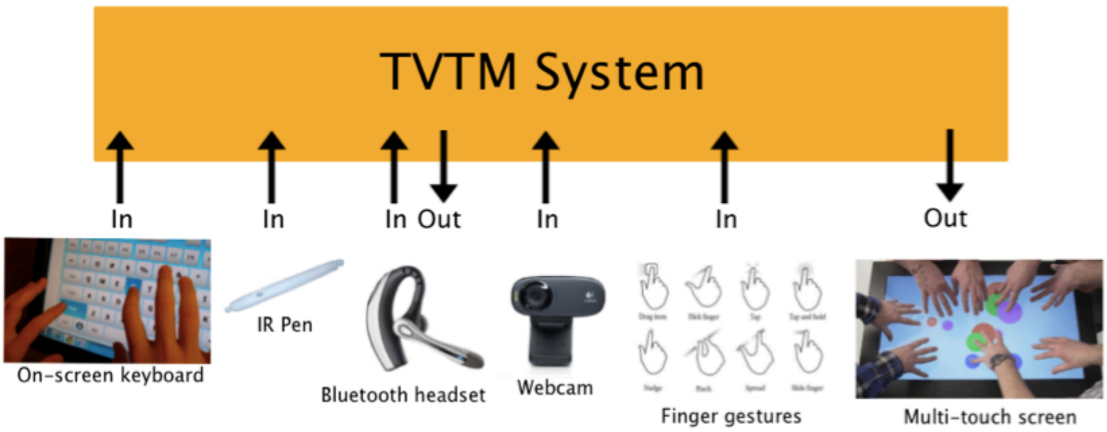


Figure 37: Input/output 'devices' within TVTM prototype

The TVTM prototype provides five different types of input modality, all are forms of information representation communicated through the TVTM prototype by its users to the remote collaborator. These include speech, text/annotation, tactile, gestures and graphic. Visual, auditory and tactile modalities are human-action modality. Speech input modality uses input devices such as microphone and output devices such as audio speaker and it corresponds to one of five major human senses; hearing (auditory) senses on the receiving end (output). Speech input is considered to be more efficient as it provides additional support channels when users are involved in multiple tasks mapped onto multiple modalities (Martin, 1989).

Text and annotation modality uses both a digital pen input device combined with infrared technology to draw onto the multi-touch screen, as well as providing easy text entry using the on-screen digital keyboard within the TVTM prototype. The main reason for providing a digital pen for users in addition to the on-screen keyboard is that Plimmer (2008) believed that pen input is ideal for tasks such as sketching and annotation, as it provides intuitive and natural computer interactions in a multimodal system.

The TVTM prototype provides tactile modality through the use of a multi-touch tactile screen device similar to Microsoft Surfaces, SMART table, HoloWall (Matsushita & Rekimoto, 1997), TouchLight (Wilson, 2004) and many others. The multi-touch technology behind the TVTM prototype is somewhat similar to Han's (Han, 2005) multi-touch interaction surface technology and FLUX (Leitner et al., 2009). The TVTM prototype provides multi-point interaction and identification as well as the gestures input modality such as finger touch and gesture tracking (e.g. tap, drag, swipe, pinch) through the TVTM's TUI.

In this thesis, I used webcams as a graphic/video input for the TVTM prototype. Video communication channel supplies moving images such as video streams, through the use of webcams. Typically visual-sensing modality is used for capturing actions such as hand gestures, lip movements, gaze, facial expressions, and head and body movements through the use of video camera (Sharma, Pavlovic, & Huang, 1998). Users of the TVTM prototype, through the use of the webcams, are able to clarify some physical aspects of their design work such as embroidery, accessories, or fabric patterns, and properties of the fabric such as elasticity. Additionally they can collaborate on their current state of the design, or attempt to resolve any design problems that may have been encountered during the prototyping or production of the garment.

Next, I will describe various multi-touch hardware developments, and also briefly describe the underlying software for the TVTM prototype.

4.4 TVTM HARDWARE DESIGN

During the time of my early research, there were no off-the-shelf products that could fully support remote collaboration in the fashion industry. I began to look at the video conferencing technology and started to analyse some of the key communication components. Video conferencing technology provides visual and audio components through webcam, speakers and microphone for a long distance conversation between remote users. However, video conferencing lacks a component potentially limiting the effectiveness of the remote collaborations between the remote collaborative participants. The missing technological component that I had chosen to adopt was a multi-touch screen technology. This technology was the key to providing a medium for remote users to perform effective remote collaboration. It would not only allow users to interact with, and manipulate artefacts, it would also allow users to create entirely new artefacts, or modify the shared artefact. I had chosen the multi-touch screen technology rather than a more traditional mouse point-and-click graphic user interface (GUI), because it allows more complex gesture interactions and direct manipulations with the shared artefact.

Based on the initial investigation of collaboration in the clothing design and manufacturing industry, I initially designed and developed a horizontal software prototype that displays a wide range of design and collaborative tools, but implementing only those that were targeting the collaborative design and problem solving process.

The aim of the prototype was to investigate and understand the three types of interaction; *Textual*, *Visual* and *Tangible*, and evaluate it using multiple validation processes as previously mentioned, to determine whether multi-touch interactions that better represent physical artefacts would be a better fit within the clothing design environment than a traditional digital interface would.

4.4.1 Diffused Illumination (DI) multi-touch screen technology

I have investigated several multi-touch hardware technologies during the software development through hardware prototyping. The first multi-touch technology I looked at is rear Diffused Illumination (DI) (NUI, 2011). The setup consisted of a frosted acrylic that acted as a touch surface; an image is projected straight behind from a projector, a webcam that has IR filter removed and an IR light source (Figure 38).

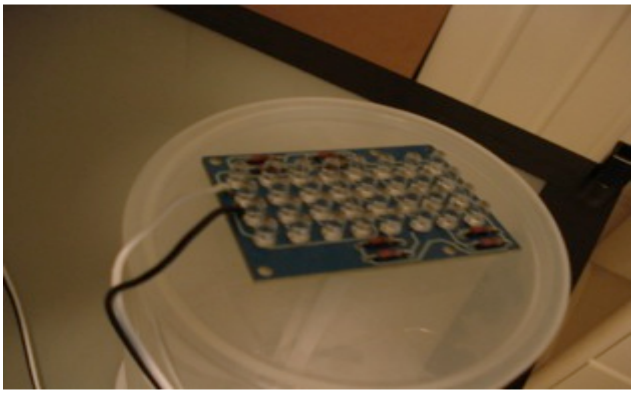


Figure 38: Components for infrared light source.

The idea behind this type of multi-touch technology is to have IR light uniformly diffused on the entire surface of a frosted side of an acrylic sheet. The IR light illuminates the fingertips when touched on the non-frosted side of the acrylic. The frosted side of the acrylic acts as a projection screen for the projector, which is connected to the computer running the multi-touch software, along with a webcam, which has IR filter removed.

Figure 39: Projector setup for DI multi-touch model

I also implemented an IR pen (Figure 40) for hand writing inputs and annotations purposes. The IR pen consists of a single IR light-emitting diode (LED) at the tip of the pen and a switch. When the IR pen is triggered, the prototype turns off the multi-touch functions to eliminate tracking errors.

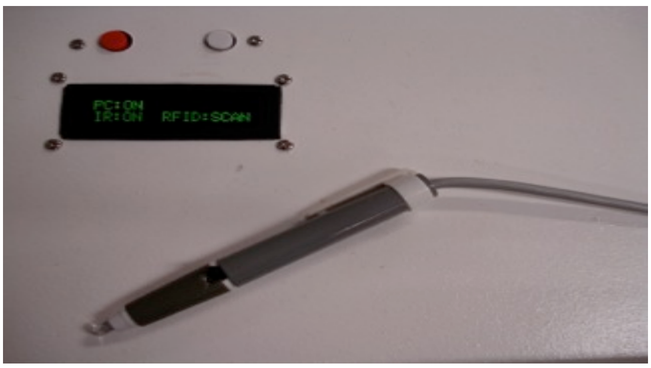


Figure 40: IR pen

This type of multi-touch technology (Figure 41) is very sensitive to background IR light. In order for the webcam to accurately track the fingertips, I had to conduct the test in a dark room, as normal office light and daylight interfered with fingertip tracking. After several attempts, I decided to abandon this type of multi-touch hardware, as having users working in a darkened room is contrary to a normal design environment.

Figure 41: DI multi-touch box

4.4.2 Frustrated Total Internal Reflection (FTIR) multi-touch screen technology

The second multi-touch technology I experimented with, was based on an optical multi-touch methodology called FTIR (Han, 2005) developed by Jeff Han.

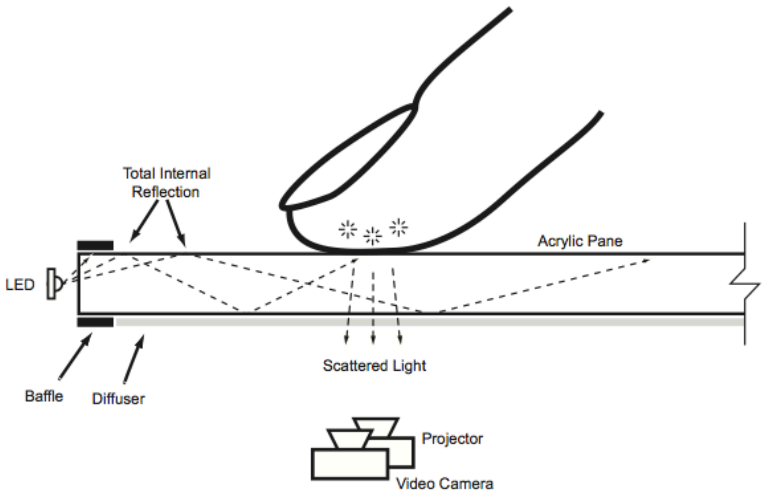


Figure 42: FTIR sensing technique by Han (2005).

The mechanism behind this type of multi-touch technology and the setup (Figure 42) of this technology is similar to the DI method. Instead of using an IR light source shining onto the acrylic, the FTIR uses several IR LEDs along the edges of the 1cm thick clear acrylic sheet. The IR light remains inside the acrylic due to total internal reflection. When fingertips touch the surface of the acrylic, they change the refractive index of the acrylic allowing IR light to escape, illuminating the fingertips.

My first attempt was unsuccessful due to several hardware issues; too few IR LEDs resulted in the prototype lacking sensitivity, and difficulties were also encountered compressing and combining projection screen material and acrylic together to allow accurate fingertip tracking (Figure 43).

Figure 43: First attempt of the FTIR setup: embedding IR LEDs to light up the acrylic

4.4.3 Diffused Surface Illumination (DSI) multi-touch screen technology

Subsequently I moved on to investigate another multi-touch technology that uses a revised and updated version of FTIR known as Diffused Surface Illumination (DSI) (NUI, 2009). This method is made possible by the development of new acrylic materials, specifically a special acrylic called *Plexiglas Endlighten* (Figure 44). This type of acrylic allows even distribution of the infrared light across the surface.

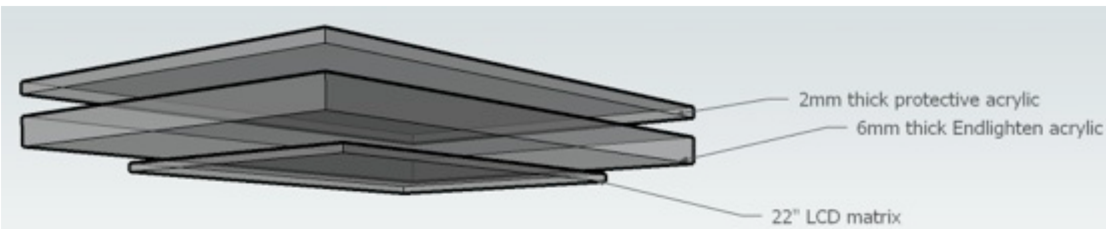


Figure 44: Adding two different types of acrylics on top of LCD screen.

The composition of this special type of acrylic contains very small mirror-like particles throughout the acrylic. In this setup, I have chosen to use strips of flat Surface Mount Device

(SMD) IR LEDs (Figure 45) instead of discrete 3mm or 5mm IR LEDs that I had used previously. The strips of LEDs ensure more intimate contact with the edge of the acrylic allowing better light transfer into the acrylic. When the IR light is shone on to the edges of this material, the IR light gets redirected and diffused over the entire surface of the acrylic.

Figure 45: SMD IR LEDs

The mechanism behind DSI is very similar to FTIR; when a finger touches the surface of the acrylic, the infrared light brightly illuminates the area of the finger in contact with the acrylic, which is detected by a webcam with an infrared band pass filter. Community Core Vision[2] (CCV) multi-touch calibration software (Figure 46) resolves the images from the camera to a series of blobs with individual coordination (x,y), each corresponding to the finger tips in contact with the acrylic. The coordinates of the detected blobs are passed to the user interface via the Table-Top Tangible User Interfaces (TUIO) and Open Sound Control (OSC) protocol ((Kaltenbrunner, Bovermann, Bencina, & Costanza, 2005)).

Figure 46: CCV multi-touch calibration software.

[2] http://ccv.nuigroup.com

4.4.4 Laser Light Plane (LLP) multi-touch screen technology

The last type of multi-touch technology that I have investigated is called Laser Light Plane (LLP) which was first developed by Alex Popovich; a natural user interface (NUI) community member. The setup consists of 4 x 780nm light wavelengths laser modules, one in each corner above the frosted glass touch surface as shown in Figure 47 below. Each IR laser module has a 120-degree line lens fitted on them to create an IR light plane above the entire touch surface. So when fingers lightly touch the surface, the IR light will hit the tip of the fingers, which will light up as IR blobs, these are then immediately captured by the webcam to be generated as multi-touch points.

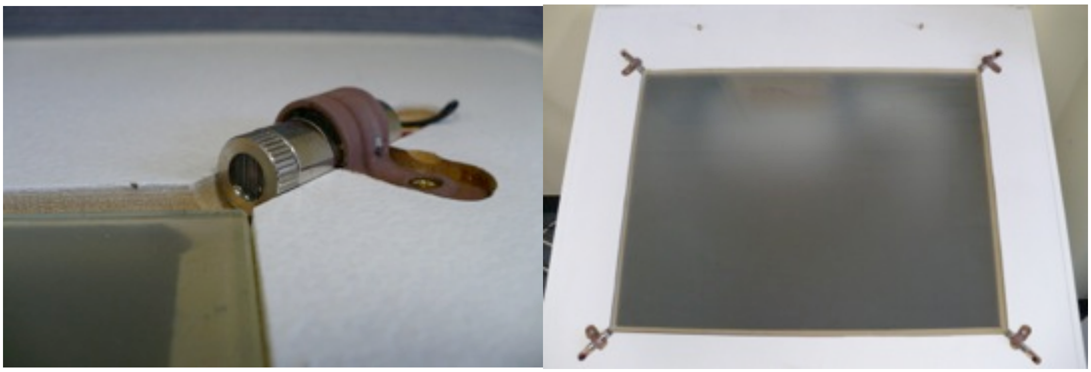


Figure 47: 780nm light wavelengths laser modules used for LLP multi-touch setup.

In order to link the two multi-touch tables, a java server; Flash Open Sound Control (FLOSC) extension (Benchun, 2002) was used to act as a gateway for both OSC (Wright, Freed, & Momeni, 2003) and Flash, to pass finger touches/blob co-ordinates between 2 multi-touch tables via an Ethernet local area network (LAN) cable or wirelessly using a Wi-Fi router.

4.5 QUICK & DIRTY USER TESTING

A quick and dirty user study was conducted, where 10 participants from interaction design disciplinary backgrounds were tested using a collaborative and ludic activity, which was built upon the concept of Charades (to encourage participants to explore the concepts presented in the design). The aim of the study was to explore which forms of interaction (textual, visual, gesture/tangible) were relevant when collaborating remotely through a multi-touch screen based interface.

4.5.1 Method

Two separate areas were set up within a meeting room to simulate two remote locations. As there was only one functional early TVTM prototype available at that time, the TVTM prototype was set up on one side of the room to simulate a remote location (remote location A). Although the participant at the other side of the room (remote location B) did not have access to a physical TVTM prototype, they were still able to fully interact with the participant at remote location A through a computer desktop system and a computer monitor with all the functionality of the TVTM system including the shared screen ability, with touch interaction simulated with a computer mouse.

A series of tasks was developed; each designed to encourage a specific style of collaboration (similar to a sentence in Charades). Each task was 'acted out' like 'Pictionary', where one participant would perform the task and, without speaking, attempt to communicate what they were trying to get across to the rest of the participants in the larger area.

The reasoning behind these tasks was to examine which tools and forms of interaction users felt best portrayed their task, and how combinations of these forms could be brought together to better explain a design. Activities were described on sheets of paper (two copies of each activity), and randomly chosen by the participant in the small area. For example, one of the tasks examined how synchronous collaboration could be incorporated into the design process, bringing in feedback from both fashion designers and manufacturers. The task required the users to enhance a pre-made design by incorporating a leaf pattern to an area on the clothing, using the capabilities of the multi-touch interface.

4.5.2 Results

I found that the participants watching the interactive feed of the multi-touch interactions successfully guessed eight out of ten activities. Each activity required around ten minutes to be performed, however the prototype interface was a contributing factor in this. The key finding from the pilot study was that participants did not choose a single type of interaction to perform an activity, rather a combination of textual, graphical and direct manipulation (motion) actions were performed:

Textual forms of interaction; typing using an on screen keyboard or writing with a pen interface, were used to portray factual information, such as measurements and descriptions.

Graphical forms of interaction, designs as well as annotations, were done using graphical forms of interactions, for example circling a specific aspect of a design or overlaying a pattern on top of a design.

Tangible/direct manipulation form of interaction, activities such as questioning the position of a pattern on a design, were portrayed by scaling, rotating and moving around patterns, to show motion and better describe how different designs, assets and materials would work together. It could be seen that this real time motion was very effective in communicating ideas to the other participants.

Participants playing the guessing role of the activity discussed what they would have liked to have been able to interact and communicate back to the main actor through the interface. While this was possible using the mouse provided in the larger area. They stated that having the multi-touch abilities to better interact would have helped in the communication. Another finding was that participants had issues when transitioning between navigating the interface, and performing direct manipulation of objects on the stage.

I had observed another interesting aspect of the tangible interactions between the participants while they were working together on completing the task using the TVTM prototype. This particular group of participants (A and B) used the TVTM prototype to complete the task in a manner that was considered as design-unintended enablement (Table 5).

Design-intended Enablement	Design-unintended Enablement
Textual: Text input using keyboard or IR pen. Annotations or drawings use IR pen.	
Visual: Static images (from image database). Live images (from webcam captures).	
Tangible: Select images by dragging. Resizing images with two fingers. Move and scroll images with finger(s)	(Based on observation) Attention-getting: Participant A verbally mentioned to participant B that they liked a particular design. Participant B was uncertain which particular design participant A liked, so participant B used the IR pen and drew a question mark on each design. Participant A then selected the particular shirt design, and holding down their finger, 'wiggled' the design up and down to get the visual attention from participant B while saying "I like this one best". Participant B then immediately knew what participant A liked and agreed with that decision.
Audio: Verbal conversations using embedded microphones and speakers.	

Table 5: Design-intended enablements and design-unintended enablement.

This was unexpected, and showed the TVTM prototype allowed intuitive and natural interactions between the users, as this would reflect how the participants would potentially interact with physical garments.

4.5.3 Summary

It is important to note that issues were encountered during the pilot study, due to the implementation of the prototype. In later discussions with participants, I found that the software was a contributing factor in issues of communication encountered by the participants. This was alleviated somewhat in the evaluation of the pilot study from informal interviews discussing their thinking process throughout each activity.

Based on my observations in the pilot study, there is a clear direction to move towards a more natural interface, where gestural interactions are used, rather than using a digital representation of physical objects (for instance being able to ‘scrunch’ together a design to delete it, rather than dragging it to a bin). Based on these findings, I had to redesign the interface, and deploy it within a clothing design learning environment, and use observation methods to examine in detail the interactions with the prototype over a longer period of time.

4.6 CHAPTER SUMMARY

I have set out to gather qualitative data for the remote collaborative issues within a business context, through an observational study and interviews that were originally conducted in a fashion design-teaching environment in Brisbane. I was able to verify some of the qualitative data through in-depth contextual interviews with fashion designers in the design and manufacturing department of a children’s clothing design firm. Since the approach to fashion design in both the teaching environment and the fashion design firm are fundamentally similar, I was able to develop a TVTM prototype based on a combination of the two findings as well as quick and dirty user testing for the first iteration of the TVTM prototype.

In the next chapter, I will describe how I conducted a multi-stage qualitative study to gain insights into what users did during the communication, what sort of modalities they used while using the TVTM prototype to remotely collaborate, and their responses to what they did during the remote collaboration.

Chapter 5: Evaluation of the TVTM prototype

I have previously described the importance of a good understanding of the problem space within the business context of the fashion industry as part of the requirements to design a remote collaborative system. By conducting the observational studies and interviews, I have gained insights into the nature of group work that is associated with a distributed fashion design organisation, as well as the social interactions that fashion designers require during any collaboration, in terms of different modes of representations during the communication. I have also described a series of iterative prototyping and evaluations that I have carried out for the TVTM prototype; a multimodal system that assists remote collaborative work.

This chapter focuses on evaluating the TVTM prototype in terms of **where** and **when** the participants focus on the technology as a 'relevant communication tool' during the remote collaboration, whether the remote collaboration can be **assisted** or **hindered** by the use of the TVTM prototype, as well as investigating whether or not the notion of social technical intersection exists in the TVTM prototype by identifying issues regarding asymmetrical access and novelty of the technology.

This chapter will begin with a brief description of the methods that I have adopted to conduct three stages of the evaluation study in section 5.1; stage one involved evaluating the TVTM prototype software with pairs of design students undertaking collaborative tasks, stage two used video that was recorded during stage one to explore and review the interactions in more detail using the video-assisted recall method and stage three followed a Video Card Game playing process to explore common interaction themes in the video data.

In section 5.2, I subsequently present the results related to the users' social and technical interactions through the TVTM prototype in two categories; remote collaboration assisted /not affected by the use of the TVTM prototype and remote collaboration hindered/affected by the use of the TVTM prototype. I will also describe the analytical process I have used to identify the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for the remote collaborative fashion design group work.

In section 5.3, I present findings relating to users' preferences, knowledge, comments and recommendation for the TVTM prototype, arising from the video-assist recall interviews that form the second stage of the multi-stage evaluation study. In section 5.4, I describe the findings of the final stage of the multi-stage evaluation study using the Video Card Game method at the evaluative stage as an alternative way of conducting an evaluation study of the design process, as well as presenting the new methodological approach of the Video Card Game from a collaborative analytic perspective to triangulate some of the data that I had collected from my previous studies. The chapter concludes with a chapter summary of my multi-stage evaluation study in section 5.5.

5.1 METHODS FOR MULTI-STAGE EVALUATION STUDY OF THE TVTM PROTOTYPE

The aim of the evaluation study is to investigate the use of the TVTM prototype for supporting remote interaction and collaboration in fashion design. The evaluation study involved three stages:

- Stage one evaluated the software with pairs of design students undertaking collaborative tasks (Figure 48).
- Stage two used video that was recorded during stage one, to explore and review the interactions in more detail, using the video-assisted recall method.
- Stage three followed a Video Card Game playing process to explore common interaction themes in the video data.

The first stage of the study was to observe the participants undertaking a design critique collaborative task. Each participant was assigned a TVTM prototype to complete the task. The participants were shown a short video clip detailing the functionality of the interface, and operating instructions prior to each user testing session. The participants were encouraged to ‘think out loud’ during the entire session, and the interaction between the participants was studied and captured by recording video during each testing session. Observations and notes took place during each of the user testing.

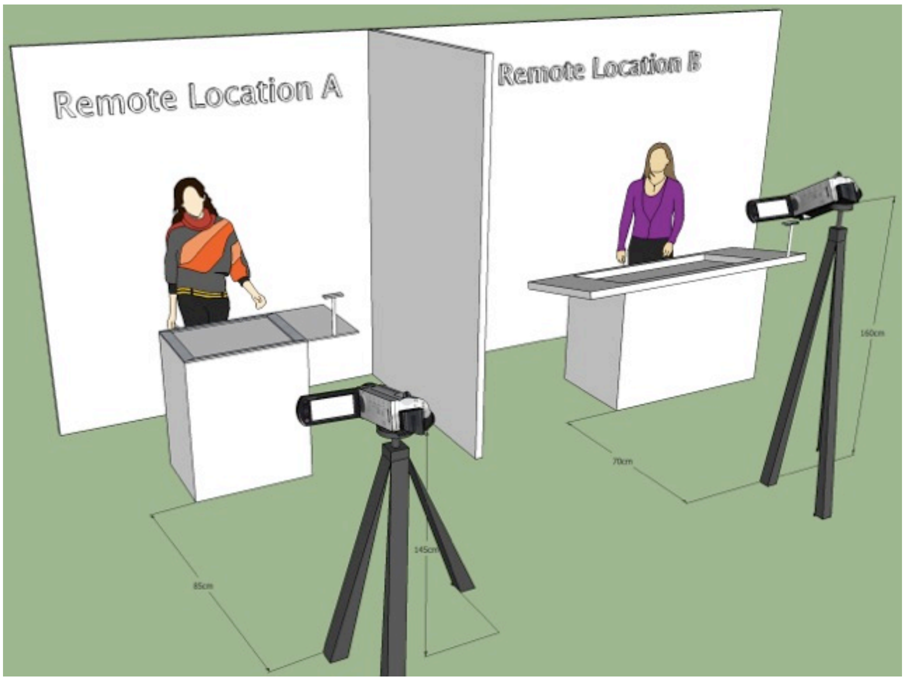


Figure 48: Apparatus setup for user testing.

At the conclusion of the first stage of the study targeted sets of questions for the video-assist recall interviews were created from (my) observation notes together with the recorded video footage. The second stage was commenced one week after the completion of the first stage study. The participants were requested to come back for the interviews in the same pairs as in the first stage of the study.

The entire interview procedure during the second stage of the study was described to the participants, followed by their viewing of a video clip of their specific user testing session. While the participants were watching video footage (Figure 49) of their participation in the first stage, a series of questions was asked, directly related to some of the interactions that were observed during their user testing session. The majority of these questions were related to why there were certain interactions with the prototype or with their partner during the user testing. The participants were also given a series of questions related to their thought processes at specific moments during the user testing, to obtain a clearer understanding of their design (thought) process while they were critiquing each other's work. The participants were also asked to describe their experience during the entire collaborative process, and at the end of the interview, feedback was obtained regarding the usability of the TVTM prototype.

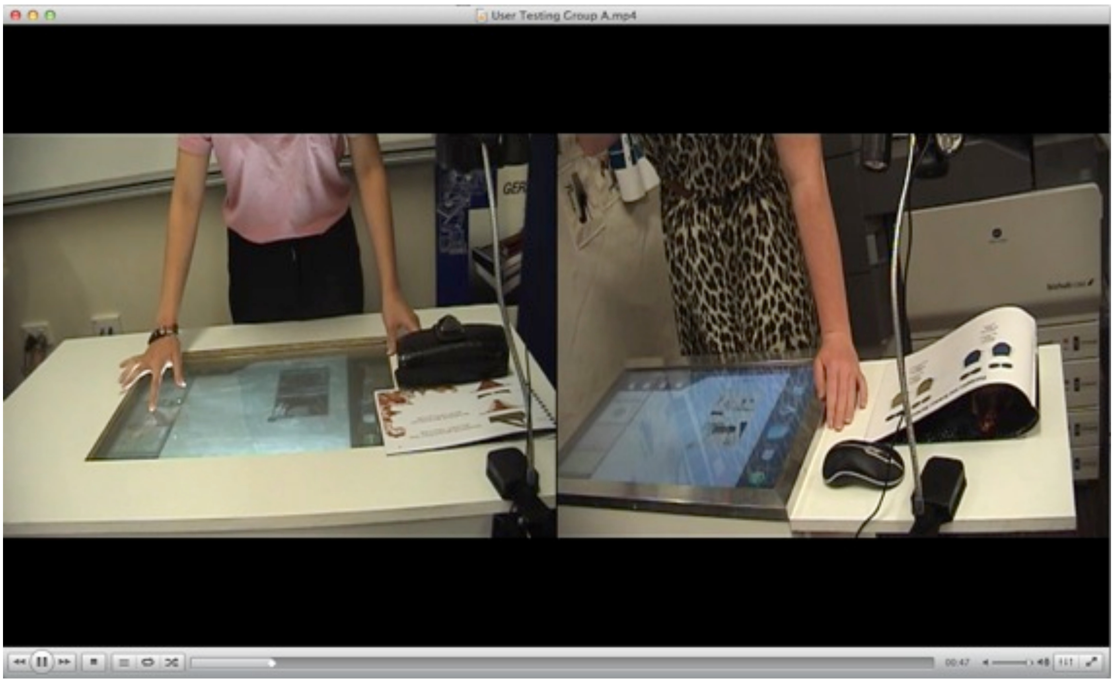


Figure 49: Recorded video footage of the user testing.

Figure 50: Fashion design student 'playing' the Video Card Game.

The Video Card Game (Figure 50) that I conducted for stage three of the evaluation study is an adaptation of the original method of the Video Card Game. I chose this method because it used a more socially focused, design-focused and playful approach to working with the video data. I adapted the original Video Card Game to suit my research study by firstly using the video footage collected from the first stage of the evaluation study to construct a series of video clips for the first step of the Video Card Game study. From those video clips, I then selected and captured a number of still images to form the ‘playing cards’ for the second step of the Video Card Game study.

Secondly, I conducted the Video Card Game with two different groups of participants. The first group was the fashion design students at MSIT College in Brisbane (Figure 51), who were the same participants who had previously participated in our study for the user trials and interviews. The second group were interaction design researchers and practitioners at the University of Queensland.

Figure 51: Fashion design students sorting cards into themes.

Each participant worked with a set of ten photo image cards (Figure 52), each relating to a short video turn. They were asked to review their cards individually and take notes on them based on their observations and reflection on interesting aspects of the activity and interactions in the video clips. Participants were then asked to group their cards into related themes (Figure 53), and to provide a description that encapsulates what the theme is about and why it is of interest to them.

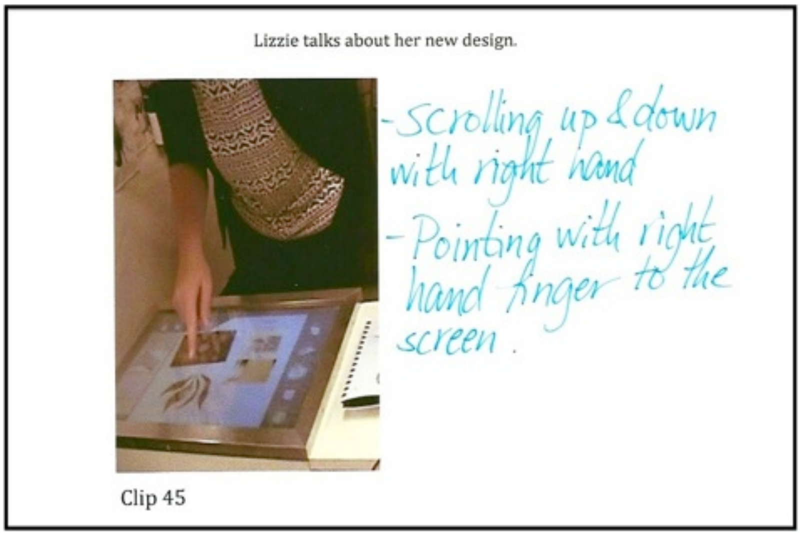


Figure 52: Example of a card representing Video Card Game clips.

Figure 53: Interaction designers working on their individual themes.

Each participant finally presented their theme to the rest of their group, and in doing so invited other participants to contribute their cards. The resulting set of themes represented the group's collective compilation of interesting activity and interaction themes in the video captured during the study. The result of this Video Card Game study will be presented in section 5.4.

The evaluation results are presented in the next sections from the following perspectives: (I) users' social and technical interactions through TVTM prototype, (II) users' preferences, focuses, comments and recommendations for the TVTM prototype, (III) users' reactions on watching others using the TVTM prototype.

5.2 RESULTS: (I) USERS' SOCIAL AND TECHNICAL INTERACTIONS THROUGH TVTM PROTOTYPE

5.2.1 Overview

In this section I will describe various social and technical interactions that were observed from the participants during the user testing of the TVTM prototype. Participants were trying to complete a job, in this case a critique design work through use of the TVTM prototype. The job consisted of multiple individual tasks such as the redesigning of a piece of fabric, or discussion about specific aspects of a particular design.

While participants were collaborating remotely using the TVTM prototype to complete their design task, they had encountered differing experiences. In some cases, the TVTM prototype enhanced participants' design work without affecting their remote collaboration experience, while in other cases the participants worked around the problems or issues that they were experiencing while using the TVTM prototype, and still managed to complete the task. There were also cases where participants could not overcome the problems or issues, which led to the participants becoming confused and frustrated with the remote collaborative experience.

I will be using the data from the first stage of the evaluation findings to determine whether participants were aware of, and able to learn anything about what they can see of their remote collaborators through the shared screen of the TVTM prototype and what their remote collaborators/participants can see of them (in terms of the interactions with the technology, body language and social interactions). These evaluation findings will be used to identify and confirm the existence of the "social-technical intersection" between the novelty aspect of participants using the TVTM prototype, and the asymmetrical access that participants were experiencing due to technological distortion while trying to achieve shared understanding during remote collaboration. I will also identify any **overheads** that were caused as the result of the intersection, which takes the form of design-intended and design-unintended, *constraints* as well *operational problems*.

I have categorised the findings of the social and technical interactions into two themes:

- *Remote collaboration* ***assisted /not affected*** *by the use of the TVTM prototype* to answer questions, as well as giving or following instructions from a partner.
- *Remote collaboration* ***hindered/affected*** *by the use of the TVTM prototype* to answer questions, as well as giving or following instructions from a partner.

Each theme is exemplified with eight examples of problems or issues that the participants were experiencing using the TVTM prototype. These examples were then arranged in order according to the number of problems or issues that the participants were experiencing, from low to high. I will describe the interesting interactions between participants and their use of the TVTM prototype for each example, followed by analysing some of the conversations between participants in relation to their remote collaborative task, as well as my observations to determine **where** and **when** the participants focus on the technology as a relevant tool, and whether or not the technology assists or hinders the remote collaborative process.

5.2.2 Remote collaboration assisted/not affected by the use of the TVTM prototype

During the first stage of the evaluation, the participants' main task was to use the TVTM prototype to critique each other's design work. The examples below show participants seeking and receiving feedback from their partner, participants giving instructions to, or following instructions from their partner, and participants referring to physical objects using webcams during the remote collaboration. I will describe and analyse each example to ascertain that the remote collaborative activities were not affected by the use of the TVTM prototype. The examples listed below are arranged according to the number of problems and issues that participants were experiencing using the TVTM prototype from low to high.

Assisted Example 1: Seeking and receiving feedback from partner

In the first example, a participant was working on an alternative fabric to replace the fabric used for her original swimwear design. The participant was then seeking and receiving feedback from her partner about the swimwear design.

	Abby		Bree	
	Action	Dialogue	Action	Dialogue
01			Bree used her finger to scroll through some fabric images.	
02			Bree dragged a fabric pattern image to the work area with her finger.	
03				*"A flowery design maybe?"*
04		*"Yeah that is cool, that would go with the bottom."*		
05			Bree went back to the pattern selection menu, and used her finger to browse through alternative patterns.	
06			Bree found a few stencils and applied them one after the other to the fabric image that she had selected previously.	

Table 6: Gestures and dialogues between Abby and Bree: Bree was seeking feedback from Abby about her fabric design.

Bree appeared to have some idea of the colour and pattern of the new fabric she wanted, and she began searching through the fabric selections using the TVTM prototype to find one that best matched her concept. Bree started browsing and scrolling through the fabric selection menu using her fingers [Table 6, turn 01]. After Bree (right) successfully dragged the fabric pattern image to the work area (Figure 54) [Table 6, turn 02], she made a comment [Table 6, turn 03]; *"a flowery design maybe?"*. Bree was requesting feedback from Abby about the candidate design (the flowery design) that Bree proposed, the word 'maybe' indicating that she was receptive to Abby's feedback. Abby replied, *"yeah that is cool"* [Table 6, turn 04], the word: 'yeah' representing confirmation from the candidate, and 'that is cool' representing a positive evaluation from Abby. Abby also added *"that would go with the bottom"*, and this provided the explanation of the evaluation, which suggested the flowery design proposed by Bree would go with the bottom of the proposed swimwear design.

Figure 54: Bree (right) managed to drag the flowery design image to the work area.

Figure 55: Bree appeared to have second thoughts.

However Bree appeared to have second thoughts about the flowery design she had chosen, so Bree went back to search for an alternative (Figure 55) [Table 6, turn 05]. She found a few stencils and applied them to the fabric image that she had selected previously. In this example, there was no acknowledgment by Bree to Abby's feedback, and subsequently Bree abandoned her original proposed changes and continued to search for alternative fabric.

This is an example of technology transparency for the purpose of seeking and receiving feedback, and it clearly shows that the technology did not hinder the remote collaboration in any way. However, using the TVTM prototype may have an impact on participants' decision-making process, and the providing of feedback. For example, Bree dragged a specific flowery design from a range of available selections within the TVTM prototype, the flowery image Bree had selected and shared on the shared screen monitor could have influenced Abby's feedback, but the data that I had collected could not clearly confirm whether this was actually the case or not. Bree was utilising the technology directly to assist her in seeking and receiving feedback from Abby, because she had chosen to use a specific stock flowery image from the image selection, rather than simply verbally describing a specific flowery image that she had in her mind.

It is also very interesting to observe that even though Abby had given a confirmation, a positive evaluation and an explanation as a form of relevant feedback, Bree subsequently did not take any of Abby's advice or feedback into account when she subsequently modified her new swimwear design. It was observed that Bree totally disregarded Abby's positive feedback, and continued to search for alternative fabric. This example showed that the technology was transparent and acting as it was intended, and in no way hindered the interactions between the participants in the remote collaboration.

Assisted Example 2: Seeking feedback from partner

In the second example, a participant was working on adding some new elements to a fabric that she had previously chosen for her swimwear design, and was seeking feedback from her partner.

	Abby		Bree	
	Action	Dialogue	Action	Dialogue
01	Abby used her finger to browse through the selection.			
02	Abby dragged an embroidery image to the work area.	*"Maybe add something like this to it?"*		
03		*"What do you reckon? (*Figure 56*)*		
04				*(2.0)*
05				*"Like an embroidery?"*
06		*"Yes some embroidery, or"*		
07		*"I like the pattern for the embroidery"*		
08				*"Ah-hum"*
09	Abby resized the image with her fingers.			
10	Abby pointed the actual physical fabric under the webcam.	*"Adding that to say in there"*		
11	Abby pointed her fingers at the embroider image.	*"But adding some of the red colours and stuff and the blue and the green and the yellow."*		
12				*"Ah-hum"*

Table 7: Gestures and dialogues between Abby and Bree: Abby was seeking feedback from Bree about her fabric design.

In (Table 7) turn 01, Abby used her finger to browse through the selections. While Abby was dragging an embroidery image that she had selected to the work area and was applying it to the scanned fabric image, she made a comment: *"Maybe add something like this to it?"*[Table 7, turn 02]. Abby was not entirely certain about her proposal. Abby subsequently asked Bree: *"What do you reckon?"* (Figure 56) [Table 7, turn 03]. Abby used a directive to request some feedback from Bree about the embroidery design that she had chosen for her fabric. However, since Abby did not specify verbally which particular type of element she had chosen and then applied that to the fabric, Bree was taking a little longer to respond to Abby [Table 7, turn 04], compared to the rest of the responses from Bree to Abby. According to Jefferson (1989), this two seconds of silence was right on the edge of the signs of trouble, and is considered as a tolerance interval during a normal conversation.

Bree then requested a clarification from Abby about the element that Abby had proposed earlier and wanted confirmation that what looked like an embroidery to her was actually an embroidery and not some other design element and asked: *"Like an embroidery?"*[Table 7, turn 05]. Abby confirmed to Bree that she had chosen some embroidery and applied them to the fabric [Table 7, turn 06], as well as commenting that she liked the end result [Table 7, turn 07]. This was identified as an occurrence of asymmetrical access, because although Abby obviously knew that the image she had selected was an embroidery, for Bree there was no information available on the screen regarding what type of element the image represented, Bree required clarification to confirm that the image she saw on the shared screen did represent an embroidery pattern. Until Bree initiated the process of clarification that the pattern was an embroidery pattern, Abby was unaware that Bree did not know that the pattern was actually embroidery. Bree did not clarify whether she liked it or not, however, as she only made a continuous response *'Ah-hum'* [Table 7, turn 08] to indicate that she heard what Abby said, and the continuous response *'Ah-hum'* allowed Abby to continue with the conversation.

Figure 56: Abby (left) wanted some feedback from Bree (right) about the new embroidery design she had chosen.

Having not received useful feedback from Bree, Abby went on to explain in more detail about the specific area of the fabric where the embroidery should be applied. Abby then used her fingers to point at a physical sample fabric in the webcam capturing area, and while she was pointing to it with her fingers, she said *"Adding that to say in there"* [Table 7, turn10]. Abby was treating the technology as a relevant tool to direct Bree's attention to the specific area that Abby wanted Bree to focus on. She then continued to talk about various colours of the embroidery that she wanted to adopt [Table 7,turn 11]. However, Bree still did not comment much, and again only responded with a non-verbal and non-specific *‘Ah-hum’* [Table 7, turn 12].

In the above example, on both occasions Abby did not receive valuable feedback from Bree, as the non-verbal and continuous response *‘Ah-hum’* from Bree did not indicate whether she liked or disliked Abby’s new embroidery design for the fabric. *’Ah-hum’* in this case could be interpreted as non-verbal support, which indicated that Bree was in fact listening, and in some way allowing Abby to continue finishing the description of her alternative design, since Bree did not provide any further explanation or comment. In this example, it is unclear whether the technology was the source of the problem; the low screen resolution limitation of the TVTM prototype may not have posed a problem for Bree, as she did not mention whether she was having trouble seeing what was on the screen. The issues with the two seconds interval gap between the responses could have happened just as easily with FTF collaboration. Additionally, Abby was able to use the TVTM prototype to focus Bree’s attention to the specific area where Abby wanted to insert the new embroidery to her swimwear design, while Abby was discussing the design changes with Bree.

<u>Assisted Example 3: 'Just to make sure we are on the same page'</u>

In order for a participant to give instructions to, and follow instructions from, the other participant, both participants first need to have the same understanding of the conversations/instructions (shared understanding), before they are able to complete their collaborative work. The example below shows one participant following the other participant's instructions, while interacting with the TVTM prototype.

In the third example, a participant was previously describing her current swimwear design to her partner and was initially trying to confirm with her partner about a particular design that they had both seen previously. One of the participants could not remember where they had both seen the particular fabric and therefore could not locate it, however her partner remembered it and managed to guide her to locate it.

	Elle		Faye	
	Gestures	Dialogue	Gestures	Dialogue
01				*"Do you think maybe you can change the colour of the top, so it matches the bottom a bit better?"*
02		*"Yeah"*		
03				*"Maybe like carry through the colour of the bottom through to the top"*
04	Elle started tapping her fingers on the screen.	*"Like that green that we saw?"*		
05				*"Yep"*
06	Elle was scrolling up and down with her fingers through the fabric selection menu on the screen.	*"Arr (2) trying to find it"*		
07			Faye moved her fingers over the screen to simulate scrolling the selection gestures herself	*"Down"*
08	Elle dragged a green checked fabric out of the fabric selection menu with her finger into the work area.	*"So this one?"*		

09				*"Yep, that one"*

Table 8: Gestures and dialogues between Elle and Faye: Faye was guiding Elle to try and find a fabric that they had both seen previously.

Faye recommended Elle to change the colour of Elle's bikini top design [Table 8, turn 01 & 02]. Elle then asked Faye if she should replace the fabric with the one that they had both seen previously [Table 8, turn 3]. Faye started to help Elle by guiding her through the image-scrolling menu (Figure 57). While Faye was watching Elle trying to find the green-checked fabric on her screen [Table 8, turn 04 & 06], Faye moved her fingers over her screen to simulate 'scrolling the selection' gestures herself, whilst describing her thought process to Elle [Table 8, turn 07]. In this manner, Faye could guide Elle to find a particular bikini top design that matched her partner's design.

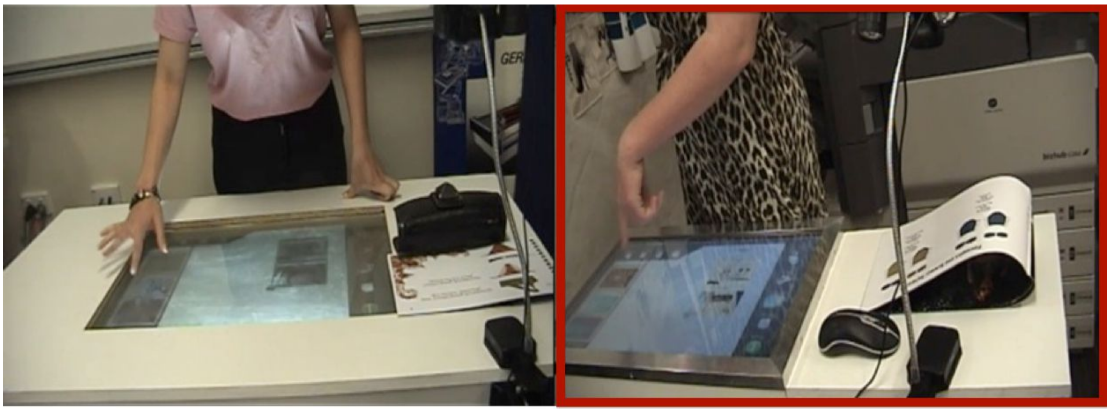


Figure 57: Faye (right) started her step-by-step guide to her partner.

While Elle was following the instructions from Faye (Figure 58), Elle was seeking confirmation from Faye, and asked *"so this one?"* while dragging the green checked fabric out of fabric selection into the work area [Table 8, turn 08].

Figure 58: Elle (left) was following instructions from Faye.

In this example, Faye used a directive to suggest to Elle to change the colour of the swimwear top. Elle subsequently accepted the suggestion. Faye then continued to explain her initial suggestion in more detail. Elle remembered seeing a green fabric while she was browsing the fabric selections earlier with Fay, and asked Faye to confirm whether the green colour that they had both seen earlier would be a suitable replacement colour for Elle's swimwear top. Fay subsequently responded *"Yep"*. However Elle was having trouble finding that particular green colour fabric and she made a non-verbal sound 'Ar', paused for 2 seconds, and then verbally acknowledged that she couldn't find it while browsing the selection on the TVTM prototype with her fingers. I identified this difficulty that she was experiencing locating the image as being due to the novelty of the technology.

During this moment, Elle wanted to focus Faye's attention to the screen monitor, hoping Faye could remember where that particular green fabric was. Faye had remembered where that particular green fabric was, and was able to guide Elle through the selection menu to locate it. Even though Elle initially had slight trouble finding the green fabric, the screen sharing functionality of the TVTM prototype provided Elle with some form of assistance directly from Faye during the remote collaboration.

Assisted Example 4: Referring to design booklet

While participants were giving instructions to their partner, they sometimes referred to the physical objects, such as garments, design drawings, catalogues, which were then captured as live images using the webcam function on the TVTM prototype.

Two participants had been previously collaborating with an alternative swimwear design using the TVTM prototype. The fourth example shows a segment of the remote collaboration where a participant constantly is referring to the physical artefact (a design booklet in this case) using the webcam function of the TVTM prototype to explain her design drawing to her partner.

	Abby		Bree	
	Gestures	Dialogue	Gestures	Dialogue
01			Bree was experiencing difficulties using the drawing tool to create a smooth drawing.	
02		*'What is that thing?'*		
03			Bree used her finger to draw a cross over her drawings.	*'Don't look at that'*
04			Bree pointed her finger at her design mock up image in her design booklet over the webcam capturing area.	*'It's like the t-shirt at the moment and it has been folded up'*
05			Bree continuously moved her fingers around the mock up image.	*'And if you crop it down a bit'*
06		*'Scrunch in the middle.'*		
07				*'Yeah scrunch in the middle! That way it will match the bottom'*

Table 9: Gestures and dialogues between Abby and Bree: Bree was using webcam to refer to a particular area of her swimwear design while describing her drawings.

Bree was experiencing difficulties using the drawing tool to create a smooth drawing [Table 9, turn 01]. Abby could not understand what Bree was trying to draw and made a comment *"what is that thing"* [Table 9, turn 02.] Bree was embarrassed due to the bad drawing, she requested Abby not to focus on the drawing [Table 9, turn 03]. Bree continued to explain what her drawing represented [Table 9, turn 04], while using her fingers to point at the swimwear top section of the image on the catalogue under the webcam (Figure 59 and Figure 60), so that Abby could see what she was talking about.

Figure 59: Bree (right) pointed her finger at her (physical) design drawing. Bree explained to Abby what her new design would look like.

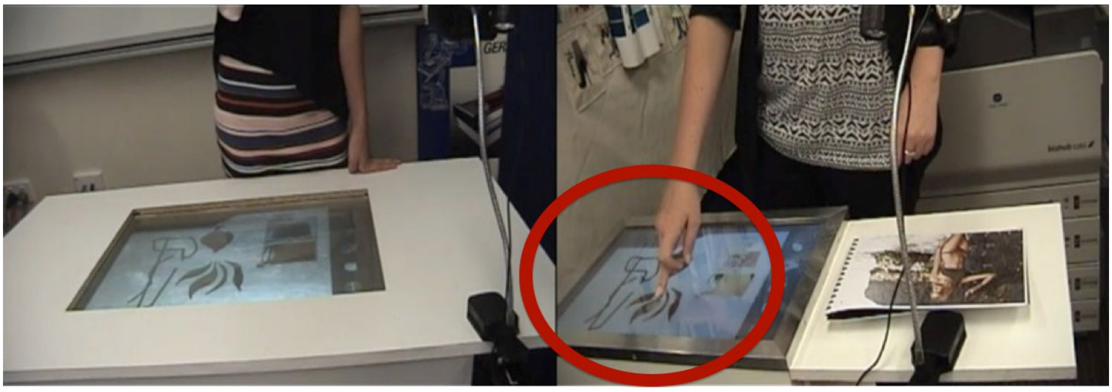


Figure 60: Bree pointed her finger at her new (digital) fabric design.

While Bree was explaining some elements of her digital design drawing on the TVTM prototype, she was referring back to her design booklet. She additionally used hand gestures to clarify some of these design elements. Abby suggested some improvements [Table 9, turn 06], in particular a new 'scrunch in the middle' design suggested by Abby (Figure 61). Bree used her fingers to demonstrate the 'scrunch in the middle' concept by scrunching her fingers together under the webcam. Bree liked the idea, and agreed to have this new change made to the new swimwear top design.

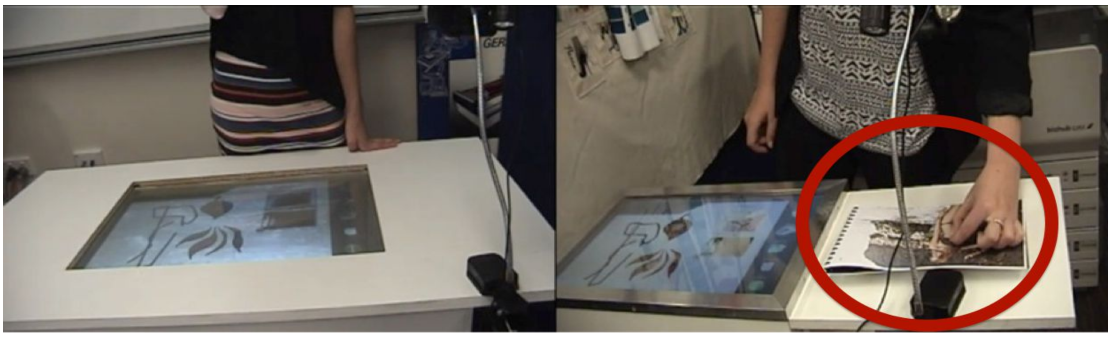


Figure 61: Bree used her fingers to mimic 'scrunch in the middle' design.

In this example, Bree was experiencing technical difficulties with drawing due to the design-unintended technical constraint. This particular design-unintended constraint was caused by unforeseen computer hardware limitations brought by the slow processing speed of the prototype. This was identified as another example of asymmetrical access in which Abby started the *repair* of the conversation by asking *"what is that thing"*, referring to the drawing that Bree had made, as Abby obviously could not ascertain what the drawing was supposed to represent. Bree requested that Abby not look at her drawings on the screen monitor, as the design drawing was difficult to understand. It was not possible for Bree to hide the digital drawings that she had attempted to draw previously from ideas she had in her mind. Bree also decided not to delete the drawing herself, and quickly diverted Abby's attention to the webcam capturing window on the screen monitor, so she could concentrate on explaining her ideas to Abby about the new alternative design, together with her design booklets under the webcam capturing area. In this case, technology did not fully translate what Bree wanted to represent with her design idea. The webcam features of the TVTM prototype did, however, resolve the drawing issues that Bree was having, as Bree was able to talk about the specific area of the swimwear top that she wanted to change. In this case, the remote collaboration was considered successful, as Abby was able to understand Bree's concern and was able to recommend an alternative design idea for Bree.

This particular example shows even though one of the participants was experiencing the design-unintended constraint of not being able to achieve smooth free-hand drawings, both participants were able to change to different levels of *meta-talk* when it was needed, in order to fully understand the conversation during the remote collaboration. In this example, Abby was having difficulties trying to contextualise the drawing that had been done by Bree. Bree had to alter the level of meta-talk in order to explain her drawing of a new bikini top design, by referring back to her previous design photo, pointing her finger using the webcam function to explain that the drawing resembled the new bikini top design. Although Abby couldn't relate that drawing to a bikini top initially, she was able to associate the word 'bikini top'. At the end Abby understood Bree's needs and she suggested 'scrunch in the middle' to the new bikini top design and thus helped keep the conversation and activity flowing.

Assisted Example 5: Touching and feeling the fabric

While the participants were describing their own design work to their partner, some of the participants were utilising the webcam functionality to demonstrate physical properties of fabrics through hand gestures and also through the finger touches. The following example shows these kinds of interactions.

The following example is a continuation from Assisted Example 1. While Abby was helping Bree with her swimwear design, she had taken up a position in the middle and in front of the TVTM prototype. The interactions between Abby and Bree continued in this example, where Abby was requesting feedback about a set of fabrics that she was thinking of replacing for her swimwear design. This is an interesting example, where one participant performed a check before proceeding further in the remote collaboration, to make sure that the technology that they were using was not causing any issues or problem. In the next section 5.2.3 I will demonstrate another example (Hindered Example 2), which shows what happened when a participant did not perform a check during the remote collaboration.

	Abby		Bree	
	Action	Dialogue	Action	Dialogue
01	Abby moved from her original position to a new position closer to the webcam capturing area and started interacting with the physical fabrics samples.			
02		*"Can you see what I am doing?"*		
03				*"Yeah"*
04	Abby was browsing through four different fabrics with her fingers.	*"So do you like any of the other ones?"*		
05				*"Of what?"*
06	Abby leaned over to the webcam area and started to touch some of the physical sample fabrics with her fingers.	*"These?"*		
07			Bree leaned forward to the screen to have	

			a closer look.	
08				*"(2) Nope"*
09		*"No?"*		
10			Bree pointed her finger at the screen.	*"That one is actually probably the-*
11	Abby used her fingers to point at the bottom two of the four physical sample fabrics.	*"-These colours are very Australian."*		
12	Abby ran her fingers through those two sample fabrics			*"They are [very]"*
13		*"[Green and gold]"*		
14				*"Composing of each other"*
15		*"I reckon if they did softer colours like floral colours, then they would be better"*		
16				*"Yeah"*
17			Bree pointed her fingers at the embroidery on the screen.	*"This looks nice with the embroidery"*
18		*"Yep"*		

Table 10: Gestures and dialogue between Abby and Bree: Abby was describing some of the sample fabrics in her design booklet to Bree.

When Abby subsequently started interacting with some of the physical fabric samples that she wanted to discuss with Bree, Abby moved into a new position where she was closer to the webcam capturing area. Abby first asked Bree if she could see her browsing the fabric selection menu on the TVTM prototype and this implied that she wanted Bree to follow her movements and interactions with the prototype [Table 10, turn 02]. After Bree replied that she could see her interactions on her screen [Table 10, turn 03], Abby then asked Bree if she liked any of the other fabric [Table 10, turn 04]. Bree was confused, and could not work out whether Abby was referring to the digital image of the fabric on the prototype or the sample fabric that Abby had on her design booklet. Abby leaned over to the webcam area (Figure 62) and started to touch some of the physical fabric sample with her fingers (Figure 63) and at the same time indicating to Bree that she was previously referring to those physical sample fabrics [Table 10, turn 06].

Figure 62: Abby (left) was seeking opinion from Bree about 4 different fabrics.

Figure 63: Abby was touching and feeling the fabrics with her fingers.

Figure 64: Bree commented on a fabric.

Bree saw some movements on the webcam live streaming window on the screen and had a closer look and responded that she did not like any of it [Table 10, turn 07 & 08]. Abby then started to describe some of the sample fabrics in her design booklet to Bree [Table 10, turn 11]. Bree pointed her finger at the screen (Figure 64) and was trying to think of a way to describe those fabrics but she did not finish her sentence [Table 10, turn 12]. Abby quickly replied and said *"very green and gold"* [Table 10, turn 13]. Bree also acknowledged and responded, *"composing of each other"* [Table 10, turn 14].

In this example, Abby moved from a position where she had been interacting with the screen monitor of the TVTM prototype into a new position where she would be able to use webcam capture for physical artefacts. Abby had learnt from the previous experience that there was an asymmetrical access during the remote collaboration, consequently, she pre-emptively commenced to check that the selected modality (in this case, the webcam) could satisfactorily compensate for the asymmetry with the meta-social-technical conversation: *"Can you see what I am doing?"* [Table 10, turn 02] In this instance, Abby was treating the technology as the focal point of an issue as she wanted to discuss and show something to Bree, and was requesting confirmation that Bree had also focused her attention to the webcam capture window. Bree replied *"Yeah"* [Table 10, turn 03], providing the confirmation Abby needed to proceed with the interaction.

At that moment, Abby had successfully resolved the initial uncertainty of using the technology to show something to her partner with the meta-conversation. Abby then began to ask Bree the first 'real' evaluation question; *"So do you like any of the other ones?"* [Table 10, turn 04]. Within the question, the indexical expression: *'the other ones'* represented the assumption that Bree could see Abby's actions over the webcam capturing area, browsing through four different fabrics with her fingers [Table 10, turn 04].

This caused an issue as to whether Bree was able to contextually disambiguate what Abby was doing. The fact that Bree replied *"Of what"* [Table 10, turn 05] indicated that Bree was not exactly clear as to what Abby was referring in the previous question, and that Bree was requesting a further explanation from Abby as to what *'the other ones'* was referring to. Abby responded *"These?"* [Table 10, turn 06] as she tried to show-and-tell what she meant by *'the other ones'*. Bree responded *"Nope"* [Table 10, turn 08], which finally answered Abby's first evaluation question. After Abby received the short disconfirmation from Bree, she responded *"No?"* [Table 10, turn 09] to further request an evaluation and explanation from Bree.

At this point, even though all Bree could see was a small webcam capturing window on her screen monitor with Abby's hand and fingers moving around the physical fabric samples, Bree did in fact pay attention to Abby's interactions under the webcam capturing area, and was also able to extract enough information from the small webcam capturing window on her screen monitor to be able to further discuss which of Abby's choices of sample fabrics and colours they preferred. In this example, both Abby and Bree did not have any issues with the TVTM prototype. This is an example where the technology did not hinder the remote collaboration, as both of the participants were able to carry out satisfactorily the rest of the remote collaborative task.

The success of this particular remote collaboration with the use of the TVTM prototype was dependent on the participant's judgement; for example, Abby initially requested confirmation that

Bree could see her interacting with the physical sample fabrics. This was the crucial factor in the interaction, as it could have altered the entire results had Abby had not first checked with Bree. It was also apparent that Abby had a much better understanding of the different kinds of access to the workspace than did Bree, and an awareness of the share workspace as being shared. As an example, the screen-sharing feature of the TVTM prototype allowed both Abby and Bree to see the same webcam capturing windows, and this feature enabled Abby to have a sense of what it is like for other people to see her during the remote collaboration.

In this example, Abby was communicating with Bree verbally, while interacting with physical artefacts, specifically a selection of physical fabric samples. While Abby was asking if Bree liked any of the other fabrics, Abby had made the assumption that Bree could see her actions (touching the fabric under the webcam), and had also assumed that Bree knew what she was referring to. However, as the prototype provided no indication of which particular communication channel each participant was working with at a particular instant, both participants needed to be fully engaged with the prototype at all times, or else they would again need to re-establish a shared understanding. Bree did not have the shared understanding of what Abby was referring to, therefore Bree created a shared understanding by asking Abby to clarify, and to be more specific about the object (in this case, the fabric) of Abby's questions.

Assisted Example 6: Hand gestures while communicating (receiving feedback)

While participants were seeking and receiving feedback and referring to physical objects using webcams, there were certain non-verbal behaviours such as using hand and finger gestures while communicating, as well as the physical body movement that occurred during communications. These non-verbal behaviours occurred naturally and subconsciously as though the participants were having a FTF conversation or discussion. I have selected a few examples to show various types of non-verbal behaviours while communicating during remote collaborations.

The example below shows one of the participants seeking an opinion regarding an alternative fabric for an existing swimwear design. While the participant was describing the detail of the new fabric that she had selected to her partner, using the TVTM prototype, she used hand and finger body language gestures to represent a particular element of the fabric. This type of gesturing can be seen in numerous occasions throughout different groups of participants.

	Cleo		Dani	
	Gestures	Dialogue	Gestures	Dialogue
01			Dani dragged a fabric image out of the selection menu into the work area.	*"What do you think about this one?"*
02		*"Like pink?"*		
03			Dani used hand gestures, and moved her fingers upwards to represent "roses"	*"Yes pink with roses and crown, a bit more romantic, maybe"*
04		*"Yes I like that pink fabric for the whole garment, with the print of the roses on top"*		
05				*"Yes that is a nice idea"*

Table 11: Gestures and dialogue between Cleo and Dani: Dani wanted feedback from Cleo about a new fabric that she had chosen.

In this example, Dani wanted Cleo's opinion about an alternative fabric for her dress design. Dani selected a fabric image and dragged it out of the selection menu into the work area of the TVTM prototype, and asked for Cleo's opinion of the proposed changes to her design [Table 11, turn 01]. Cleo responded that she wasn't sure whether the colour was pink or not (Figure 65) [Table 11, turn 02].

Figure 65: Dani (right) was not sure about the colour of the fabric.

Dani then described the properties of the fabric image in more detail [Table 11, turn 03]. While Dani was describing the pattern she used hand gestures, and moved her fingers upwards to represent 'roses' (Figure 66). Cleo then commented that she liked that pink fabric for the whole garment, with the print of the roses on top [Table 11, turn 4]. Dani agreed with the changes and responded that she liked the idea too [Table 11, turn 05].

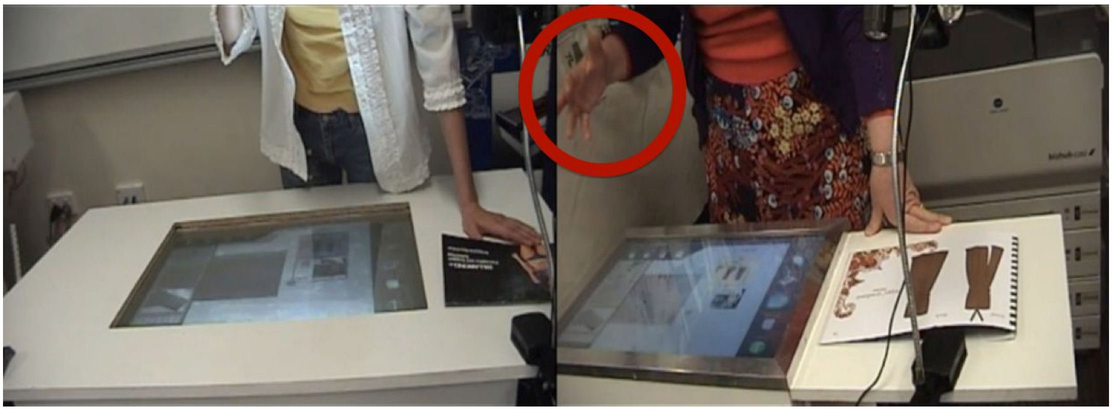


Figure 66: Dani used hand gestures to describe 'roses' pattern.

Dani later explained in the video-assist recall interviews (section 5.3) that performing this kind of gesturing was a part of the conversation just like in FTF conversation.

Assisted Example 7: Hand gestures while communicating (using webcam)

The next example shows one of the participants verbally requesting her partner to raise the design booklets closer to the webcam while using hand gestures.

	Elle		Faye	
	Gestures	Dialogue	Gestures	Dialogue
01			Faye used hand gestures moving upwards	*"Can you move it up bit more?"*
02	Elle adjusted her design booklet under the webcam capturing area.			
03		*"Like this? Can you see it?*		
04				*"Yep"*

Table 12: Gestures and dialogue between Elle and Faye: Faye couldn't see Elle's design drawing clearly so she ask her if she could adjust it.

In this example, Elle was describing the swimwear design to Faye, however Faye could not see the swimwear design clearly (due to asymmetrical access), so she initiated the repair by asking Elle to raise the swimwear design catalogue toward the webcam (with hand gestures moving upwards at the same time) [Table 12, turn 01], so that the webcam could present an enlarged image (Figure 67). Elle then adjusted her design booklet [Table 12, turn 02] and asked Faye if she had positioned it appropriately, and also if she could see it better this time [Table 12, turn 03]. Faye responded that she could see it better now [Table 12, turn 04].

Figure 67: Faye (right) used hand gestures while asking Elle (left) to move her design catalogue upwards.

This kind of gesturing may or may not be an important factor to the flow of the remote collaboration, as this example demonstrates that even though Elle could not see Faye's hand gestures due to asymmetrical access, Elle was still able to respond accordingly to Faye's request.

Technically, the participants were missing gestural cues when they were using the TVTM prototype, because the prototype did not offer additional front facing cameras to capture the users' upper bodies. Even though participants had used hand gestures and body language during the remote collaboration in Assisted Example 6 and Assisted Example 7, these missing gestural cues are considered as redundant cues (Eisenstein & Davis, 2005) as the remote collaboration was not hindered by the missing or redundant cues in both examples.

Assisted Example 8: Time allowance for experimenting with the touch interface

While participants were communicating with their partner and interacting with the TVTM prototype, they were using multiple hand and finger inputs to interact with the prototype. The eighth example below shows how a participant used multiple fingers to interact with screen, and at some point during the remote collaboration, the participant used two hands and fingers to interact simultaneously with the TVTM touch screen.

In this final example of remote collaboration assisted /not affected by the use of the TVTM prototype, Elle and Faye were having a discussion about an alternative fabric for Elle's swimwear design. Both Elle and Faye agreed to change the fabric to one that they were working on earlier. Elle went ahead without discussing her thought process, and attempted to find the 'green checked' fabric she had seen earlier. She tapped on the image again and soon realised she needed to drag it out into the working area on the left hand side of the screen. Elle dragged an image out of the selection to the main work area of the screen, however the image was too big to fit the screen so she resized it using her fingers. She tried to use multiple fingers (Figure 68) on her right hand as well as using her fingers on both right hand and left hand to resize the image.

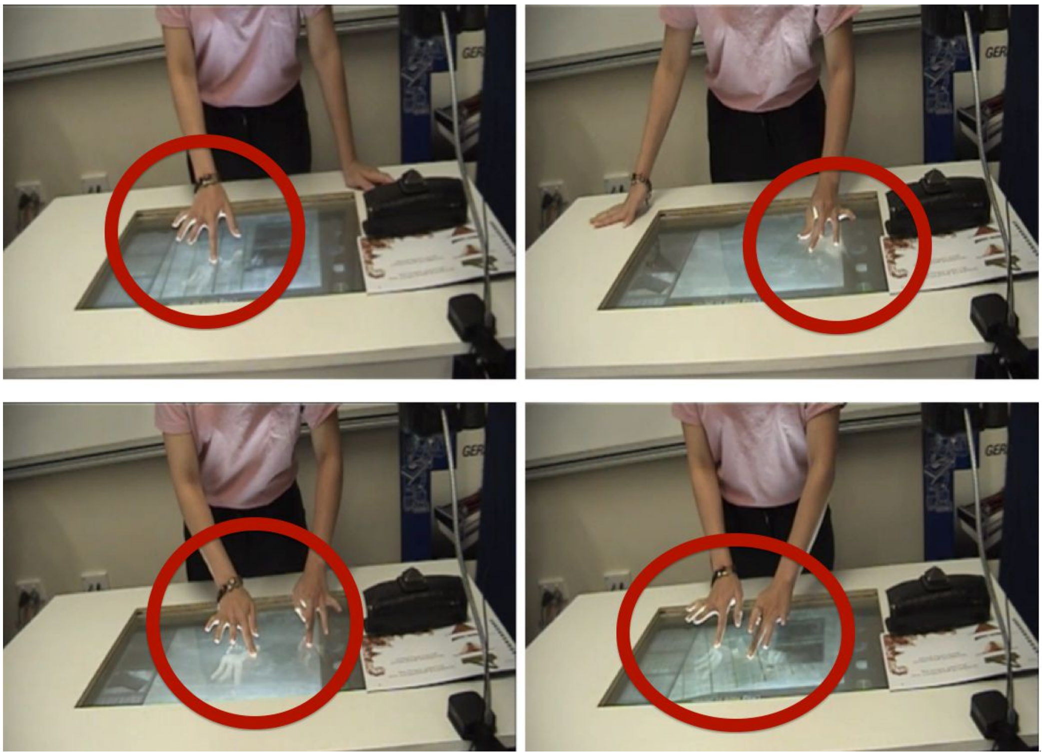


Figure 68: Elle was using multiple fingers to resize the image (snapshot of clips are presenting clockwise, starting from the top left).

In this particular example, Elle's partner was waiting patiently, so as to allow Elle to 'experiment' with the touch interface of the TVTM prototype, before asking questions. In this case, the time allowance for experimenting on the TVTM prototype did not hinder the remote collaboration, as the other participant was also able to see the resizing of the images. The overheads issues may have been caused by the unfamiliarity of the TVTM prototype, as I had only demonstrated the functionality of the TVTM prototype to the entire group of participants once, before they began their user testing sessions.

Summary

I have described eight examples of participants seeking and receiving feedback from their partner, participants creating a common understanding of the conversations/instructions while giving or following instruction by their partner, and participants referring to physical objects using webcams during the remote collaboration. These examples demonstrate the participants achieving a degree of success in using the TVTM prototype to collaborate remotely. These examples also show the value of the webcam capturing function for demonstrating physical artefacts, as well as the touch screen of the TVTM prototype that enabled participants to view live video streams from the webcam capturing area.

The findings also showed changes in spatial awareness that were similar to those found in Kim and Maher's (2008) research study. For example, when participants were using the TVTM system to interact with digital artefacts, they experienced a change in spatial awareness when they were trying to figure out how to translate physical artefacts into digital artefacts as part of the creative design processes in order to solve the fashion design problem that they had, with their remote collaborator.

Physical gestures, in particular pointing gestures, are considered as non-linguistic indexical behaviours (Engberg-Pedersen, 2003; Estep, 2003; Helmut, 2008), that potentially had an influence on achieving a successful remote collaboration. The examples that I have described so far suggest that the TVTM prototype supports this kind of indexical behaviour, and in most cases the remote collaborative activities were not affected by the use of the TVTM prototype. Assisted Example 5 showed, however, that the success of the remote collaboration might have been dependent on the participant's judgement, such as the participant performing an initial check before proceeding further during the remote collaboration.

In Assisted Example 5, when the participant conducted an initial check to verify the fidelity of the live video feed image, the flow of the remote collaboration seemed to go smoothly, and the meta-talk seemed to be woven with the collaborative task talk. Assisted Example 6 and Assisted Example 7 showed the missing gestural cues to be considered as redundant, as Eisenstein and Davis (2005) pointed out that the gestural cues do carry unique information, but they are also considered as a weak and noisy signal as they do not contribute to large performance improvements (Eisenstein & Davis, 2005; Harper & Shriberg, 2004). There is also a noticeable absence of participants wondering what their partner was trying to do. In particular, Assisted Example 8 showed the willingness of a participant to allow time for her partner to attempt to learn how to interact with the prototype, since it was the first time the participants had interacted with the TVTM prototype. The overheads may have been large at the initial stage, but this could be expected to reduce over time due to increasing familiarity with the prototype.

Next, I will describe another eight examples where *remote collaboration was hindered/affected by the use of the TVTM prototype*. In some instances, the remote collaborative activities were disrupted due to some TVTM hardware malfunctions and limitations, which caused frustration and confusion while using the prototype during the remote collaboration.

5.2.3 Remote collaboration hindered/affected by the use of the TVTM prototype

There were multiple occasions where participants' remote collaborations were hindered by their use of the TVTM prototype. Some of the remote collaborations were also affected due to the hardware malfunctions and limitations of the TVTM prototype causing frustration and confusion to the participants. I have arranged the following examples in ascending order, according to the degree of trouble that the participants were experiencing. The first two examples, Hindered Example 1 and Hindered Example 2, discuss the participants experiencing some difficulty, primarily caused by limitations of the TVTM prototype, which hindered the flow of the remote collaboration. Later I use some examples to describe hardware malfunctions (Hindered Example 3 to Hindered Example 8), and some inherent hardware and software limitations of the prototype, which directly affected the participants' choice of methods to communicate with the other participant, and these limitations significantly affected the flow of the remote collaboration.

Hindered Example 1: Showing physical object under the webcam

While the participants were using the prototype to answer questions, participants may have been referring to physical objects using webcams; this is where participants selected graphic/video input modality to assist with their work. The first example shows participants utilising the webcam to assist with their remote collaborative task, however, the flow of their remote collaboration was hindered by the limitation of the technology.

	Cleo		Dani	
	Gestures	Dialogue	Gestures	Dialogue
01	Cleo picked up her design booklet and placed it under the webcam capturing area.			
02		*"Can you see the picture I am holding here?"*		
03				*"Is that the technical drawing? It is a bit hard to see that one."*
04	Cleo leaned over to have a quick look at the screen of the TVTM prototype.	*"Yes it is a bit bright, I will show you the technical drawing"*		
05	Cleo raised the booklet up a little	*"Can you see that?"*		
06				*"Yeah"*

Table 13: Gestures and dialogue between Cleo and Dani: Cleo was using webcam to show Dani her swimwear design.

In this example, Cleo was trying to show Dani her design for the swimwear. Cleo started by picking up her design booklet with the mock-up image of her swimwear design [Table 13, turn 01], and placed it under the webcam capturing area (Figure 69) of the TVTM prototype. Cleo then asked Dani if she could see the image clearly or not [Table 13, turn 02]. Dani responded that she was confused as to whether the image was a technical drawing or not, as she could not see it clearly on the screen [Table 13, turn 03].

Figure 69: Cleo (left) was showing Dani (right) her current swimwear design.

Cleo had a look at the screen and admitted that the image from the webcam that was displayed on the TVTM prototype was too bright [Table 13, turn 04]. Cleo then decided to show Dani the technical drawings of the design instead. Cleo wanted to ensure Dani could see the design drawing clearly over the webcam, so she lifted the booklet closer to the webcam [Table 13, turn 05], and asked if Dani could see it better now. Dani acknowledged and responded *"yeah"*[Table 13, turn 06].

In this example, Cleo utilised the webcam function of the TVTM prototype to assist her during the remote collaboration. Cleo requested feedback from Dani to confirm whether Dani could clearly see the design mock up image before Cleo proceeded further with the discussion. It was subsequently confirmed that Cleo had indeed exercised sound judgement in checking with Dani first, as the outcome may have been significantly different had Cleo ignored the 'checking step' [Table 3, turn 02]. In this case, Dani was in fact experiencing a problem, and in response to Cleo's request she explained to Cleo that as a result of being unable to see the image clearly, she could not ascertain whether the image was a technical drawing or not. Cleo acknowledged that there was an issue with the webcam function of the TVTM prototype and also the low screen resolution of the monitors (as part of a design-intended constraints).

Cleo then proceeded to overcome the problem by raising her design booklet closer to the webcam. Cleo next offered to show Dani the technical drawing, since Dani's last feedback indicated that she might be wanting to see the technical drawing, rather than the mock up swimwear image that Cleo had showed her earlier. Cleo subsequently performed another check [Table 3, turn 05] with Dani, to prevent any further confusion that may have disrupted their discussion, and to focus Dani's attention once again to the webcam capturing window of the TVTM prototype in order to continue their discussion about Cleo's swimwear design. In this case, the technology did somewhat hinder the flow of the remote collaboration due to some limitations of the TVTM prototype, however, one of the participants was able to solve the problem and continued with the rest of the remote collaboration. The design-intended constraint in this case was to unify the screen resolution between the two different sized multi-touch screen monitors. This particular example demonstrates how users overcame the design-intended constraint and were able to recover from a communication breakdown. The participants discovered a communication problem during the remote collaboration, and successfully managed to resolve it by themselves.

Hindered Example 2: Hand gestures to describe fabrics

Using hand/finger gestures while communicating during the remote collaboration was often seen during the user testing. An example below shows a participant using finger gestures to describe the pattern of the fabric. However, one of the participants did not conduct a check to see if her partner could see the live webcam image clearly or not on her screen monitor. As a result, the other remote collaborative participant needed to request clarification of what her partner had said, and what she saw on her screen. This is in complete contrast to the Assisted Example 5 in section 5.2.2 that I have described and analysed.

	Elle		Faye	
	Gestures	Dialogue	Gestures	Dialogue
01			Faye pointed her finger at her design booklet.	*"So we are looking at the bandeau top and high waist pants and got string detail on the side.*
02		*"So is it like a high-"*		
03			Faye was using two fingers in a downward swiping motion in the webcam area, to represent the vertical stripes on the fabric	*"Yea high waisted, And it has got vertical stripes on the bottoms and geometric patterns at the top"*
04		*"Is it blue?"*		
05			Faye pointed her fingers at the two different fabric samples on her design booklet.	*"Yea blue and purple, and this one is like a different variation of grey."*
06		*"Is there a colour in here that is the same?"*		
07			Faye went back to the fabric selection menu and used her fingers to browse up and down.	
08		*"That checked one but darker"*		
09			Faye stopped and slowly scrolled it down with her finger to try to find that checked fabric that Elle wanted.	*"Yeah that checked with dark blue and the dark purple, what do you think?"*
10		*"Yeah"*		

Table 14: Gestures and dialogue between Elle and Faye: Faye was describing her design using her design booklets under the webcam to Elle.

Faye was describing her design to Elle, using her design booklet [Table 14, turn 01]. Faye told Elle that there were two colour choices for the stripes on her swimwear pants design, and two different geometric patterns for her swimwear top design (Figure 70) [Table 14, turn 03 & 05]. While Faye was describing the two different stripe colour variations, she was using two fingers in a downward swiping motion in the webcam area, to represent the vertical stripes on the fabric (Figure 71).

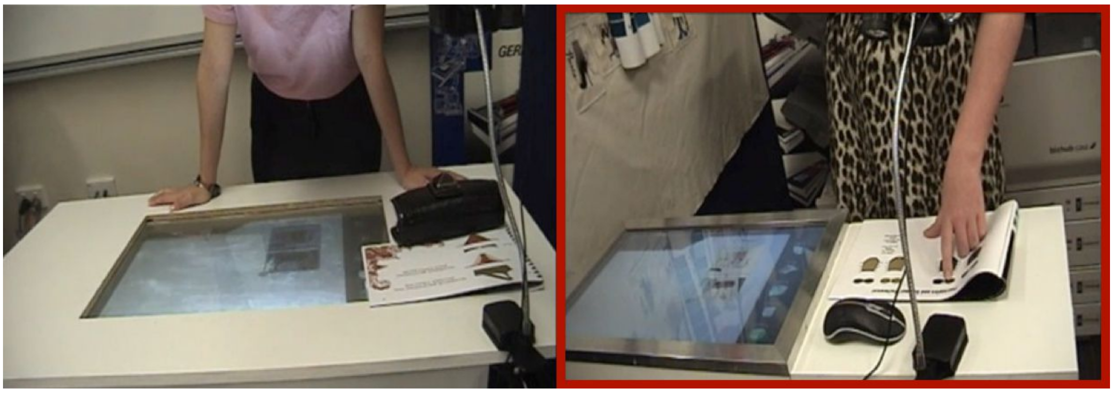


Figure 70: Faye (right) was describing different choices of fabric for her swimwear pants design.

Figure 71: Faye used hand gestures to represent the vertical stripes on the fabric.

In this example, Faye proceeded to describe her swimwear design to Elle, without first checking to see if she could see Faye's design booklet clearly on her webcam capturing window on the screen monitor. There were two occasions where Faye described some design features of her swimwear design to Elle, with Elle subsequently asking Faye questions, to verify and clarify what she saw on her screen monitor. Even though Faye was pointing her finger at her design booklet to try to emphasise the area that she was describing to Elle, it appeared as though Elle could not clearly see Faye's swimwear design from the design booklet.

The design-intended constraint of unifying the screen resolutions consequently caused the design-unintended constraint of a reduction in the ability to show correct colour, and a decrease in the level of detail of digital artefacts presented on the screen monitor. The technology to some degree hindered the flow of the remote collaborative process, due to limitations of the TVTM prototype, and the collaboration became somewhat disjointed. However, Elle and Faye were able to overcome the technical limitation of the TVTM prototype, and were able to carry on with the remote collaboration after Faye verbally explained her design in more detail to Elle.

Hardware malfunction: Audio issues

From observations made during the user testing sessions, participants seemed to experience occasional hardware malfunctions while interacting with the TVTM prototype. These occasional hardware malfunctions, in combination with some inherent hardware and software limitations of the prototype, directly affected the participants' choice of methods to communicate with another participant, while undertaking remote collaboration.

Hindered Example 3: Facial expression showing frustration at not being able to hear properly due to audio issues.

Some participants also seemed to experience difficulties hearing through the Bluetooth audio headset. Following are some examples showing the participants' facial expression, body movements and hand gestures when they have been unable to hear the conversation clearly during the user testing.

In this example, Gail was previously collaborating with Hana on Hana's swimwear dress design. Gail continued to have trouble hearing and understanding what Hana was saying through the Bluetooth headset. At that moment, Gail's facial expression indicated that she was getting frustrated by not being able to hear clearly. She then leant forward to try and listen to her partner's conversation (Figure 72). Hana said she wanted to know whether she should go for beadings for her new dress design or not.

Figure 72: Gail (left) leant her body forward.

Hana repeated her suggestion for her current design multiple times to Gail. At this point Gail seemed to be able to hear the conversation again, and suggested that she should go for embroidery.

This example shows that the remote collaboration was interrupted multiple times due to the design–unintended constraint, which caused audio issues of the TVTM prototype. This particular design–unintended constraint, was due to the low sensitivity of the microphone and the unexpected low speaker volume. However, the remote collaboration was finally resumed when Gail was able to hear the conversation.

Hindered Example 4: Hand gestures expressing frustrations at not being able to hear clearly

In this example, two participants were working on an alternative fabric for one of the participant's swimwear top design. Due to the audio issues, one of the participants could not hear the conversation clearly, subsequently attempting to answer the question from her partner. This design-unintended constraint led to confusion from her partner as well as continuing to experience frustration of not being able to hear from her partner clearly.

	Cleo		Dani	
	Gestures	Dialogue	Gestures	Dialogue
01			Dani dragged a fabric image out from the selection menu using her fingers into the work area.	
02		*"Is that an embroidery or beadings?*		
03				*"Yes, I like that"*
04				*"What do you think about that on the tie"*
05		*"Hum"*		
06		*"Is that a purple colour? Can we change it to a purple colour? It is kind of dark"*		
07			Dani shrugged her shoulder with opened hands.	*"Sorry Cleo, you have to speak up, I can't hear you"*
08		*" I said that purple colour is quite dark, compare to the pink one"*		
09			Dani again shrugged her shoulder with opened hands.	
10				*"Do you mean the top sash?"*
11		*"Yes the top sash"*		

Table 15: Gestures and dialogue between Cleo and Dani: Dani was having trouble hearing from Cleo.

Dani dragged a fabric image out from the selection menu using her fingers into the work area [Table 15, turn 01]. Cleo asked if the fabric Dani had selected was an embroidery or beading. Since Dani had not clearly heard Cleo's question, she responded incorrectly [Table 15, turn 03]. However, Dani then asked if Cleo liked the newly selected fabric for the tie design. Cleo paused for a few seconds and asked whether Dani could change the colour of the fabric that Dani had selected [Table 15, turn 05 & 06]. During that time, Dani shrugged her shoulders with opened hands (Figure 73). Dani then asked Cleo to speak up, as she could not hear her clearly.

Figure 73: Two video frames showing Dani (left) shrugging her shoulder with opened hands expressing her frustrations for not being able to hear clearly.

Cleo repeated her question about the colour of the fabric [Table 15, turn 08]. While Dani was attempting to answer the question, she pointed her finger at a specific fabric sample on the screen and shrugged her shoulders again with opened hands. Some confusion existed regarding which fabric sample Cleo was referring to, as there were two samples on the screen (Figure 74) [Table 15, turn 09]. Dani then asked whether Cleo was referring to the top sash fabric or not [Table 15, turn 10]. Cleo responded "yes" in [Table 15, turn 11].

Figure 74: Dani (right) attempted to answer Cleo's question.

In this example, Dani was unable to clearly hear Cleo, and as a result of the audio issues that Dani was experiencing, she responded to Cleo’s request incorrectly. This subsequently caused a certain degree of confusion for Cleo, particularly when Dani asked a question that was completely off topic from Cleo’s initial question. The initial conversation was about embroidery and beadings; however, due to the audio issues, the subject of the conversation was changed to colour choices thus causing the conversation to become disjointed. During this remote collaboration, Dani did not answer the initial question that Cleo had asked, therefore the remote collaborative process broke down, and was greatly affected by the hardware malfunction.

Hardware malfunction: Touch screen technology

Many participants had previous experience using touch screen technology with devices such as iPhones, iPads, tablets, PCs and other touch screen enabled devices. However, the touch screen technology used in the TVTM prototypes reacts in a different manner to that experienced using other common touch screen devices. There were many instances where participants were experiencing difficulties interacting with the touch screen (design-intended constraint), which caused frustration and confusion to the participants. This particular design-intended constraint was originally intended to reduce the sensitivity of the multi-touch input during the calibration setting to allow the computer within the TVTM prototype to capture a more consistent multi-finger input capture results. However, the following example showed a participant experiencing frustrations due to the design-intended constraints of reducing the touch screen sensitivity.

Hindered Example 5: Touch screen sensitivity causing frustration

The following example was observed during the same remote collaborative activity in the previous example (example 2 of audio issues) where one of the participants was experiencing difficulties scrolling the selection menu using the touch screen, which led to frustration.

Dani and Cleo were previously working on an alternative fabric for Dani's swimwear top design. While Cleo was asking Dani about selecting another similar colour for the fabric, Dani was still busy trying to get the scrolling function to work, so she could show some of her ideas to her partner. Dani appeared to have considerable difficulty interacting with the touch screen (Figure 75), as the screen appeared to have no response to her touch. She tried scrolling with just her index finger, but the screen appeared insensitive and unable to detect her finger touch, so she tried to scroll with both index and middle fingers. The prototype was unable to register her fingers' touch; therefore the scrolling function seemed to be not working for her.

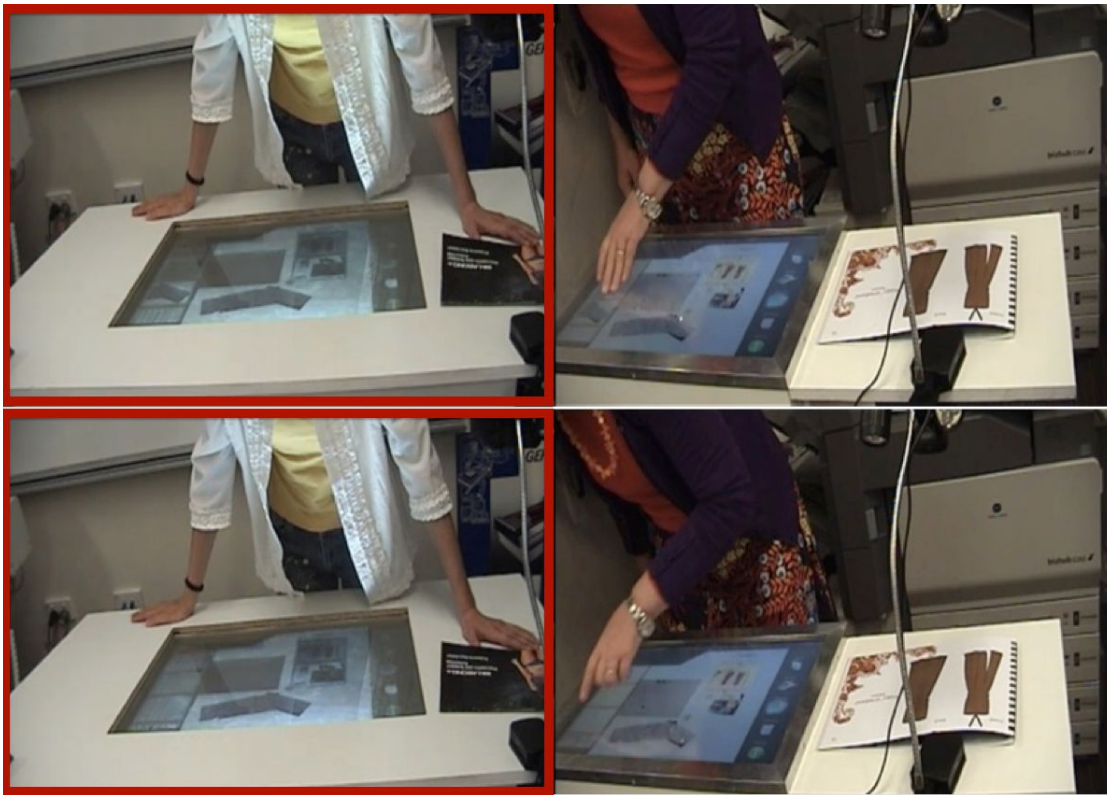


Figure 75: Two video frames showing Dani (left) struggling to scroll through the image selection menu with her fingers.

At the end of the exercise, Dani appeared to be frustrated with the prototype, as she was unable to make the prototype do what she wanted. Cleo was also having some degree of difficulty with the scrolling function (Figure 76); she tried scrolling using her index fingers, thumb, then back to index finger. She then tried to use both of her index fingers, however she could not scroll images easily. At the end, Cleo finally managed to scroll to a section and was also able to drag a fabric image out of the selection area to the work area of the screen.

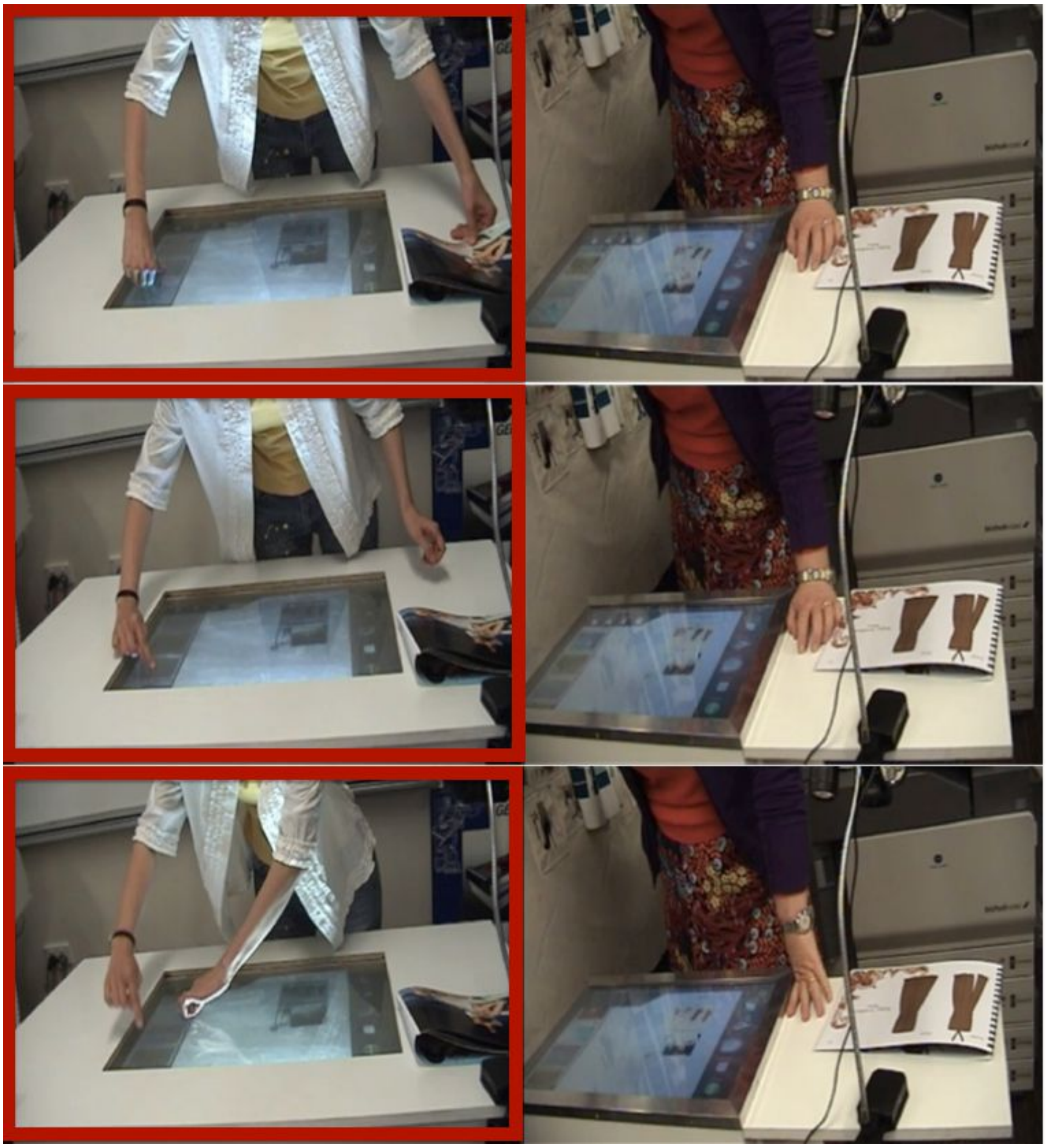


Figure 76: Three video frames showing Cleo (left) also appearing to have difficulty scrolling through the image selection menu with her fingers.

In this example, both participants were experiencing issues with the touch screen sensitivity of the TVTM prototype. Both participants spent considerable time in getting the touch screen to recognise their finger touches. This caused frustration for the participants who were trying to interact with the prototype, and consequently confusion for their partner at the other remote location, as neither participant was necessarily aware that her partner was experiencing technical difficulties. As the result of these hardware issues, significant delays were introduced to the remote collaborative process.

Hindered Example 6: Touch screen input methods confusion

In addition to the touch screen sensitivity issues, some participants were also confused about the touch screen input methods. This appeared to be primarily caused by differences between touch screen input methods of the TVTM prototype, and other touch screen devices that they had previous experience interacting with. The following example illustrates issues relating to the touch screen input method and confusion that a participant was experiencing. The participant, however, managed to figure out the touch screen input method eventually.

Dani (right in Figure 77) was unsure how to select a fabric image and put it in into the workspace area, and said: "*I don't think it is working*". She repeatedly tapped on the screen and swiped her fingers up and down on the scrolling selection menu on the right hand side of the screen. Dani then realised that she needed to drag the image out and onto the workspace, and while she was doing that she said "*oh drag (giggles) I am used to the iPhone*".

Figure 77: Three video frames showing Dani (right) trying to use her finger to tap, swipe and drag on the touch screen.

During the video-assisted recall interview (in section 5.3), Cleo subsequently revealed that she did not know what Dani was doing during the time she was waiting. She actually wanted to help Dani, but had made a conscious decision to allow Dani more time to complete her contribution to the allocated task. Cleo also raised the issue that there was no indication of which particular communication channel Dani was using, and no way of ascertaining whether Dani was experiencing difficulties with the prototype at any time during the remote collaboration. This latency issue significantly reduced the efficiency of the remote collaboration, and degraded the overall user experience of the prototype.

Hardware limitation: Simultaneous input behaviour

There were a few instances where both participants were interacting with the TVTM prototype at the same time and thus making the prototype unstable. This appeared to be one of the design-unintended constraints where the prototype allowed for simultaneous input on both machines, however it caused the prototype to become unstable or to crash. Following are two examples showing simultaneous input behaviour by the participants, which caused confusion and delays during the remote collaboration.

Hindered Example 7: Both interacting at the same time

Hana (right) wanted to discuss the dress coat, and requested some help from Gail (left) to make minor alterations to the design. Gail then started browsing the database with her fingers, scrolling up and down, while Hana was simultaneously interacting with the screen (Figure 78).

Figure 78: Gail and Hana were both interacting at the same time.

The prototype became unstable due to some inherent hardware limitations of the prototype, which caused instability when both participants were interacting at the same time. Both participants became confused, and did not know what had happened to the prototype. This ultimately required intervention on my part, by requesting Hana to remove her fingers from the touch screen, and let Gail go first (Figure 79).

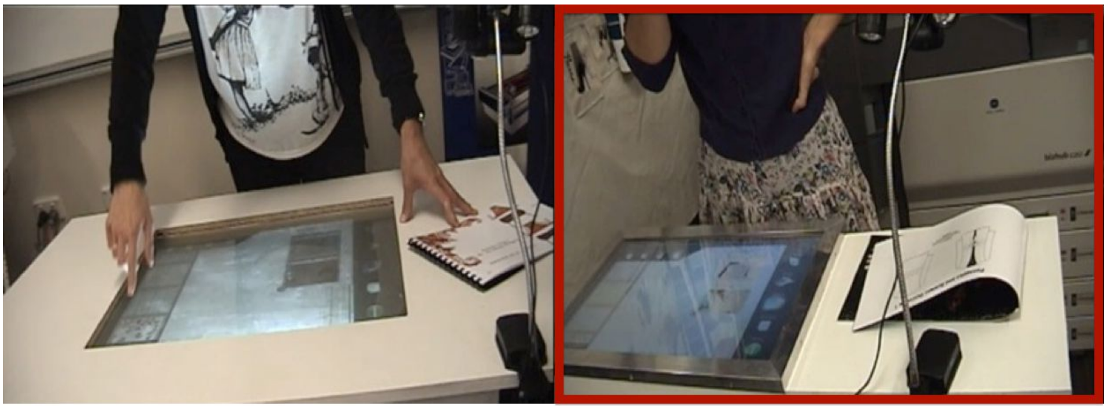


Figure 79: Hana (right) stopped interacting with the screen and told Gail to continue with her work.

Hindered Example 8: Screen not responding

The example below shows a similar hardware malfunction issue caused by simultaneous inputs by both participants.

Elle (left) discovered that the prototype had been frozen for a few minutes. Elle was also confused, and did not know what had happened to the prototype. She pulled her hands away from the screen while waiting for the prototype to respond. Elle subsequently deduced that Faye (right) had earlier been interacting the screen at the same time, which had caused the prototype to appear unresponsive on Elle's screen. Faye also realised what the problem was, so she requested Elle to carry on her work.

Figure 80: Elle (left) held her hand back due to prototype malfunction.

Summary

Due to the technical limitation of the TVTM prototype, some participants had exhibited signs of uncertainty and confusion during the remote collaboration. In Hindered Example 1, one of the participants decided to initiate the remote collaboration by requesting feedback from her partner before proceeding further with the discussion. It was later found that the TVTM webcam screen resolution was not high enough to see the detail of the live video feed. The outcome of that remote collaboration may have been significantly different had that participant ignored the ‘checking step’. Even though the participant acknowledged that there was an issue with the low screen resolution of the monitors associated with the webcam function of the TVTM prototype, the participant tried to overcome the problem by raising her design booklet closer to the webcam. It is a very different story for Hindered Example 2 where one of the participants did not conduct a check to see if her partner could see the live webcam image clearly or not on her screen monitor. As a result, the other participant ultimately requested clarification of what her partner had said, to attempt to verify what she was seeing on her screen. In both cases, the technology did somewhat hinder the flow of the remote collaboration, due to some limitations of the TVTM prototype. Participants were able to solve the issues however, and continued with the rest of the remote collaboration. Using ‘the checking step’ to verify the fidelity of the live video feed image is considered to be an important step. As I have clearly demonstrated in Assisted Example 5 and Hindered Example 2 in the next section that the flow of the remote collaboration was dependent on it.

I have also used examples to describe participants’ facial expression, body movements and hand gestures while experiencing audio malfunction, an apparent lack of touch screen sensitivity, some confusion regarding input methods, and simultaneous input behaviour by both participants, causing frustration, confusion and delays during the remote collaboration due to both design-intended constraints and design-unintended constraints (Table 16). Next, I will present the findings from the video-assist recall interviews.

Design-intended Constraints	**Design-unintended Constraints**
	IR pen lagging issue prevented participants from achieving smooth free-hand drawings.
Unified screen resolution between two different size multi-touch screens.	Limited screen resolutions reduced the ability to show correct colour and the detail of digital artefacts.
Calibration for detecting multi-touch inputs was set to ‘below average’ sensitivity to achieve more consistent finger inputs detections.	Participants were able to interact with digital artefacts on the screen simultaneously, which subsequently caused system overload, and in some cases system breakdown. Participants sometimes needed to press hard on the screen in order for the system to recognise touch inputs.
	Microphone and speaker volumes were not high enough.

Table 16: Design-intended constraints and design-unintended constraints.

5.3 RESULTS: (II) USERS' COMMENTS, PREFERENCES, KNOWLEDGE, AND RECOMMENDATIONS FOR THE TVTM PROTOTYPE

There were a total of eight participants who took part in the video-assist recall interviews. Each interview was conducted with the same pair of participants that had previously participated in the earlier user testing session. I observed many different aspects of interactions throughout all of the four user-testing sessions, and used these observations to tailor specific questions for the video-assist recall interviews for each group. The majority of the questions for the interviews were related to social interactions, and how participants interacted with the technology. A typical sample of some the questions derived from the observations during the user testing study are presented below:

- *"I (the interviewer) have noticed this (e.g. interaction/behaviour), how/why did you (the participant) do it that way?"*
- *"Did you (the participant) have trouble doing this? (e.g. interact with the prototype or communicate with your partner)".*
- *"When you (the participant) said/described this (e.g. comments from the conversation or thinking out loud), what did you mean by that?"*

There were also two general questions that were asked of all four groups towards the end of each interview:

- *How does this prototype compare to the FTF communication?*
- *Any feedback or suggestion/recommendation about the prototype?*

The qualitative results from the video-assist recall interviews helped me gain further insights into how and why participants interact (socially) with the other participant, and also how and why participants interact with the TVTM prototype (technology) in a certain way, while they were in a remote collaborative setting. I will detail the users' comments, preferences, knowledge, and recommendations for the TVTM prototype through a series of examples from the interview feedback.

5.3.1 Users' comments: FTF versus TVTM prototype

I had asked the participants to comment on their experience of using the TVTM prototype to communicate, as opposed to FTF communication. One of the participants commented that "*it is good that you can have the system in front of you and you can both interact with it*" (Appendices Transcript 5.3.1 Quote 2). However, there are some comments that reflect negatively on the usability of the TVTM prototype, for example, one of the participants commented that the TVTM prototype is not easy to use and she would need to "*find a way to learn how to use it*" (Appendices Transcript 5.3.1 Quote 1).

Another participant commented that "*FTF is easier to hear and see*" compared to the TVTM prototype (Appendices Transcript 5.3.1 Quote 3), due to her inability *to manipulate* the TVTM prototype, which interrupted the normal flow of conversation during the remote collaboration. She then added that she was focusing more on trying to get the touch screen of the TVTM prototype to work, rather than communicating with her remote collaborative partner about the fashion design task.

There was an interesting comment from one of the participants during one of the video-assist recall interviews, who noticed that "*obviously you still have the audio component, but you know we are so used to the paralinguistic gestures that you do miss out on that extra level of communication. So it would help if the system had similar visual function to let users see each other as well.*" (Appendices Transcript 5.3.1 Quote 4). Similarly, one of the participants also commented that the use of hand gestures during remote collaboration is part of the interpersonal communication; "*I like to use hand gestures to show people what I am thinking*" (Appendices Transcript 5.3.1 Quote 2). It is apparent from these user comments that the addition of a visual feature of the TVTM prototype that allowed users to see the other collaborative partner's gestures would enhance the collaborative experience when compared to FTF collaboration.

5.3.2 Users' comment: Hardware issues

During the interview, I also wanted to obtain some user feedback relating to some hardware issues, such as the limitation on simultaneous input and the audio problem that prohibited users from performing certain actions. Participants identified various hardware design constraints and limitations that prevented them from interacting and communicating naturally. For example, after reviewing video footage of a remote collaborative exchange, one of the participants explained that although she wanted to intervene and assist her partner, she chose not to. "*I knew if I touched the screen again it would interrupt the system and cause the system to crash as you can't both interact at the same time*" (Appendices Transcript 5.3.2 Quote 1).

Audio malfunction also seemed to cause some confusion and misunderstanding for participants. After reviewing the video footage during the video-assist recall interview, one of the participants commented how she was feeling during the remote collaboration at the time; "*it is like I am talking to you and you can't hear what they are saying is really frustrating*" (Appendices Transcript 5.3.2 Quote 2). The participant also commented that she was trying very hard to hear the conversation in order "*to make sure that we were on the same page*" (Appendices Transcript 5.3.2 Quote 3), demonstrating that the participant recognised the importance of establishing shared understanding during remote collaboration.

5.3.3 Users' preferences: Gestures while communicating with the other participant during remote collaboration

I had observed a couple of interesting hand gestures (section 5.2.2, Assisted Example 6) that some participants used while communicating with their partners in the user testing video footage. I had asked participants to watch a particular segment of the video footage where the particular hand gesture behaviour occurred, and then asked participants some relevant questions.

While observing the interaction between the participants' interaction with the TVTM prototype, I had noticed that one of the participants was using hand gestures to describe 'pink and roses'. It appeared as though she was using gestures as if she was communicating in a FTF situation.

During the video-assist recall interviews, I asked her to explain the reason behind the use of hand gesturing when she described 'pink and roses'. After reviewing the video footage, she confirmed: "*it is part of the conversation just like in FTF conversation*" (Appendices Transcript 5.3.3 Quote 1). There are other similar cases relating to gestures that occurred while communicating with the other participant. Similarly, one participant described the use of hand gestures over the chest to represent the height of the dress like "*an automatic thing*" (Appendices Transcript 5.3.3 Quote 2) or similarly, the use of hand gestures to represent long sleeves during a remote collaborative exchange (Appendices Transcript 5.3.3 Quote 3). This confirms that even though the collaborative participants were aware at the time that the remote collaborative partner was unable to see any of the hand or finger gesturing, most participants still preferred to use gestures during the remote collaboration, consequently, the use of this gesturing during communication should be considered a natural part of a user's remote collaborative experience..

5.3.4 Users' knowledge: Ability to apply previously learned technical skills to new technology

Some participants were able to figure out very quickly how to interact with the TVTM prototype. While observing the participants interacting with the TVTM prototype during the user testing study (from section 5.2.3), it was noted that the participants appeared to demonstrate the use of knowledge that had been previously learnt from other touch screen devices. I showed one of the participants video footage of herself scrolling through images on the TVTM prototype, and asked how she understood the scrolling function on the TVTM prototype. She replied: "*it is basically like an Apple product, so it is very straightforward*" (Appendices Transcript 5.3.4 Quote 1). Similarly, when asked about how she knew she could resize the images using two fingers, she responded: "*I remembered you could do the resizing like iPhone and iPad*" (Appendices Transcript 5.3.4 Quote 1).

After showing another participant video footage in which she had made a comment "*I am used to touch screen technology like iPhone*", I asked what particular features she was familiar with. She replied that the touch input methods were somewhat similar, but the TVTM prototype was "*much heavier to use and not very responsive*" (Appendices Transcript 5.3.4 Quote 2). This example shows that users were able to apply previously learned knowledge/technical skills to new technology such as the TVTM prototype, confirming my original interpretation of the interactions.

5.3.5 Users' recommendations: additional features (future work)

Towards the end of the video-assist recall interviews, I had asked participants to describe their experience using the TVTM prototype and any recommendation they had, to make the remote collaboration more natural and efficient. Based on this feedback (Appendices Transcript 5.3.5 Quote 1-10), participants identified that they would like to see additional features such as better support for sketching, including colour palette and basic graphic editing functions. One of the participants pointed out that these features would allow the exchange of some details of the fashion designs that cannot be described verbally.

A few participants thought that the resolution of the webcams was too low, causing confusion for some participants during the remote collaborations because the images captured by the low-resolution webcams were blurry at times. They also recommended other hardware improvements such as faster computers with increased processing power to speed up the system and make it more responsive.

Another interesting recommendation from one of the participants was that the screen be divided into two areas, with one side to act as an individual working area, and the other to act as the shared screen for remote collaboration purposes. She gave an example; "*I can work on the alternative design or solution to a design problem when she was presenting her design problem and vice versa*" (Appendices Transcript 5.3.5 Quote 3). These recommendations will be part of future representative challenges for the next iteration of the TVTM prototype in the future work.

5.3.6 Summary

Having analysed the video data collected from the fashion design environment setting, I subsequently used the video to conduct interviews with the same group of participants in the video-assisted recall interview in order to verify different aspects of interactions that I had observed and analysed, to gain further insights into how and why participants interact socially with the other participants, and how and why participants interact technically with the TVTM prototype in a certain way.

During the interviews, the majority of the participants gave positive feedback on the usability of the TVTM prototype during the interactions and sharing of fashion design ideas. However, some of the participants commented that the collaborative experience was not the same as the FTF for various reasons. For example, some participants commented that they would have preferred the TVTM prototype to be able to show each other's hand gestures during remote collaborations to enhance the collaborative experience. They also suggested that the TVTM prototype has a steep learning curve, as the current version of the TVTM prototype does not provide any tutorial or help functions to assist users. Other participants however, commented that they knew how to interact with the TVTM prototype instinctively, due to their experience in the use of similar touch screen technology. When asked about the usability of the touch screen technology, some participants commented that it was sometimes difficult to manipulate digital objects within the TVTM prototype due to the lack of sensitivity of the touch screen, causing temporary disruptions to the remote collaboration. There were other hardware related issues with some participants commenting that they were getting frustrated due to audio related hardware issues causing difficulties in hearing conversations. During the interviews, participants recommended a few improvements, such as better support for sketching, higher resolution webcams for clearer images, and more powerful computer hardware to minimise system delays.

Next, I will show how I used the video data collected from the first stage of the evaluation study to conduct the Video Card Game as a design-thinking tool rather than analytic tool.

5.4 RESULTS: (III) USERS' REACTIONS ON WATCHING OTHERS USING THE TVTM PROTOTYPE.

5.4.1 Taking video beyond 'Hard Data'

So far, I have presented two different analytic approaches to analysing the video data that was collected from the participants who were using the TVTM prototype. By following an interaction design methodology, it can be seen from the interaction design literature that there are alternative ways of treating video data (Buur, Binder, & Brandt, 2000; Buur & Soendergaard, 2000). This section describes how I chose to explore a more socially focused, design-focused and playful approach to working with the same video data in collaboration with teams of fashion design students who had participated in the previous multi-stage evaluation study and interaction design researchers.

I adopted Buur's Video Card Game method as a way of engaging participants in the design process to determine if the themes they produced can be used to triangulate the results from the previous analysis of the video data. The original Video Card Game was intended to enhance collaboration and to generate design ideas between user-centred design teams and engineering development teams. However, I adopted this novel use of the method at the evaluative stage of the design process because I wanted to better understand the problems involved with remote collaboration. Also I was interested to investigate how the Video Card Game could be used to generate design insights around the use of high-fidelity prototypes.

The Video Card Game was run on two occasions with two groups of participants, one group being the fashion design students who had participated in the initial user testing sessions, and the second group being interaction designers. By having both the subjects of the original user testing sessions and researchers participate in the Video Card Game separately, with the expectation that the themes arising from the two groups would show some interesting differences, it was hoped the results from the two groups would independently verify the validity of the data obtained in the previous studies (Chapter 4). As expected, the results did show that there were significant differences between the groups, due to different levels of knowledge of materials, content, and critique processes being followed by the two groups of participants in the study.

5.4.2 Video Card Game with the fashion design students

The themes produced by the fashion design students were focused more on the content of what 'actors were performing' in each of the video clips and also the content of the clip in terms of the actual fashion design process. For example, the participants' comments written on the cards (Figure 81) both indicated that the 'actors' in the dedicated video clips associated with those cards were 'performing' a somewhat similar action, which was identified as *selecting* digital artefacts.

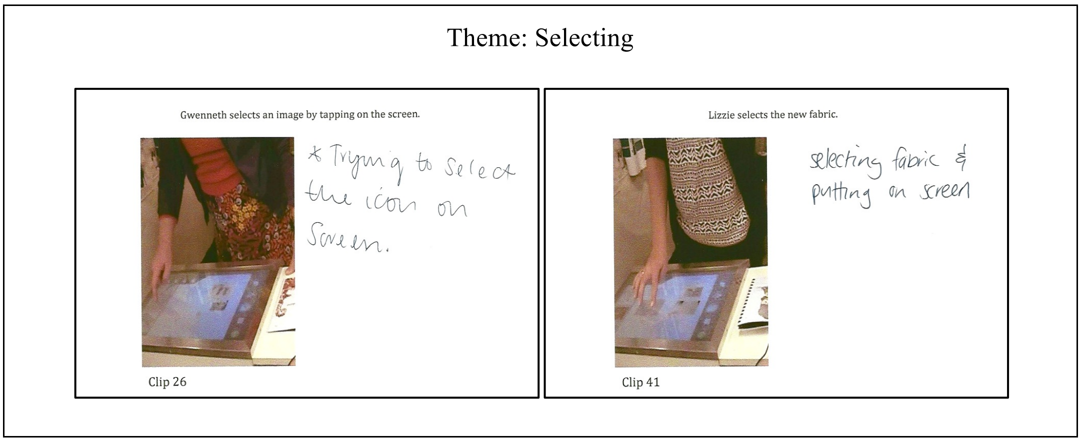


Figure 81: An example of two cards that were grouped under the theme – "Selecting" generated by the fashion design students during the Video Card Game study.

The fashion design students generated a total of sixteen individual themes, including Selecting, Navigating Systems And Changing Orientation, Pointing At Screen During, Conversation, Choosing /Conversing, Asking Advice And Seeking Confirmation, Showing And Explaining, Drawing, Looking And Searching, Communication With Partner, Changing Designs, Scrolling Selections, Putting Fabric Onto The Screen, Choosing Shape And Putting Shape Onto

Fabric, Resizing, Searching For Pattern and Asking Questions About Design theme (see Appendices section I example of cards for each theme).

During the group meeting session of the Video Card Game with the fashion design students, these individual themes were collected and formed higher level and more general themes (Table 17); *Communication & Discussion*, *Changing Design* and *Looking and Searching*. For example, the way fashion students came up with the *Communication & Discussion* general theme when one of the participants presented her theme *Discussing and Explaining*, some participants shouted out and said, *"I have got the same theme as you"*. One of the participants said she was not entirely sure if her themes *Communicating With Partner* and *Asking Questions* individual theme belong to the same group. However, based on the group discussion, everyone agreed that since those two individual themes were about 'communicating', they should fall into the *Communication & Discussion* main category theme.

	Overall themes generated by the fashion design students		
	Communication and Discussion	**Changing Design**	**Looking and Searching**
Individual themes	Asking Advice And Seeking Confirmation	Selecting	Navigating Systems And Changing Orientation
	Showing And Explaining	Drawing	Choosing /Conversing
	Communication With Partner	Resizing	Looking And Searching
	Pointing At Screen During Conversation	Changing Designs	Scrolling Selections
	Asking Questions About Design	Putting Fabric Onto The Screen	Searching For Pattern
		Choosing Shape And Putting Shape Onto Fabric	

Table 17: Individual themes by fashion design students that formed three general themes during group discussion.

The fashion design students decided that the *Changing Design* general theme (Figure 82) should have included interactions such as creating new design elements, which included selecting, adding, manipulating digital artefacts as well as drawing design sketches. The fashion design students believed that interactions that involved anything from navigating the TVTM prototype to scrolling fabric selection menus should belong to the *Looking and Searching* general theme.

Figure 82: Example of cards that belong to one of the main themes (changing design) by the fashion design students.

5.4.3 Video Card Game with the interaction designers

In comparison, the themes produced by the interaction designers were focused more on how the participants interact with the technology (Table 18), harnessing it for their purposes of sharing and critiquing alternative designs. Themes identified by the interaction designers included: *Gestures*, *Physical interaction without screen*, *Hand gestures to show something being talked about*, *Hand gestures to confirm something with partner* and *Hand gestures to show what to do*.

Themes from TAFE students	Themes from interaction designers
Communication & Discussion Changing Design Looking and Searching	Gestures Physical interaction without screen Hand gestures to show something being talked about Hand gestures to confirm something with partner Hand gestures to show what to do.

Table 18: Overall themes generated by the fashion design students (left) and the interaction designers (right).

For example, the interaction designers generated *Gestures* theme, based on their observation of actions found in the clips associated with the manipulation of objects on the screens. These manipulations involved the use of finger gestures such as standard multi-touch gestures for rotation, scaling, or drag and drop.

One of the interaction designers noticed that there were a lot of *Physical interactions* that were not associated with the multi-touch screen itself, and she clarified to the group that there were hand gestures that performed underneath the webcam and some of them were related to 'discussing'. *Hand gestures to show something being talked about* theme was referring to hand gestures that were performed to demonstrate something or using hand gestures to show the position of the waist or to show part of the image on the design booklet. *Hand gestures to confirm something with partner* theme was referring to hand gestures that were performed while participants in the clip were converging their conversation, for example, pointing to images in their designs or on the screen to confirm the things that they were talking about. *Hand gestures to show what to do* theme included hand gestures that were performed to request other physical actions such as 'lift this thing' or 'this is what I want you to do'.

5.4.4 Using Video Card Game to triangulate data

The Video Card Game was successfully conducted with two diverse groups of participants at the evaluation stage, and provided insight into how well the technology supported the actual content from the fashion design students, and from the interaction designers group. It additionally allowed the recognition of more general themes about how people use this kind of remote collaborative technology. For remote collaboration interaction, the themes were dependent on the specific context that they were working in. It was observed that participants from both groups were able to relate and compare FTF communications and interactions with the technology, especially when they compared the interactions to natural hand gestures and body language.

"Even though you can't see each other, you still use natural hand gestures/body language to communicate with each other" said one of the fashion design students during the group discussion of the Video Card Game. This indicated that the fashion design students were in fact thinking about how these natural hand gestures and body language related to FTF interaction, as well as the course work that they were undertaking, and the design processes that they were engaged in.

From the methodological perspective, the use of multiple data analysis methods should produce greater confidence in the findings. The video interaction analysis produces data from a strictly scientific analysis perspective, and the video assisted recall confirmed that my external analysis matched the subjects' perception. The video card game led to a collaborative engagement with the data, rather than a more scientific analysis, and allowed the identification of themes in the data from a collaborative rather than an individual analytic perspective. By conducting this video card game with subjects and researchers separately, there was to a degree, a correlation between the video interaction analysis and the video assisted recall in that there is effectively both participants and external researchers analysing the data. These methods allowed triangulation of the data to produce a more robust set of results.

The observational study showed that participants use hand gestures to talk about physical artefacts, to demonstrate ideas, and to position or to move artefact during FTF collaborations. The interaction designers generated similar themes from the Video Card Game study, confirming the validity of the data obtained from the observational study. Likewise, the data obtained from the Video Card Game analysis also confirmed the importance of gestures used during remote collaboration as reflected by the participants' feedback during the video assisted stimulated recall interviews.

Another objective of the Video Card Game study was the exploration of a participatory design approach to see how it can provide insights at a later stage in the design process, rather than the earlier stages where HCI researchers would normally encounter it. Working with higher fidelity prototypes allows more detailed analyses of technology-mediated interaction, with participatory explorations of how the affordances of the technology support the design activities that I am focusing on.

5.5 CHAPTER SUMMARY

In this chapter, I have explored a variety of methodological approaches to understand the requirements for technological support for remote collaboration in design. I was increasingly able to *triangulate* my results between the multi-stage evaluation study and also discover new findings such as the discovery of the social technical gap within the TVTM prototype. The combination of the Video Card Game, using diverse groups of players, alongside detailed video interaction analysis provided me with insights into which of the findings from the evaluation study I can have a greater degree of confidence in, and which findings warrant further study, and what impact 'decision on design' methodology can have on research outcome.

The process of identifying the social-technical intersection within the TVTM prototype was conducted through a multi-stage evaluation study. The results of the first stage of the evaluation study indicated that there were issues brought about by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype. Additionally, I was able to confirm that participants were able to learn to some degree about *what they can see of the others* and *what the others can see of them* (the intersection between the novelty and the asymmetrical access) while undertaking to achieve shared understanding, and initiate the necessary steps to compensate for these limitations. The data analysis also reconfirmed the theory of the social technical gap by Ackerman (2000), in which the *gap* is a technical problem and there is a need for fundamental understanding of the social aspect. The second stage of the evaluation was carried out using the video-assist recall interview methods, and the qualitative results were presented according to users' preferences, knowledge, comments and recommendations for the TVTM prototype. The results from the third and final stage of the evaluation were presented as two distinct sets of themes that were derived from the Video Card Game, by two different groups of participants; one from the fashion design students and the other from the interaction designer in particular the themes generated by the interaction designers confirmed the validity of the data that I have obtained in the observational study. It also confirmed the importance of gestures used during remote collaboration as reflected by the participants' feedback during the video-assisted recall interviews.

In the next chapter, I will discuss these four different elements of the social technical gap in more detail, and discuss how the TVTM prototype can support or minimise the gap in terms of what the prototype supports socially and technically. I will additionally discuss how mash-up technology can establish ways in which further research may prevent problems associated with the negative aspects, and advance the benefits of the positive aspects, of the four different elements previously identified.

Chapter 6: Discussion

I was inspired by Buxton's design principle "*let's do smart things with stupid technology today, rather than wait and do stupid things with smart technology tomorrow*" (Buxton & Moran, 1990). My design approach for the development of the TVTM prototype, which provides the translation mechanism from physical to digital artefacts, was user-centred rather than technology-driven. The findings from my evaluation study directly reflect upon the design of the TVTM prototype (a technological mash-up), to overcome the barrier between physical artefacts and the digital representation of those artefacts, and support remote fashion design collaboration. The findings showed that the design of TVTM prototype did support distributed collaborative design work, however there were overheads that required participants to put in 'extra work' in order to achieve a shared understanding during remote collaboration. These overheads were caused by the social-technical intersection, the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype.

This chapter focuses on discussing issues relating to the social-technical intersection. The chapter begins with a discussion on issues associated with establishing shared understanding during remote collaboration, including the requirement of a specific level of fashion design knowledge along with full engagement with the remote collaborative system to prevent misunderstanding, otherwise the need to reestablish the shared understanding. This discussion also covers the use of hand gestures to validate certain actions, and the importance of users understanding what information is relevant to the current interaction or communication, and how that information is presented in a useful and meaningful way to create common ground. This is followed by a discussion on how asymmetrical access occurs during remote collaboration, and also problems caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype, during remote collaboration. The chapter later discusses issues with overheads that are predominately due to design-unintended constraints during remote collaboration, and the need to switch communication channels or alter meta-talk in order to collaborate successfully during remote collaboration. These discussions ultimately form a principled way of dealing with the problem associated with the creation of shared understanding that is caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for remote collaboration.

6.1 ACHIEVING SHARED UNDERSTANDING

According to the data that I have obtained previously (section 5.2), users were required to have the same understanding of the conversation or the given instructions, so as to achieve a common ground before issuing instructions, or following instructions during remote collaboration. Participants therefore required a specific level of detail to gain a shared understanding, dependent on the complexity of the task they were undertaking, and the goals they were trying to achieve, while they were communicating with each other during the remote collaboration. There were many instances where the level of detail was clearly too low, and participants needed to clarify meanings during the conversations, in order to establish a shared understanding. It was also found that users needed to be fully engaged with the TVTM prototype at all times during the remote collaboration, or they might potentially lose some task critical information, which could possibly cause misunderstanding, with the subsequent need to re-establish a shared understanding. These findings suggest that an increased probability of achieving mutual understanding during communication requires more than overlapping *fields of experience* as Schramm (1954) suggested in the literature review.

I have also identified additional factors that could potentially influence the ability achieving mutual understanding during communication. The theme *'Asking advice & seeking confirmation'* produced by the group of the fashion design students from the Video Card Game study (section 5.4), reflects the recognition of the establishment of a shared understanding. Similarly, the theme *'hand gestures to confirm something with partner'* produced by the interaction designers' group resulted from the observed participants (fashion design students) in the video clips trying to use hand gestures to validate certain actions. This type of social interaction can also be seen as an effective way of creating a shared understanding or sharing of common ground (Clark & Brennan, 1991; S R Fussell et al., 2000; Schramm, 1954) thus preventing or minimising errors during remote collaboration.

Also my findings regarding the *shared/mutual understanding* confirmed Berlo's (1960) belief that the 'relationship'; *to create or to share information with one another* (Rogers & Kincaid, 1981), between the sender and the receiver is important, as it may affect the *mutual understanding* during the communication process as well as the outcome of a remote collaboration. Likewise, the choice and the use of suitable CMC technology has a significant impact on the establishment of the common ground, as the technology needs to be able to support the social interaction in order to achieve a successful remote collaboration experience.

In terms of the amount of impact when an organisation such as the fashion design firm adopts a new technology system like the TVTM prototype, "*the potential for significant* *transformations in people's work, in organizational business processes, and in organizational performance outcomes is sometimes – but not always – there*" (Markus, 2004, p. 4). It is crucial to maintain the same levels of shared understanding not only during the design and manufacturing stages, but also across the entire production cycle. The element of creating shared understanding for a distributed team (designers and manufacturer) can pose the threat of a major loss to a company, especially due to the nature of outsourcing. It is therefore important to create and maintain a shared understanding, knowing what is relevant to communicate, and how to present this information in useful and meaningful ways, for if there is a slight difference in assumptions, expectations and knowledge of construction in clothing manufacturing during the remote collaboration, it will potentially cause communication breakdown.

Tacit knowledge is highly personal (e.g. insight, perception, intuitions that stem from personal experiences etc.) and hard to formalise; this therefore makes it hard to share with others (Nonaka & Nishiguchi, 2001). In the fashion design world, tacit knowledge can also be associated with the specific clothing design know-how, clothing construction and crafting skills. Alternatively, explicit knowledge is the formal knowledge or technical language that can be transmitted and disseminated between individuals and groups. Fashion designers use design drawings and written design specifications that require a high level of fashion design knowledge and understanding, in order to understand them. Even though the explicit knowledge can be shared between two parties, it may be difficult to be understood by individual fashion designers or a manufacturer, without further introduction of previous clothing design experience, or the necessary clothing design skills into the area of question.

Since fashion designers and manufacturers often collaborate to resolve design or manufacturing issues associated with specific garments, there are two types of knowledge sharing that occur in this situation. One is categorised as *externalisation* (tacit to explicit knowledge) based on Marwick's (2001) conversion of knowledge theory between tacit and explicit form, when one party is responding to the question. Additionally, *internalisation* (explicit to tacit knowledge) can occur at the same time while one individual is trying to understand and internalise by creating his or her own tacit knowledge in order to act upon the information and "*these processes do not occur in isolation, but work together in different combinations in typical business situations.*" (Marwick, 2001, p. 815).

I agree with Marwick that knowledge management and creating and maintaining shared understanding cannot be easily addressed by technology (Marwick, 2001). Therefore, I believe the TVTM prototype is <u>not</u> the cause of the gap (in terms of technological limitations) between the social and technical aspects of *achieving* a shared understanding during remote collaboration.

However, the results from the evaluation study suggested that there was a problem *achieving* a shared understanding and this problem was due to the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for remote collaboration as will be discussed in the following section.

6.2 ASYMMETRICAL ACCESS AND NOVELTY OF THE TECHNOLOGY

During remote communications, an asymmetrical access occurs when the producer of the information that is to be exchanged is unaware that the receiver is experiencing some kinds of problem with the reception of this information, which, in most cases, to some degree limits the ability of the receiver to understand the conversation. In order to carry on the conversation, the receiver must initiate a *repair* to the conversation, because the producer may not be aware of the existence of any problem and consequently will not initiate the repair (Heath & Luff, 2000; Rintel, 2010). A simple way to describe the formation of asymmetrical access within the remote collaboration is that: I know what I am doing and I know you can see me but I am unable to see how you see me and how you perceive what I am currently doing (Heath & Luff, 2000). The asymmetrical access may potentially cause delays or uncertainty in responses, due to the technical distortion or issues with social interaction (Rintel, 2013b) .

The evaluation results showed that these asymmetries introduced into the interpersonal communication occurred when participants were trying to achieve a shared understanding during the remote collaboration. The occurrence of the asymmetrical access was dependent on both the complexity of the collaborative tasks, and on what type of information was required at the time in order to achieve a shared understanding.

The evaluation results also showed signs that the participants were learning what the TVTM prototype could do and what limitations the TVTM prototype had. The results showed that the participants not only had to learn how to use the TVTM prototype including the available modalities, and the function and limitations of each of these modalities in order to select the most appropriate modality for a given situation, but also to learn the concept of how to participate in remote collaboration using the TVTM prototype. There were some additional issues about how to deal with the technological idiosyncrasies of the TVTM prototype. The novelty problem of the TVTM prototype was expected, and was confirmed by the evaluation results. However, it was interesting to observe that even though participants were familiar with, and knew how to use, each individual type of the technology (e.g. the multi-touch screen technology, webcam technology etc.) in isolation, when it came to interaction with the mash-up of these various different types of technology into one system, they appeared to have issues related to the novelty of the mashed-up technology.

Even though participants were relatively unfamiliar with the TVTM prototype, as they used the prototype they became more familiar, and learnt that the prototype allowed the modalities to get through to the receiver. For example, the sender asked the receiver: 'can you see what I am doing here' to confirm that the same visual artefact could also be seen from the receiver's end. However, they did not necessarily know under which condition each modality was most effective, or how much information was being shared. These uncertainties caused overheads, and these overheads were considered to be as a result of the intersection between asymmetrical access and the novelty of the technology.

6.3 OVERHEADS

The findings from the evaluation study allowed me to reflect on the TVTM prototype, which was designed and developed with certain design-intended enablements that allowed users to achieve certain tasks, in addition to some design-intended constraints to limit or prevent operational problems. The findings suggested that the TVTM prototype exhibited some overheads issues that were mainly due to design-unintended constraints. These overheads can be described as *extra effort* that users are required to undertake in order to complete the task during remote collaboration. Overheads that take the form of design-intended constraints, design-unintended constraints and operational problems, were a direct result of the intersection between asymmetrical access and the novelty of the technology.

Design-intended Enablement	**Design-unintended Enablement**	**Design-intended Constraint**	**Design-unintended Constraint**
Textual: Text input using keyboard or IR pen. Annotations or drawings use IR pen.			**Limited processing speed:** IR pen lagging issue prevent participants from achieving smooth free-hand drawings.
Visual: Static images (from image database). Live images (from webcam captures).		**Common screen resolution:** Unified screen resolution between two different size multi-touch screens.	**Inappropriate screen resolution:** Limited screen resolutions reduced the ability to show correct colour and the detail of digital artefacts.
Tangible: Select images by dragging. Resizing images with two fingers. Move and scroll images with finger(s)	**Attention-getting:** Participants 'wiggled' the design up and down to get the visual attention from their remote collaborative partner	**Touch sensitivity:** Calibration for detecting multi-touch inputs was set to 'below average' sensitivity to achieve more consistent finger inputs detections.	**Concurrency:** Participants were able to interact with digital artefacts on the screen simultaneously, which subsequently caused system overload, and in some cases system breakdown. Participants sometimes needed to press hard on the screen in order for the

			system to recognise touch inputs.
Audio: Verbal conversations using embedded microphones and speakers.			**Audio level:** Microphone and speaker volumes were not high enough.

Table 19: Overall design-intended and design-unintended enablements and constraints of the TVTM prototype

The overheads caused by design-unintended constraints were mainly caused as the result of design-intended constraints as shown in Table 19. For example, in order for the screen sharing ability of the TVTM prototype to function correctly, a design-intended constraint was put in place to unify screen resolution between two different sized multi-touch screens. However, as the result of this design-intended constraint, it caused a design-unintended constraint, which limited the screen resolutions of both monitors and thus reduced the ability to show correct colour and the detail of digital artefacts.

Hardware & software malfunctions often cause operational problems. As I have found from the evaluation study in chapter 5, participants experienced occasional hardware malfunctions while interacting with the TVTM prototype. These occasional hardware malfunctions, in combination with some inherent hardware and software limitations of the prototype, directly affected the participants' choice of methods to communicate with another participant, while undertaking remote collaboration. The direct effects were frustration and confusion to the users during the remote collaboration as well as affecting users' choice of methods to communicate with the other remote user and in some severe cases, remote collaboration came to a halt.

Constraints (design-intended and design-unintended) and operational problems are considered as technical issues that can be either hardware or software related. Most of the constraints and operational problems can be overcome through bug fixing or by undergoing different hardware/software iteration design, however these have the potential to introduce additional unforseen overheads.

In real world settings, people who engage in collaboration apply various channels of interactions to cope with these complexities of workflow; in most cases, overhead or operating cost is involved (Neale et al., 2004; Short et al., 1976). If the group collaboration suffers from a high level of overheads, it is possible that the time lost due to these overheads may not be regained by the use of the richer communication channels, leading to a potentially less efficient collaborative experience, and possible abandonment of the joint activities.

Designers and developers may need to consider that the notion of overheads may be related to the notion of cognitive overload, which can be identified by tracking participants' thought processes while they are completing a task. New channels may not necessarily create overheads or eliminate existing overheads. Designers and developers of CMC systems can bring new channels into use for particular tasks, however overheads have an influence on how effective new channels are for users working remotely. Therefore they should not necessarily expect an immediate improvement to workflow. It is my opinion that richer communication channels may not necessarily equate to greater efficiency in the collaborative process as the new channels may potentially introduce further design-unintended constraints.

6.4 SWITCHING CHANNELS AND ALTERING META-TALK DURING REMOTE COLLABORATION

Social activity is fluid and nuanced (Ackerman, 2000) but when it comes to remote collaborative activities, there may be potential conflicts that lead to breakdowns between users. However, people are usually good at resolving breakdowns (Suchman, 1987) as seen in the Hindered Example 1 in Chapter 5, section 5.2.3 where one of the participants was able to recover from asymmetrical access (due to the particular participant being unable to see a particular webcam live image clearly on the multi-touch screen) by requesting a verbal description about that image or requesting an alternative or similar static visual image from the other remote user in order to continue with the rest of the remote collaborative task.

Technically, the TVTM prototype is not capable of detecting communication breakdown or overheads, however the prototype was built upon a mash-up of multiple rich communication channels that provide users with a number of alternative ways to compensate for these overheads during remote collaboration.

Yetim (2002) believes that when breakdown occurs, it should be considered as a potential solution to the problem, and I agree with the author's suggestion that "*a flexible communication system should provide users with means to define or change the existing properties or structures of the system*". (Yetim, 2002, p. 164) Socially, the multimodal features within the TVTM prototype allow users to send and receive fashion design information in a variety of ways through the use of multimodal representations. If a participant sends a message, and the participant receiving the message fails to interpret it correctly, it will potentially lead to a communication breakdown. However, since communication is circular by nature (McQuail & Windahl, 1997), when a user detects such an issue, the user would be able to recover from communication breakdown easily by re-sending the message using different modalities (switching channels) in order to re-establish the shared understanding, and at the same time preventing or reintroducing any communicative overheads.

Ackerman believes that the communication through CMC components allows people to make necessary social adjustments (Ackerman, 2000). Since knowledge by nature is contextual "*because what might be knowledge to one individual might not be knowledge to another*" (Hansen, p. 38), this adjustment includes the need for the ability to change to a different level of meta-talk during remote collaboration.

Fashion designers can produce prototype garments or design sketches of the garment as a way of conveying their thoughts about how the garment might work, and how it should be designed. The prototype garment has extensive tacit knowledge embedded within it, and can serve as a basis for feedback or problem solving without the need for fashion designers to describe distinctively their mental knowledge of the garment design. For example, I have identified in Assisted Example 4 (section 5.2.2.) where a participant was able to alter her meta-talk when it was needed to fully understand the conversation during the remote collaboration. This particular example shows one participant having difficulty trying to understand a drawing that had been done by the other remote participant. That remote participant subsequently had to alter her meta-talk in order to explain her drawing of a new swimwear top. This was achieved by pointing her finger at her design booklet under the webcam to explain that the drawing resembled the new bikini top design. Even though the first participant could not relate that drawing to a bikini top initially, she was subsequently able to associate the object 'bikini top' to understand and relate it back to the drawing that she had difficulty in understanding in the first place. Therefore "*people can see for themselves the way that knowledge is represented and negotiate shared meanings*" (Hinds & Pfeffer, 2003, p. 20) in order to repair a conversation.

I concur with Hinds and Pfeffer's (Hinds & Pfeffer, 2003) view that the expertise is predominately tacit, and is embedded within the context; in this case fashion design. For example, fashion designers have limited ability to explain their tacit knowledge compared to the way that they represent the knowledge in their memory. Therefore fashion designers may find it difficult to communicate the fashion design knowledge to other people such as the manufacturers. However, the theme "*hand gestures to show something being talked about"* produced by the interaction designer group during the Video Card Game study can be seen as explicating their tacit knowledge to others as well as altering the level of meta-talk during the remote collaboration. This process is considered to be dependent on the sharing and understanding of information during communication, coordination and collaboration interfaces (Fong, Valerdi, & Srinivasan, 2007) and it is thought to be a creative achievement by the users (Dittrich, 1998). Technically, the current state of the TVTM prototype allows this kind of behaviour; as Grudin (1994a) pointed out, this is not the case of lack of technical means, but instead it is users' interaction with cooperative activities in the use of the TVTM prototype. Socially, the TVTM prototype provides the mechanism for the switching of communication channels for users to effectively deal with the remote collaboration and also to preserve the flow of work.

6.5 CHAPTER SUMMARY

The TVTM prototype was designed and developed to provide the 'translation mechanism' to bridge the gap between physical artefacts and the digital representation of the artefacts. From the HCI point of view, the gap between the 'physical' and 'digital' can be seen as a 'social technical intersection'. Users of the TVTM prototype needed to gain mutual understanding, knowledge, beliefs and assumptions, in order to make sense of their roles in the context of solving fashion design problems during remote collaborations. They faced additional challenges, including asymmetrical access and the novelty of the mash-up technology, which caused potential overheads requiring additional effort to achieve a shared understanding during remote collaboration.

The phenomenon of the asymmetry during remote collaboration was dependent on both the complexity of the collaborative tasks, and on what type of information was required at the time in order to achieve a shared understanding. Therefore asymmetric access is both a technical and social issue.

As participants used, and became more familiar with the prototype, they learnt that the modalities allowed information, such as digital artefacts, through to the other remote collaborative partner. However, the participants did not necessarily know under which condition each modality was most effective in this information transfer, or how much information was being shared, causing overheads that were considered to be as a result of the intersection between asymmetrical access and the novelty of the technology.

Overheads can be described as extra effort that users are required to undertake in order to complete the task during remote collaboration, and were caused by design-intended constraints, design-unintended constraints and operational problems. The overheads caused by design-unintended constraints were mainly the result of design-intended constraints. The TVTM prototype was built upon a technology mash-up, providing multiple rich communication channels that allowed participants to compensate for these overheads during remote collaboration by changing channels and/or changing the meta-talk of the intercommunication.

The principled way of dealing with these overheads associated with achieving shared understanding that are caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype, are the requirements for users:

(1) to learn that there is an asymmetrical access,

(2) to learn the condition of the asymmetrical access in terms of overheads, which take the form of constraints and operational problem,

(3) to learn how to cope with overheads, which involves switching channels and altering meta-talk.

Chapter 7: Conclusion

7.1 THESIS SUMMARY

Due to the changes in manufacturing strategy within the fashion industry, most firms have adopted an outsourcing business strategy, in order to remain competitive with other firms around the world. Outsourcing improves overall manufacturing profitability, however the adoption of new technology for the fashion industry still remains an issue for firms that are trying to gain competitive advantage in an increasingly dynamic market. Therefore there is an increase in the need to support remote collaboration in the fashion industry.

There are a number of problems and considerations associated with designing a technology mash-up to support remote physical-digital fashion design collaboration. Fashion designers often use physical manipulation to compare various design ideas, trying different fabrics and colour choices to suit a particular design. One of the problems the fashion design industry faces, in the context of distributed collaboration, is that there is a gap between the physical artefacts associated with the process of fashion design, and the digital version of artefacts or the representation of those artefacts through technology. From the HCI perspective, the physical and digital barrier can be seen as a social technical intersection.

7.1.1 Summary of research methodology

In order to design and develop a solution using off-the-shelf technologies that can be combined or 'mashed up' to provide a physical-digital translation mechanism, designers and developers need to have a clear understanding of how fashion designers work with physical fashion design artefacts, and how these can be represented and shared as digital artefacts.

For any remote collaboration to happen successfully, it is important for the collaborative participants to achieve a shared understanding of the design problem, and the solutions. However, there are additional problems that the collaborative participants face in order to achieve a shared understanding, which include asymmetrical access and the novelty of the mash-up technology.

In order to identify these problems, a method of research in and through design approach (Dalsgaard, 2010) was used for the investigation. I exemplified the design process starting from an initial requirements study (in chapter 3) to understand the "problem space" within the business context of the fashion industry through interviews, followed by a series of qualitative studies in chapter 4 including the observation of the social interactions between remote collaborative participants, and gaining an understanding of the nature of the collaboration in the fashion design domain, with particular focus on the interactions with the physical design artefacts, and the different modes of representations (textual/visual/tangible) that fashion designers required during their (fashion) design process.

Using an iterative design process of data collection, I initially investigated the fashion design process within the teaching environment at the MSIT College, to identify and understand some of the work practices, and why certain design tasks are performed. In order to compare the data that was collected from the fashion education environment to the "real world" setting, I obtained additional data through the investigation of the interactivity of the actual design processes carried out in a normal clothing design company.

The concepts identified in these early studies were subsequently incorporated into a prototype multimedia and human-centred multimodal remote collaborative system called the TVTM prototype. This prototype consists of an inexpensive mash-up of currently available technologies, and was designed to support remote collaboration by providing a means of resolving issues between the actual garment design and the manufacturing of the final product within the business context of fashion design. The TVTM prototype allows users to select the most appropriate modality or combination of modalities to interact with other remote users, depending on what level of interaction they are currently involved in, either the task level, semantic level, syntactic level or interaction level.

I set out, through a multi-stage evaluation study, to investigate where and when the participants focus on the technology as a "relevant communication tool" during the remote collaboration. The second purpose of the multi-stage evaluation study, previously described in chapter 5, was to investigate how users of the TVTM prototype were dealing with the collaborative fashion design process or solving design problems during remote collaboration, within the business context of the fashion industry. I also investigated whether the remote collaboration could be assisted or hindered by the use of the TVTM prototype.

I have used a variety of methodological approaches for the evaluation study to understand the requirements for technological support for remote collaboration in design. In order to verify the data obtained from these previous studies, I chose and adopted Buur's Video Card Game method to explore a more socially focused, design-focused and playful approach to working with the same video data in collaboration with teams of fashion design students who had participated in the previous multi-stage evaluation study, and interaction design researchers. I was also able to use the Video Card Game to triangulate the qualitative data that had been collected using different methods between different studies.

7.1.2 Summary of findings

Through the iterative design process of data collection, I initially gained insights into the fashion design process within the teaching environment, identifying and understanding some of the work practices that are similar to the real world environment, and why certain design tasks are performed. In particular, I recognised the need for visual and tangible elements of communication during the fashion design process. I found that fashion designers required different modes of interaction and representation during individual as well as collaborative work. These ‘requirements’ allowed me to be able to make reasonable assumptions as to what users would do (socially) in which situation, and what kinds of modality (technically) they would likely use to achieve successful remote collaboration.

From the user requirements studies, I then identified the kinds of technology that are best applied to solve the business problem in the context of remote collaboration in the fashion industry, and identified five types of input modality that would be able to enhance users’ remote collaborative experience within the TVTM prototype; speech, text and annotation, tactile, gestures and graphic. Visual, auditory and tactile modalities are human-action modalities. Each type of input modality corresponds to one of the human senses. The TVTM prototype allows users to select the most appropriate modality or combination of modalities to interact with other remote users, depending on what level of interaction they are currently involved in, either the task level, semantic level, syntactic level or interaction level. I have identified issues that are brought about by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype. The empirical findings confirmed that participants were able to learn to some degree about what they can see of their remote collaborators through the shared screen of the TVTM prototype, and what their remote collaborative participants can see of them, while trying to achieve shared understanding.

The empirical findings also confirmed the existence of different types of overheads as the result of the social technical intersection, which required users to do extra work in order to achieve a shared understanding during remote collaboration. The evaluation study identified that users resolved the problem of overheads by either changing communication channels using the multimodal abilities of the TVTM prototype, or changing the meta-talk during the interpersonal communications. However, problems caused by the complexity underlying the social activity are difficult to resolve.

The empirical findings from the Video Card Game confirmed the importance of gestures used during remote collaboration, as reflected by the participants’ feedback during the video-assisted recall interviews. I have found that the use of the Video Card Game at the evaluation stage can lead to a collaborative engagement of the analytical process of the video data, rather than a more scientific analysis.

As expected, the methodological findings from the Video Card Game showed that there were significant differences between the themes identified by fashion design students and by the interaction design researchers. This is considered to be due to different levels of knowledge of materials, content, and critique processes being followed by the two groups of participants in the study. The themes generated by the interaction designers confirmed the validity of the data obtained in the observational study.

I found that when people are using verbal communications to communicate during remote collaboration, there is a limitation in terms of how far they are able to fall back to the other richer and nuanced communications such as body language that occur naturally during FTF communications. My assumption was that using a tangible based interaction modality combined with audio and visual communications would address this shortcoming in the CMC. However, I have found that the problems associated with social computing such as the social-technical gap that Ackerman (2000) proposed still remain, even with the use of a combination of current technologies that are mashed together. Therefore, it is my opinion that the social-technical gap can be found between the TVTM prototype, and the social requirements such as the need to change to a different level of meta-talk during remote collaboration dictate how well the TVTM prototype will fit in an organisation such as a fashion design firm.

However, I have a different view with regards to the theory of social technical gap by Ackerman (2000). My evaluation data suggested that the gap between social requirements and technical feasibility relies on several human factors rather than the technology itself. For example, in order for users to take full advantage of the TVTM prototype, they will need to become familiar with the prototype, as the adaptation and familiarity can promote new and more effective communication among remote users during their remote collaboration. However, this is dependent on the user's technology literacy and the user's technological acceptance. Theoretical findings from my research indicate that there are other human factors such as a user's ability to exchange and convert between tacit and explicit knowledge during events such as problem solving in the context of fashion design and manufacturing, as well as the ability to understand the tacit knowledge associated with the specific clothing design know-how, clothing construction and crafting skills during remote collaboration. Hence, the social technical gap of any remote collaborative system is dependent on human factors.

This social-technical gap is an entirely different metaphor to the physical-digital gap that I have previously addressed. While the TVTM prototype was designed and developed to provide the ‘translation mechanism’ to bridge the (physical-digital) gap between physical artefacts, and the digital representation of those artefacts, an additional problem arose during the process of achieving a shared understanding. That problem was due to the social technical intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for remote collaboration.

These findings ultimately form a principled way of dealing with the problem associated with the creation of shared understanding that is caused by the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of using the TVTM prototype for remote collaboration. Therefore, in order to improve the current design of the TVTM prototype, designers and developers must understand the requirements for users to learn that there is an asymmetrical access, to learn the condition of the asymmetrical access in terms of overheads, which take the form of constraints and operational problems, and also to learn how to cope with overheads, which involves switching channels and altering meta-talk.

7.2 RESEARCH CONTRIBUTION

Pycock and Bowers (1996) are two of the early researchers who conducted their ethnographic research in the fashion industry to inform the development of a CSCW system using Virtual Reality (VR) technology to support cooperative information retrieval and visualization of 3D splines or cloth animation. The “designing for fashion” is the overall scope of my research. The ethnographic research work by Pycock and Bower as well as many other related work into collaborative technologies inspired me to conduct a more detailed research in the filed of CSCW to learn how the design of a technological mash-up can overcome the barrier between physical artifacts and the digital representation of those artifacts, to enhance and support remote fashion design collaboration. There are a number of contributions of this thesis in the research area of supporting remote collaboration for the fashion industry. They are as follows:

The methodological contribution of the thesis was the exploration of the use of the Video Card Game method at the evaluation stage of the design process, to allow the identification of themes in various data from a collaborative view rather than an individual analytic perspective. Therefore, the use of the Video Card Game in the later stage to validate a combination of other methods may contribute to how other interaction design researchers could potentially conduct and confirm their analysis using such an approach in the future. Also, researchers would be able to conduct the Video Card Game in the evaluation stage to both analyse what kinds of impact their ‘decision on design’ methodology have on their research outcome, and improve their subsequent design based on their Video Card Game analysis.

The other (design) methodological contribution is the use of mashed up technology in designing and developing the TVTM prototype to assist remote collaboration for the fashion industry. Unlike most of the systems that I have previously described (section 2.4.2 to 2.4.5), the novelty and the uniqueness of the TVTM prototype are due to the way it was designed and developed in a short period of time using the mash-up of multiple readily available current technologies such as multi-touch screens, projectors, infrared pen, webcams, networked computers, microphones and speakers, with each providing its own unique features. Therefore, designers and developers who wish to support artefact-focused interactions with shared digital artefacts during remote collaboration, can quickly come up with different prototypes in a similar way, by mashing a variety of currently available technologies to provide flexible yet very rich communication channels for users to use during remote collaboration.

The theoretical contribution of this thesis is twofold. Firstly, the thesis contributes to the discovery of the intersection between the asymmetrical access of the interpersonal communications and the novelty aspect of a remote collaborative system. This social-technical intersection is build upon an extension with a variation to the social-technical gap theory by Ackerman (2000). I believe designers and developers should be aware of the social-technical gap, as they are required to have a fundamental understanding of the social aspect when designing and developing a CSCW system, but should be focusing on how to minimize the gap. As Dourish pointed out that "*design is critical, but designs must always be put to work in particular contexts, adopted and adapted by people in the course of practice*" (Dourish, 2006, p. 546). In my opinion, the TVTM prototype can potentially be affected by the social-technical gap, but it does not mean that the system is poorly designed or suffers from a lack of usability. Designers and developers need to realise that the usability of the TVTM is user dependent and dynamic, as my research finding suggested that each user of the TVTM system has a different perception of the usability of the system during a collaborative exchange.

A set of empirical findings form the second part of the theoretical contribution. These include the articulation of the meta-social-technical talk during remote collaboration, and the need to switch communication channels or alter the level of meta-talk, in order to collaborate successfully during remote collaboration. Also, the identification of overheads caused by design-unintended constraints implies that the designers and developers of the remote collaborative system should be aware of the 'extra effort' that may be required from users in order to achieve a good shared understanding during remote collaboration.

While some of the issues relating to overheads may be large at the initial stage, these overheads may reduce over time due to users' increasing familiarity with the system. Designers and developers need to be aware that if the group collaboration is affected by a high level of overheads, users may not only have a less efficient collaborative experience, but there exists the possibility of the abandonment of the joint activities altogether. Designers and developers who wish to introduce new communication channels to their existing system should consider the possibility that these overheads may be related to the concept of cognitive overload, however this can be confirmed by tracking users' thought processes while they are completing a remote collaborative task. Therefore, designers and developers should bear in mind that richer communication channels may not necessarily equate to greater efficiency in the collaborative process, as the new channels may potentially introduce further unforeseen design-unintended constraints.

7.3 LIMITATIONS

Since the context for this thesis is focused on the fashion industry, when I began my initial requirement study, I had intended to conduct my research with the fashion designers and employees from a fashion design firm in Taiwan, however, due to the geographical restrictions, I had to seek alternative firms that were willing to participate.

Unfortunately, I was unable to find a similar clothing design firm locally in Brisbane to conduct subsequent field work after I had conducted the initial requirement study with fashion designers and employees from the department at the fashion design firm. The validity of my data was somewhat limited by the type of participant that I have chosen in chapter 4. The subsequent observational study was conducted at the MSIT College with a class of fashion design students in their final semester. In my opinion, those fashion design students who participated in my research were considered one of the best alternative groups other than the fashion designers from a "real world" clothing design firm as they were in the advance stages of acquiring skills of the professional fashion designers. They were a good choice for proxy for actual fashion designers as they were not entirely novices. They were a graduation away from being employable as fashion designers and they were on track to become professional fashion designers.

However, I had an opportunity to visit Taiwan again a few months after I had conducted the observational study with the fashion design students. I was able to conduct contextual interviews with the same group of fashion designers and employers at the fashion design firm where I went to conduct my initial interviews. The purpose of the contextual interviews was to validate my findings from the observations that I had conducted at the fashion design college.

Another reason for not being able to conduct my user testing using the prototypes that I have constructed with the fashion designers was that the prototypes were too large; therefore they were too hard to transport to the design firm in Taiwan and also to the manufacturers in china. The multi-stage evaluation study that I have described in Chapter 5 was conducted with another group of fashion design students. Although the study was conducted with a different group than the first group who participated in Chapter 4, section 4.1, the second group had similar fashion design skills compared to the first group because the second group were also in their final semester.

I acknowledge that the number of participants in my studies may also contribute to the limitations of the validity of my studies. However I have experienced difficulties recruiting participants (both fashion design firm and also the MSIT College). For instance, there were a total of eight fashion designers and employees from the design department of the fashion design firm who participated in the initial interviews and also contextual interviews. On the other hand, there were only seven students in the first group of the fashion design students from MSIT College as well as one teacher who participated in the same classroom for the observational study. Similarly, there were eight students who participated in the user testing and evaluation study. With regards to the fashion design knowledge and skill differences between the two different types of participants (students versus fashion designers), in my opinion, even though the fashion design students may not have the “real world” experience compared to the fashion designers, the clothing design skills that the students have learnt together with their basic understanding of the current “real world” manufacturing process through their teaching course may be sufficient to understand the “real world” problems that some clothing design firms are currently facing. Therefore I believe that, in choosing the fashion design students to participate in some of my research, I have used the best alternative group of participants beside the actual fashion designers and their offshore manufacturers.

I conducted the Video Card Game study with the two diverse participants; fashion design students and interaction design researchers. The fashion design students who participated in my evaluation study (including the video-assisted recall interview) also participated later in the Video Card Game study. The limitation and the risk of the validity of the data in this case was that the participants who were participating in both video-assisted recall interview study and the Video Card Game study might have generated some of their themes for the Video Card Game based on the knowledge and the discussions that occurred during the video-assisted recall interview. However, it was very difficult to detect and identify whether the fashion design students did in fact “borrow” some of the ideas from the previous studies for the Video Card Game.

7.4 FUTURE WORK

The future research work will cover a number of areas. First, the TVTM prototype can undergo another iteration based on the feedback from the evaluation study. This feedback can be applied to improve both software and hardware components of the prototype. Typically, the hardware could be upgraded to a newer, more reliable and more responsive multi-touch screen incorporating the latest technology, as well as the benefits afforded by the faster computer processing power and faster network configuration and infrastructure between the two remote locations.

As I have previously stated, in order to overcome the limited validity of my research data due to the limited number of participants, future research should consider the recruitment of an increased number of participants from within the fashion industry. In order to broaden the scope of the data, participants could be recruited from a number of different design firms, and also a broader demographic that may contribute to differences in users' technology literacy and users' technological acceptance.

It was noted from my user testing findings that objects (such as a keyboard or ruler), which replicated the attributes of their physical counterparts, were less useful than the more abstract interactions such as the scaling of patterns. Therefore it would be an interesting topic for a future study to determine whether removing as many traditional interface elements as possible, and replacing them with a more gestural navigation would help reduce these issues.

Finally, future research should consider the deployment of the TVTM prototype in an actual workplace for an extended period of time, which would potentially enhance learnability as well as increase users' familiarity and the acceptability of the TVTM prototype.

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Appendices

A. Ethical Clearance, Information Sheet, Consent Form And Gatekeeper Letter For Conducting Observational Study At MSIT College (Formally Known As Moreton Institute of TAFE) In 2006.

B. Observational Raw Data Collected Across Six Sessions At The MSIT College.

C. Observations And Contextual Interviews At A Fashion Design Firm In Taiwan

D. Quick And Dirty User Testing Information Sheet And Questionnaire.

E. Ethical Clearance, Information Sheet, Consent Form And Gatekeeper Letter For Conducting Research Studies At MIST College In 2009.

F. Ethical Clearance, Information Sheet, Consent Form And Gatekeeper Letter For Conducting Multi-Stage Evaluation Study At MSIT College In 2011.

G. TVTM User Interface (Screen Captured)

H. Transcripts for chapter 5, section 5.3

I. Example of cards generated for each individual theme by the fashion design students during the Video Card Game study

A. Ethical Clearance, Information Sheet, Consent Form And Gatekeeper Letter For Conducting Observational Study At MSIT College (Formally Known As Moreton Institute Of TAFE) In 2006.

CLEARANCE Nº (office use only)

THE UNIVERSITY OF QUEENSLAND

Application Form for Ethical Clearance for Research Involving Human Participants

For review by: **Medical Research Ethics Committee (MREC)**
Behavioural & Social Sciences Ethical Review Committee (BSSERC)
For Staff and Student Research
Refer to last page for website and other information, including mailing address

Please tick boxes:

MREC		BSSERC	
Full Review		Expedited Review	√

Project Title:
Fashion Parade Observational Study

Principal Investigator:	Jason Shih-Sheng Yang
Staff Nº/Student Nº: (cross out if not relevant)	30092824

Co Investigator/s:	
Project Co-ordinator (or authorised contact)	

Supervisor/s: (if applicable)	Dr. Stephen Viller Mr. Theodor Wyeld

Schools/Departments:	The School of ITEE

	Telephone	Fax	Email
Contact details of Principal Investigator	07- 3365 1634 (0412088029)		jyang@itee.uq.edu.au
Contact details of Project Co-ordinator or authorised contact			

Degree Enrolled (if student):	PhD
Funding Body:	
If Project Funded - What year? - Reference no. if available	

Project Location:	St. Lucia	Project Duration:	2 Months

A. **Is this submission identical or very similar to a previously approved protocol?** YES/NO (circle)

If **YES**, please provide clearance no° **and** indicate whether identical or very similar):____________________

B. **Does this submission hold other ethical clearance?** YES/NO (circle)
Note: Copies from other **AHEC** fully registered ethics committees must be attached.

C. **Are you applying for Expedited Review?** YES/NO (circle)
Note: Please see UQ Guidelines page 9 for the conditions necessary to qualify for Expedited Review.

D. **Is the project a Clinical Trial (eg, a trial of a drug, device, therapy, intervention, treatment, etc) ?** YES/NO (circle)
If **YES**, please specify:____________________

PLEASE ANSWER ALL OF THE FOLLOWING QUESTIONS:

1) Who are the participants or informants?: e.g., Children, University students, or other persons.
Note: Details of approximate **number**, age range, and male/female ratios are required.

Students and staff members of the fashion department at the Moreton Institute of TAFE in Brisbane.

2) Vulnerable Groups

The NHMRC has identified certain social groups as vulnerable and requires all researchers to take special care to protect the interests of these groups if they are in any way involved in the project. Those groups include: **children** (Section 4); **intellectually disabled** (Section 5); **those people highly dependent on medical care** (Section 6); **those people in dependent relationships** (Section 7); and **collectivities with their own social structures linked by a common identity and or common customs** (Part 8). Separate guidelines have been developed for **Aboriginal and Torres Strait Islander Peoples** (Part 9).

In preparing your research project and application for ethical clearance, you should investigate thoroughly, through consultation with supervisors, colleagues in your school and other professional groups/organizations, how these vulnerable groups may or may not be represented in your research.

Note: If participation of vulnerable groups is a focus of the research, the protocol can not qualify for expedited review (unless other current HREC clearance is held and a copy provided).

2a) Aboriginal and Torres Strait Islanders Group

Specify how this proposal accommodates / addresses the needs and interests of any Indigenous Australians who may be involved (as part of a sample, as volunteers or as the specific focus of the research). [For further assistance on indigenous cultural issues, please contact the UQ Aboriginal and Torres Strait Islander Studies Unit.]

no participation likely	some participation likely	a focus of the research
☐	✓	☐

Provide a careful and considered rationale for your response: [Reasoning for the exclusion or inclusion of strategies to focus on this group must be clearly stated in your application for ethical clearance. All three possible responses require a considered statement, detailing your rationale]

There are some indigenous students in the class; therefore it is likely that they will participate in my research. They are not, however a focus of this research and so will not receive different treatment to other participants.

2b) Other Vulnerable Groups

Specify how this proposal accommodates / addresses the needs and interests of any of the above groups that may be involved (as part of a sample, as volunteers, or as the specific focus of the research). – Specify the groups.

no participation likely	some participation likely	a focus of the research
☐	☑	☐

Provide a careful and considered rationale for your response: [Reasoning for the exclusion or inclusion of strategies to focus on any of these groups must be clearly stated in your application for ethical clearance. All three possible responses require a considered statement, detailing your rationale]

I am aware of the fact that I am dealing with the student and staff members in the same department, there is an inequality in terms of the relationship between them, but this is not the focus of my study. My interest is to observe their interactions only. Their participation in my study is entirely voluntary and they are free to withdraw at any time without penalty.

3) Participant recruitment details: Please provide exact details of contact.

There will be two types of recruitment; one for the fashion parade committee, and the other one for the students involved in the fashion parade. I will first contact the head of fashion parade committee and request permission to attend the monthly meeting. After permission has been granted, I will attend the next fashion parade committee meeting and give a brief introduction about the study, and my presence as an observer. During the brief introduction, I will hand out the information sheets and consent forms to all the members who wish to participate in my research. I will then collect the consent forms at the end of the meeting and exchange contact details for those potential participants.

In order to ascertain which students will be involved in the fashion parade, I will liaise with the course teacher to collect the names of the participating students. I will then contact the participants via email with the information sheets and consent form.

4) In EVERY-DAY or LAY LANGUAGE please provide a summary of the project – including aims and benefit: This section MUST be completed in LAY LANGUAGE.

The aims to this project are to study collaboration around the organization and running of the fashion event, with a particular focus on the collaboration and coordination of the people involved.

I will first examine and observe the way people interact during various phases of the manufacturing of a garment, when these people are in the same location. I want to identify the various types of information that are exchanged and the manner in which this information is exchanged. In particular I want to observe the gestures used, methods of illustration, and methods of clarifying in a face-to-face situation.

After collecting the results from the observational studies, I will analyse and identify the key elements of the interaction in face-to-face situation from the data I collected of this project. The benefit of this project is to observe a broad range of face-to-face interaction in a setting that is as close as possible to a natural working environment in a fashion process.

5) Give details of the research plan:

Note: The committee needs sufficient information to put into context the ethical considerations listed in later questions.

Note: This section should be completed in LAY LANGUAGE *as much as possible* so that it can be understood and appreciated by all Committee Members, including Lay Members.

Note: For application to the MREC – please keep response to a MAXIMUM of 2 pages.

The focus of the study is the annual fashion parade event. I will recruit students doing Diploma of Textiles Clothing and Footwear and also Advance Diploma of Textiles Clothing and Footwear who will be involved in the annual fashion parade event and also members of the fashion parade committee.

The observational study will take place throughout the semester and towards the end of fashion parade. My initial plan is to attend the monthly fashion parade committee meeting as soon as I have permission to observe the meeting. As for the students involved in the fashion parade, I will start observing the students twice a week starting from second week of April until the end of their first semester which is 20th-June 2006. The observational study will resume from 2nd-July 2006 until mid September when the fashion parade will take place. I will also be observing in the back stage during the fashion parade event. I will conduct informal interviews at a time convenient for the participants after meetings/observations in order to clarify notes taken during observations.

My observational study will be mixture of 'quick and dirty' ethnographic study with elements of informed ethnographic study. The reason why I have chosen to use quick and dirty ethnographic study is that it is capable of providing an informed sense of what the design work is like in a short period of time. As for the informed ethnographic part, I will be observing the participants doing their project for the fashion parade in their environment. I will be taking notes and also voice recording as a backup for my note taking, information to be recorded including dialogues between participants and other students, descriptions of non-vocal aspects of interaction such as gestures and body language; and also descriptions of interaction between people and machines at the end of each session. The interaction analysis will take place after I have completed all my observational study.

6) Give details of the ethical considerations attached to the proposed project:

In this setting there is potential for a student and staff power relationship as the students are already in a collaborative relationship with the staff in order for the fashion parade to take place. The key to overcoming this is by obtaining informed consent, and making it completely clear and easy for student to withdraw from my study if they wish. Therefore the students are not under any pressure at all to participate in this project, even though their teachers are involved. All participants will understand that should for they chose to withdraw for any reason, there will be no penalty for them, and their participation will not affect their grades for the course they are doing.

The presence of the observer (in this case me) in the classroom could potentially affect students performance. In order to minimise this potential issue, the observational study should occur later in the course which should minimise the problem.

All participants will be treated fairly and with dignity, and the participant's interests will be protected.

The nature of this research should ensure there is no physical risk from retribution or mental risk to the participants, all participants will be treated equally, and there will be no discrimination. (age, gender, ethnic etc).

Should there be any problems during the meeting of fashion parade committee, I will remove myself from the meeting room immediately. If the students become uncomfortable with my presence during the observation, I will discontinue the observation, and remove myself immediately.

7) How will informed consent be obtained from participants or informants?

After meeting with the fashion parade committee, I will hand out the information sheets including consent forms to all the members who wish to participate in my research. I will then collect the consent forms with participants' signature at the end of the meeting.

In order to ascertain which students will be involved in the fashion parade, I will liaise with the course teacher to collect the names of the participating students. I will then contact those students via email with the information sheets. For those students that wish to participate my study, I will give them a consent form each to fill out and request it back either by post or collect in person.

8) Provide details of procedures for establishing confidentiality and protecting privacy of participants or informants:

Participants will be clearly informed that the data collected from my observational study will only be used in my research also their personal details such as name will be de-identified.

9) Provide details of data security and storage:
Refer to the NHMRC National Statement, Section 14.

Information relating to the site and facility (fashion department) will be kept confidential.

Recorded data such as paperwork, audio clips will be stored in a secure locked cabinet and all digitally recorded material will be password protected.

10) In what form will the data be <u>collected</u>: Note: Tick the most appropriate box:		
(i) Identified ☐	(ii) Potentially Identifiable ☑	(iii) De-Identified ☐

11) In what form will the data be <u>stored and/or accessed</u>: Note: Tick the most appropriate box:		
(i) Identified ☐	(ii) Potentially Identifiable ☑	(iii) De-Identified ☐

12) Give details of how feedback will be available to participants or informants:
My email contact will be available on information sheets and consent form. Documents for the observational study will be made available upon request via email or post.

13) Does the project involve any of the following possibilities? If YES, Give Details

a) The use of drugs.

No

b) Any invasive procedures (eg blood sampling)

None

c) The trial of any intervention, therapy, or treatment (whether medical, behavioural, physical, or other)

No

d) The trial of any device

No

e) The possibility of physical stress/distress, discomfort

No

f) The possibility of psychological/mental stress/distress, discomfort

No

g) Deception of/or withholding information from, participant at ANY stage of the project

No

h) Access to data held by a Commonwealth Department or Agency (Please also specify the number of records to be accessed)

No

i) Access to data by bodies or people other than the investigators (eg. Medical Records)

No

14) Please Indicate What You Think Is The Level Of Risk For Prospective Participants Against The Scale Below: *Tick the most appropriate box. (Refer to the UQ Guidelines)*

☐ **Extreme Risk**
☐ **High Risk**
☐ **Some Risk**
☐ **Minimal Risk**

√	No Foreseeable Added Risk Above the Risks of Everyday Living

15) Please provide details to assist the committee as to why you indicated the level of risk to prospective participants or informants in the question above (Question 14):
N/A
16) How has the possibility of withdrawal from the project been addressed?: **Note:** Ensure that details and effects of withdrawal without prejudice AT ANY TIME have been considered and explained. Refer to the NHMRC National Statement section 1.12.
Should any participant withdraw from the project, any identifiable information about them that has been gathered up to that point will be destroyed. If a participant has decided to withdraw after an interview, all interview data will be destroyed, any observational notes specifically about that participant will also be destroyed and from that point in time, I will not engage with that individual further about the project.

Please note that this section (Question 17) must be completed for funded research or the application will not be processed.

17 a) Is this project receiving financial support to conduct the research? YES/NO (circle)
17 b) If Yes, from what source(s)?
17 c) Who will be administering the budget?
17 d) Please provide details of the budget distribution. (Or attach a copy of the budget statement.)
17 e) Provide details of any other "in kind" support for the project or direct or indirect payment to any investigator:
17 f) Please provide details of participant reimbursement for their involvement in the Project, if any: **Note:** This could be cash payment, food vouchers, free services, or movie passes, etc.
18) In undertaking this research do any "conflict of interest" issues arise? **If YES, please provide details.** **Note:** Conflict of Interest may arise, for example, because a researcher, or someone close to the researcher, stands to benefit financially from the research or the carrying out of the project or because inconsistent or incompatible obligations exist. Refer to Sections 2.20-2.21, & 12.5-12.6 of the NHMRC National Statement:
NO

19) Is the project a multi-centre or site project? If YES, provide the name of the principal ethics committee. Please provide copies of any conditions or requirements placed by other AHEC registered Human Ethics Committees: **Note:** The Principal Ethics Committee is the Institutional Ethics Committee where the budget is to be administered.
NO

20a) Some projects may involve permits from National Parks & Wildlife in relation to collection of data and Native Title issues. How have you addressed this issue?: (Refer to the UQ Guidelines)	
NO	
20b) Does the project require biosafety clearance?	YES/NO (circle)

(Sample For Committee members)

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences &
Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(07- 3365 1634, mobile: 0412088029)

INFORMATION SHEET

Title of Research Project: Building a framework of a global shared workspace system within virtual collaboration environment

Name of Principal Investigators: Jason Shih-Sheng Yang

My research is focused on designing a computer system that will potentially allow businesses that have manufacturing departments located remotely to function as effectively and efficiently as if they are in the same location. I have chosen to carry out my research in the fashion industry because it is a good example of a distributed manufacturing industry.

I would like to first examine and observe the way people interact during various phases of the manufacturing of a garment, when these people are in the same location. I want to identify the various types of information that are exchanged and the manner in which this information is exchanged. In particular I want to observe the gestures used; methods of illustration; and methods of clarifying and understanding in a face-to-face situation.

I will be observing the behaviour of the fashion parade committee members as if they are the project managers. The observational study will take place at the monthly meetings. Once each meeting has finished, I may ask some questions of specific committee members regarding events that took place during that meeting to clarify my observations only. This will only occur after the meeting has finished so there is no interruption to the meeting. The information you give will remain confidential. Only the investigator of the project will have access to your responses and also recorded footage. The results of this research will be made available once the study is finished in late 2006. If you would like a copy please contact me.

This study has been cleared by one of the human ethics committees of the University of Queensland in accordance with the *National Statement on Ethical Conduct in Research Involving Humans* guidelines. You are of course free to discuss your participation in this study with my associate advisor (Dr Theodor Wyeld on (07) 3381 1381). If you would like to speak to an officer of the University not involved in the study, you may contact the Ethics Officer on (07) 3365 3924.

This form is yours to keep. If you have any questions regarding this project I will be happy to answer them. You can contact me on (07) 3365 1634, 0412 088029 (mobile) or alternatively email me at jyang@itee.uq.edu.au.

Jason Shih-Sheng Yang
PhD Student
The University of Queensland

Complaints may be directed to the Ethics Officer, The office of Research and Postgraduate Studies, The University of Queensland, QLD 4072 AUSTRALIA (phone 07-33653924, fax 07-33654455, email humanethics@research.uq.edu.au).
Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome

(Sample For Students)

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences &
Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
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I would like to first examine and observe the way people interact during various phases of the manufacturing of a garment, when these people are in the same location. I want to identify the various types of information that are exchanged and the manner in which this information is exchanged. In particular I want to observe the gestures used; methods of illustration; and methods of clarifying and understanding in a face-to-face situation.

For the students involved in the fashion parade, I will be observing the design process from beginning to the final product. The observational study will take place through out the semester and to the end of fashion parade. Each session will take approximately 1-2 hours. I may ask you a number of questions about your activities. The information you give will remain confidential. Only the investigator of the project will have access to your responses. The results of this research will be made available once the study is finished in late 2006. If you would like a copy please contact me.

This study has been cleared by one of the human ethics committees of the University of Queensland in accordance with the *National Statement on Ethical Conduct in Research Involving Humans* guidelines. You are of course free to discuss your participation in this study with my associate advisor (Dr Theodor Wyeld on (07) 3381 1381). If you would like to speak to an officer of the University not involved in the study, you may contact the Ethics Officer on (07) 3365 3924.

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Jason Shih-Sheng Yang
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(Sample For Committee members)

School of Information Technology
& Electrical Engineering
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PhD Student: Jason Shih-Sheng Yang

The University of Queensland
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Australia
Contact: jyang@itee.uq.edu.au;
(07- 3365 1634, mobile: 0412088029)

CONSENT FORM

Title of Research Project: Building a framework of a global shared workspace system within virtual collaboration environment

Name of Principal Investigators: Jason Shih-Sheng Yang

I agree to take part in the observational study exploring my activities and interactions regarding my involvement in the fashion parade committee as explained on the information sheet.

I have read (or had read to me) and understood the Information Sheet that explains the research project.

I am aware that all the data collected will only be used for its stated purpose and my personal details will remain confidential. Should I be quoted in the report, my identity will remain undisclosed.

I am aware that I may not gain anything from taking part in this research. I also understand that I am not being graded on my participation in this study and I will not be affected academically should I discontinue my involvement.

I understand that this survey is voluntary and I am free to ask questions or to withdraw from participation at any time without penalty.

CONSENT BY PARTICIPANT

I have read, or had read to me, and understood all the information provided. I agree to take part in the research as described in this consent form.

Signature of Participant Date

____________________ ____________________

Complaints may be directed to the Ethics Officer, The office of Research and Postgraduate Studies, The University of Queensland, QLD 4072 AUSTRALIA (phone 07-33653924, fax 07-33654455, email humanethics@research.uq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

(Sample For Students)

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences &
Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(07- 3365 1634, mobile: 0412088029)

CONSENT FORM

Title of Research Project: Building a framework of a global shared workspace system within virtual collaboration environment

Name of Principal Investigators: Jason Shih-Sheng Yang

I agree to take part in the observational study exploring my activities and interactions regarding my design work for the fashion parade as explained on the information sheet.

I have read (or had read to me) and understood the Information Sheet that explains the research project.

I am aware that all the data collected will only be used for its stated purpose and my personal details will remain confidential. Should I be quoted in the report, my identity will remain undisclosed.

I am aware that I may not gain anything from taking part in this research. I also understand that I am not being graded on my participation in this study and I will not be affected academically should I discontinue my involvement.

I understand that this survey is voluntary and I am free to ask questions or to withdraw from participation at any time without penalty.

CONSENT BY PARTICIPANT

I have read, or had read to me, and understood all the information provided. I agree to take part in the research as described in this consent form.

Signature of Participant Date

____________________ ____________________

Complaints may be directed to the Ethics Officer, The office of Research and Postgraduate Studies, The University of Queensland, QLD 4072 AUSTRALIA (phone 07-33653924, fax 07-33654455, email humanethics@research.uq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

Ethical Clearance for Research Involving Human Participants

AMENDMENTS TO APPROVED PROPOSALS

Behavioural & Social Sciences Ethical Review Committee *(BSSERC)*
Medical Research Ethics Committee *(MREC)*

Please tick box:

MREC		BSSERC	

Clearance Number of Original Project: 2006000253

Approved Project Title:
Fashion Parade Observational Study

Approved Principal Investigator:	Jason Shih Sheng Yang
Staff No°/Student No°:	30092824
Approved Co Investigator/s:	N/A

Approved Supervisor/s: *(if applicable)*	Dr. Stephen Viller & Mr. Theodor Wyeld

School/s - Department/s:	ITEE

Contact Details of Principal Investigator:	***Phone***	***Fax***	***E-mail***
	07-38787868 0412088029	N/A	jyang@itee.uq.edu.au

Degree Enrolled (if student):	PhD
Approved Funding Body:	N/A
If Project Funded - What year? - Reference No° if available?	

Approved Project Location:	Moreton TAFE	**Approved Project Duration:**	31st Oct 2006	

Does This Amendment Submission Hold Other Ethical Clearance?:
YES/NO
Note: *Attach copies from other **AHEC** Registered Ethics Committees*
(circle)

PLEASE ANSWER ALL OF THE FOLLOWING QUESTIONS:

1) Have The Participants been amended? How?:
YES/NO
Note: *Details of approximate number, age range, and male/female ratios are required.*
(circle)

2) Have The Participant Recruitment Details Been Changed? How?:
YES/NO

(circle)

3) In 'Every-day/Lay Language' Please Provide A Summary Of The Project Amendments:
Note: clearly detail the changes from the originally approved protocol

In order to capture the "gesture" used by the participants (students), it is difficult to draw the illustration of the gesture
accurately within a short period of time during the observation. It would be easier and more accurate to capture
"gesture" using a digital still camera.

4) Give Details Of The Ethical Considerations Attached To The Proposed Amendments:

The ethical considerations remain the same as the original proposal. The ethical consideration for this proposed amendment would be that the use of digital still camera will only be used when there are protracted interactions and gestures that are difficult to capture using pan and paper. The digital still camera will only be focused on hands and materials that the students are working on.

5) Has The Participant Informed Consent Process Been Amended? How? YES/NO

(circle)

6) Have Details Of Procedures For Establishing Confidentiality And Protecting Privacy Of Participants Been Changed? How?: YES/NO

(circle)

7) Have Details Of Data Security and Storage Been Changed? How? YES/NO

(circle)

8) Have Details For Participant Feedback Been Changed? How?: YES/NO (circle)

9) 'Risks, Inconveniences and Discomforts' - How Have These Issues Been Addressed For The Proposed Amendments?:
There will be no risks involved with the amendment that I proposed.
There will not be any inconveniences with the amendment that I proposed.
Some students may find discomforts with the camera pointing at them when they are doing their design work, but I will assure
them that the camera will only be focusing on their hand movements and the material they are working on. I will show them all
the photos I have been taken at the end of each observation.

10) Has The Known Project Funding Changed? How?: YES/NO (circle)

11) Due to the Proposed Amendments Does Any 'Conflict Of Interest' Issues Now Arise? If YES, Please Provide Details. **Note:** *Conflict of Interest may arise because a researcher, or someone close to the researcher, stands to benefit financially from the research or the carrying out of the project or because inconsistent or incompatible obligations exist*
NO

12) Are you applying for an extension to the duration of ethics clearance? YES/NO If YES, to what date, and explain why the extension is requested. (circle)

ATTACHMENTS:

1) Consent Form Yes/No

2) Information Sheet Yes/No

3) Questionnaire Yes/No

Note: *please attach ONLY those developed or adapted specifically for this project*

4) Indemnity Yes/No

5) Gatekeepers Yes/No

Note: *A 'Gatekeeper' is a letter of Authority and Recognition from an Organisation of ANY type Involved with the research on the project*

6) References Yes/No

7) Other - Please Specify

____

____

____

We/I, the undersigned researcher(s) have read and agree to abide by The University of Queensland's Human Ethics Guidelines 2000 and have considered the ethical issues relevant to this research project.

Signature of Principal Investigator:______________________________

Date: / / .

Signature of Supervisor *(if applicable)*:______________________________

Date: / / .

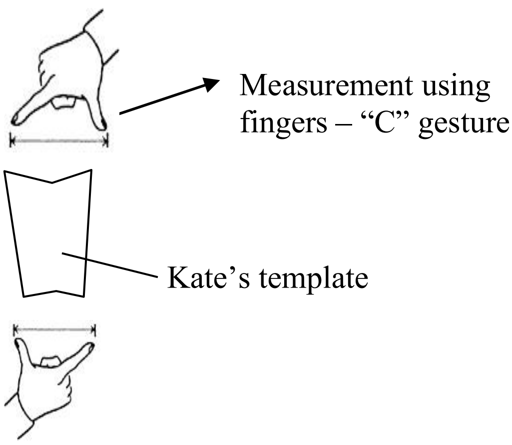
B. Observational Raw Data Collected Across Six Sessions At The MSIT College.

Observation session 1 **(Triangulation method)**	10th-May-06, 1:30pm – 4pm
Observation session 2 **(Focusing on gestures)**	17th-May-06, 2:30pm – 3:45pm
Observation session 3 **(Using digital still camera to capture gesture movements)**	31st-May-06, 10am –11:30pm
Observation session 4 **(Capturing series of actions using burst shots)**	7th-June-06, 1:30pm – 3:45pm
Observation session 5 **(Solving several problems: story telling by capturing series of actions)**	14th-June-06, 1:35pm – 3:20pm
Observation session 6 **(More story telling with burst shots & focusing on gestures)**	21st-June-06, 1:30pm – 3:45pm

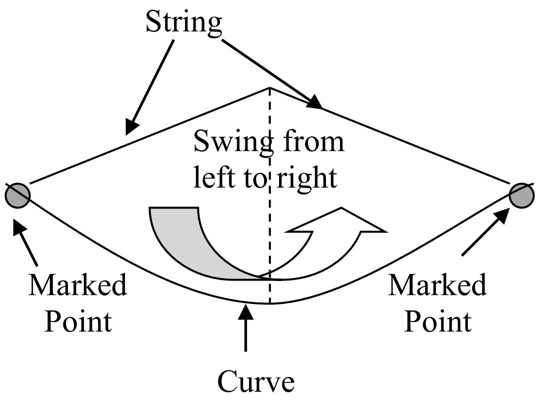
Observation session 1: 10th-May-06, 1:30pm – 4pm (Building G3-9/G3-18)
Advance Diploma Class
Total: 10 students; 7 students participated, 3 had chose not to participate.

<table>
<tr>
<td>1:38 pm</td>
<td>
<u>Quote:</u>
Kate: “I am having trouble with the size of this one, Ashley what do you think?”
Ashley: “Let me have a look”

<u>Interpretation:</u>
Kate and Ashley were discussing a particular size problem with one of Kate’s templates (paper). Kate used her thumb and index finger to measure the top and bottom of the particular template she was working on.



<u>Clarification:</u>
Kate: Sorry I don’t really remember what I did last week.
Ashley: Yes I think that’s what I did; I can’t really remember exactly what I did with Kate.
</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</table>

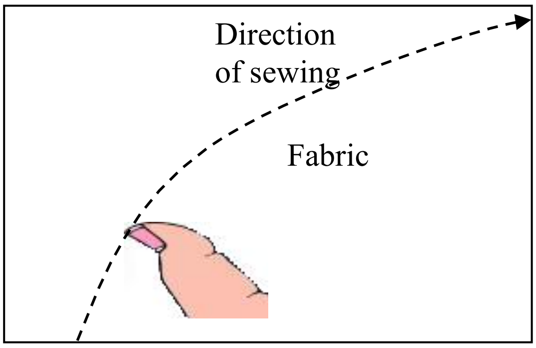
1:50 pm	Chris (teacher) helped a student with her template using a tape measure and pencil to draw lines/curves, also using a string to measure one point and mark another point with equal distance to the template, and then joint up the dots to form a curve. 
1:50 pm	Kate took out a specific template and overlapped it with another to confirm the fit (“pinching/clipping” gesture: she used her thumb and index fingers on both hands for measurement). She then selected a fabric and started tracing the outline of the template on the fabric using chalk.
2:10 pm	<u>Quote:</u> Kate: “Ashley, I can’t seems to decide which colour I want to use here” Ashley: “Which part are you talking about?”, “show me your sketch”,” Oh, is this what you mean?” Kate: “Yes, I can’t decide what colour I want to use there.” <u>Interpretation:</u> Ashley and Kate were discussing Kate’s design. Kate couldn’t decide which colour she will be using for the skirt part of the dress she designed. Ashley pointed to Kate’s drawing using index fingers “up and down” on the skirt part of the dress and suggested Kate to use black fabric for that particular part of the skirt. <u>Clarification:</u> Students cannot remember what they did or said.

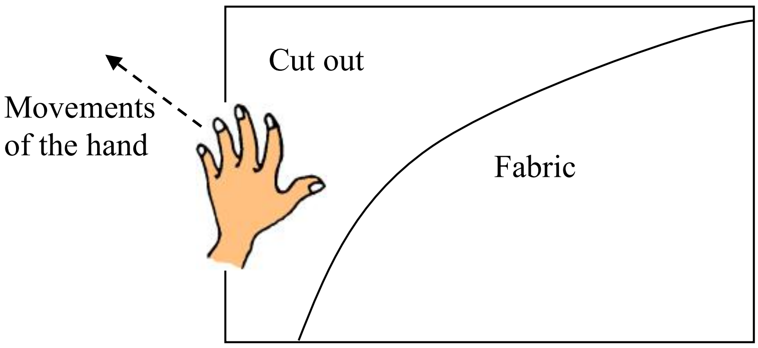
2:12 pm	<u>Quote:</u> Natalie: “Hey Maria, could you try this on please?” Maria: “Sure, give me a minute” Natalie: “How are the pockets like on the jacket? Is it too small?” Maria: “They are fine I think” <u>Interpretation:</u> Maria was asked to try out a partially finished garment (formal female jacket), and as asked, put her hands inside the pocket to check the size. <u>Clarification:</u> Students cannot remember what they did or said.
2:20 pm	Chris went to help Kate with her skirt template (paper form). Chris folded the template and tried to trace or make some sort of measurement. Chris then used pins to pin two templates together to stop them from moving. Chris asked Kate to show her the actual unfinished garment she made to see if she could solve the size problem of Kate’s skirt design.
2:30 pm	Zoe used tape measure to measure a distance between 2 points on a particular template she is working on, she then took out a textbook to look for a table of measurements. She then took measurements at different positions on the template several times, and then referred back to her textbook again.
2:33 pm	Alexis overlaid her ready-made template (cloth with fabric) on to a different fabric and started to cut out a portion of the new fabric. She then went back to the sewing machine to integrate the new fabric to the current piece (to add a new layer) that she is working on.
2:35 pm	Chris was still helping Kate with her skirt, Chris advised Kate to change part of her skirt design, also showing her what she need to modify by comparing a “basic” template (from the wall) and overlaying it on Kate’s template.
2:38 pm	Natalie (left-handed) rearranged all her templates (with different sizes) and laid them on top of a black cloth fabric, she then used pins to stop the templates from moving. She then cut the outline of each individual template.
2:43 pm	Alexis finished sewing and went back to her desk to try and join another part of the unfinished garment. She folded one side of the garment and tried to attach the part she just made. She then took several measurements using a tape measure. Afterwards, she took out a blue denim jacket from her bag and looked at it closely on the back of the jacket and then compared it to her unfinished garment.
2:51 pm	Ashmita finished sewing part of her template (cloth), she then went back to her desk to compare this to another unfinished garment for measurements using the “pinching/clipping” gesture of her both hands and overlapping another finished garment.
2:55 pm	Ashely took out her templates (paper) for part of her skirt design and put it onto herself to see the length, she then wrote down some measurements. I asked her why she did all that, she said because the model is going to be very tall so she has to make some adjustment to it. She also mentioned that the templates hanging on the wall are the “basic” templates for each part of skirt/pants/sleeves etc. She said she will have to remake the template by using the “basic” templates and modified it according to her skirt design.
3:00 pm	Chris went to help Maria with her design. Chris then redrew Maria’s sketches and helped her with the templates that Maria was currently working on. Chris and Maria went to another room to get a golden silk-like fabric. Chris showed Maria what she could use for part of her design. Chris used lots of hand/finger gesture movements to show Maria the area of the design that can utilise the golden fabric. Chris also used a

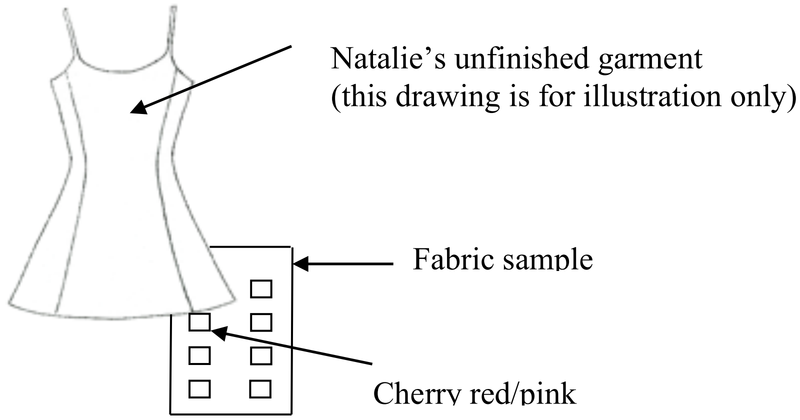
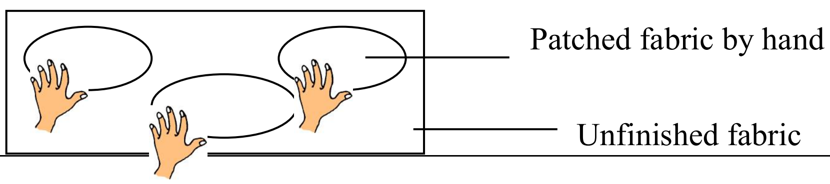
	"finger measurement" (e.g. about 2cm Chris said) and told Maria that it is the amount by which she needs to modify her template.
3:04 pm	Kate asked her friend to try out an unfinished garment (dress) and see how much she actually needs to modify the waist line, she then wrote down the measurement that she needed to modify. She was unsure about it so she went to seek help from Chris.
3:10 pm	Chris went to help Kate with her garment that was already fitted on a student, Chris used pins to adjust the fabric of the garment (it was too big and Chris was trying to adjust it to make it fit on the student). Chris also told Kate what measurements she will need to change to adjust the skirt, and Chris marked some lines on Kate's original template (paper). Chris said to Kate that she has helped Kate with the back part of the skirt and now Kate needs to do some adjustments to the front part of the skirt. Chris helped Kate with some calculations.

3:17 pm	Ashmita wanted to make a copy of her templates, so she went and took some paper from a roll located at the front of the room. She laid the big piece of paper first then the template that she already made on top of it. She used a tool called “tracing wheel” to mark the outline of the original template onto the paper. The tracing wheel made many tiny little dots on the paper. She then joined those dots with a pencil and then cut out the outline of the new template. She then stuck those two identical templates together using glue.
3:23 pm	Alexis joined up all 3 parts of the templates (cloth) and folded her unfinished garments to make some lines using a blue chalk. Pins were inserted where the blue lines were. Chris came to help her and told her what she needed to do to sew all 3 parts together. Chris demonstrated with the action of “flipping” a corner of the garment (the denim jacket) to show Alexis the methods and outcomes of different sewing styles that can be applied to her design. Chris took out some of the pins Alexis has put in earlier and readjusted the positions. Chris took apart the seam in the garment and readjusted the position and showed Alexis where she needed to sew.
3:43 pm	Chris went to help Zoe with her design. Chris took Zoe’s unfinished garments and flipped it inside out to see the stitching Zoe had made. Chris found some errors and suggested to Zoe to remake part of the garment or undo the stitching. Chris then asked to see the original template (paper) in order to make some adjustment to the measurement.
3:43pm	Ashmita asked Alexis to try on her skirt (unfinished garment) to see the height and proportion.

Observation session 2: 17th-May-06, 2:30pm – 3:45pm (Building G3-9/G3-18)
Advance Diploma Class
Total: 10 students; 7 students participated, 3 had chosen not to participate.

<table>
<tr><td>2:40 pm</td><td>Chris was helping Alexis with the skirt template, Chris recommended that she redo the paper template. Chris folded the paper template using the pre-drawn lines to form the outline for the waist part of Alexis skirt template.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>2:48 pm</td><td>Chris showed Alexis how to sew the fabrics. Hand gestures: using thumb and thumb nail to draw a curved line mimicking the direction of sewing.


Alexis used hand gestures to show Chris (or re-confirm to Chris) what needed to be cut out before sewing.

</td></tr>
<tr><td></td><td></td></tr>
<tr><td>3:00 pm</td><td>Chris went to help Natalie with her design. Natalie wanted to change the colour of the fabric that she wanted to use for her design. She then told Chris that she decided to use “bright red” (Hand gestures of “sparking” see below)</td></tr>
</table>

	 Natalie showed Chris what sort of fabric and colour she intended to use in order to match up with another piece of unfinished garment. Natalie told Chris that she wanted the same "feel" through out her design. Natalie asked Chris what sort of red she would use. Chris went to the other room and brought back a fabric sample card for Natalie to have a look. Chris recommended Natalie use the colour called "cherry red/pink" on the fabric sample card. She then put the sample fabric card underneath the unfinished garment that Natalie had previously made and compared it to the other. 
3:20 pm	Chris went and discussed with Ashmita's design. Ashmita told Chris that she could not make up her mind about the use of fabric. Ashmita used hand gestures to point this out.
3:35 pm	Natalie used hand gestures movement across her chest and told Chris she was having trouble with part of her design. She started to lay out a few round shape fabrics to her unfinished garment that she made; she was trying to show Chris her idea of "patching" another fabric to her unfinished garment. 

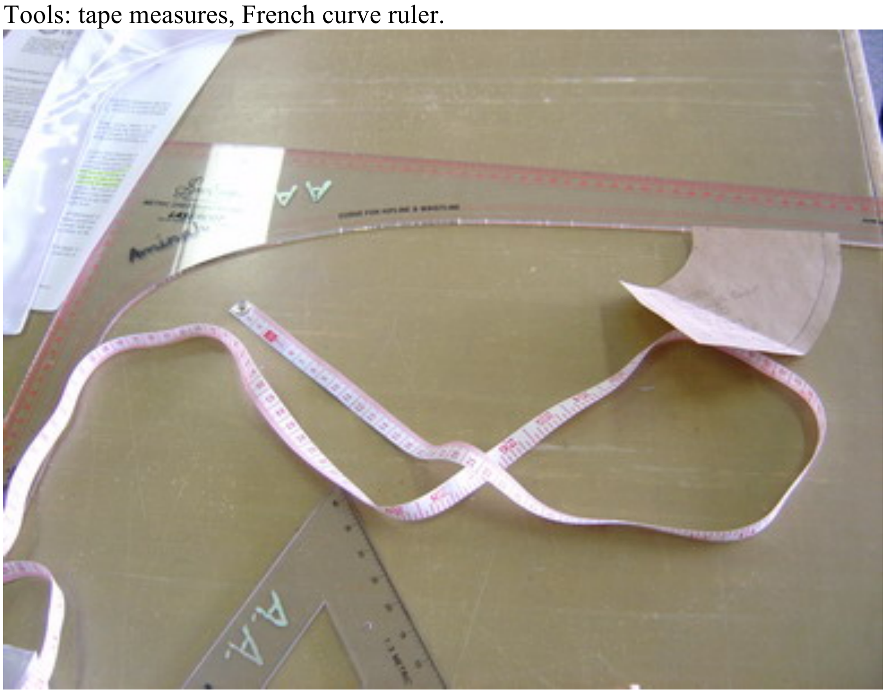
Observation session 3: 31st-May-06, 10am –11:30pm (Building G3-9/G3-18)
Advance Diploma Class
Total: 6 students; all 6 students participated with amended consent form for photos.

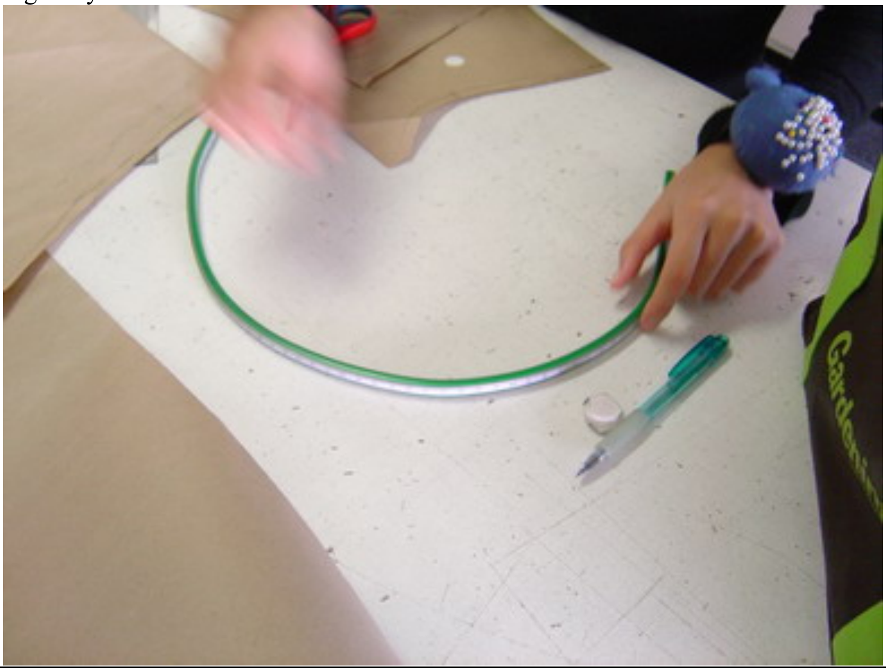
10:45am	Photo: DSC00001 Misako used pins to assemble her partially finished garment on the dummy model. 
10:45am	Photo: DSC00002 Aminah used free hand to draw curves. 

10:47am	Photo: DSC00003 Ebony used both hands to roughly measure the width of the garment. She then used a ruler to make more accurate measurements. 

10:47am	Photo: DSC00004 Zoe used tape measure for measurements.  Photo: DSC00005 Zoe folded a particular part of the unfinished garment.  Photo: DSC00006 Zoe used tape measure to measure and then mark the jeans fabric for adjustments.

10:53am	Photo: DSC00007 Aminah used various rulers to help her to draw some curves for her paper template.  Photo: DSC00008 Tools: tape measures, French curve ruler. 

10:54am	Photo: DSC00009 Misako used a flexible ruler for drawing curves. She said she sometimes used free-hand to draw curves because at times she needs to draw a long curve and the tools are not able to do what she wants. She said if possible she has to practice using free hand regularly. 
11:11am	Photo: DSC00010 Aminah used an awl to make very small holes for duplicating paper templates.  Photo: DSC00011 Aminah wanted to double check that she had successfully marked the template underneath for duplication.

Observation session 4: 7th-June-06, 1:30pm – 3:45pm (Building G3-9/G3-18)
Advance Diploma Class
Total: 8 students; 6 students participated, 2 students had chosen not to participate.

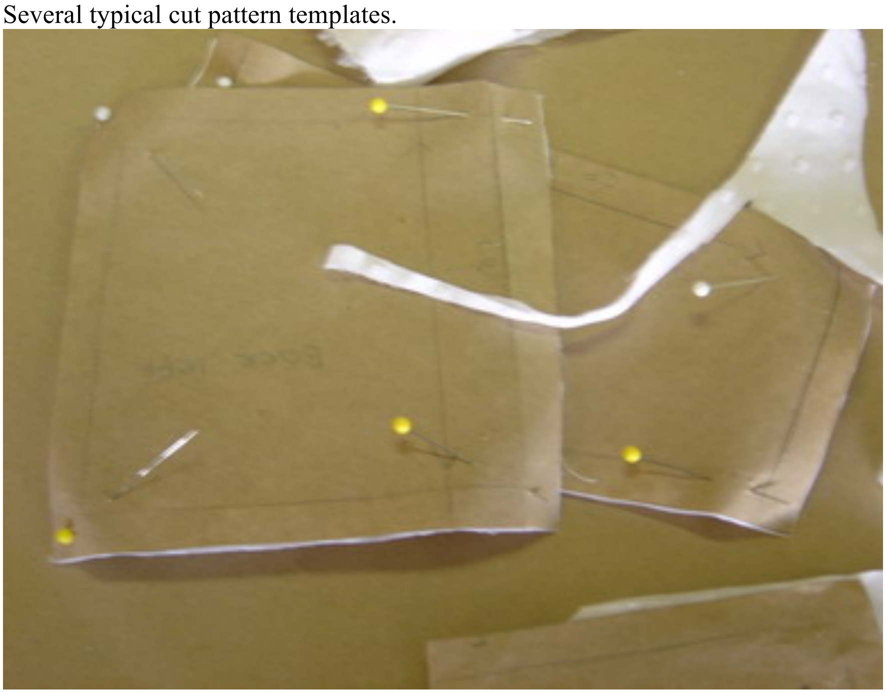
<table>
<tr><td>1:54 pm</td><td>Photo: DSC00013- DSC00014
Chris helped Zoe with her pants pocket design, especially with the order of assembly and method of sewing. (Folding gesture and fingers movement as the direction of sewing).

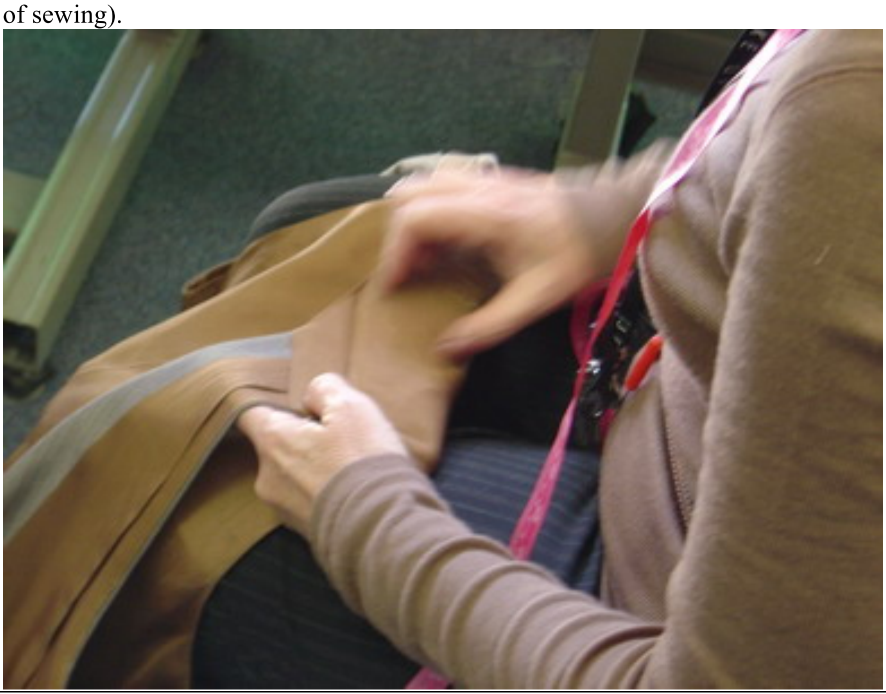

Photo: DSC00015
Chris looked closely at the sample (retail pants) and checked the way they made their pocket (order of assembly).</td></tr>
</table>

Photo: DSC00017
Chris removed the previous sewing in order to work out the assembly according to Zoe's pocket design.

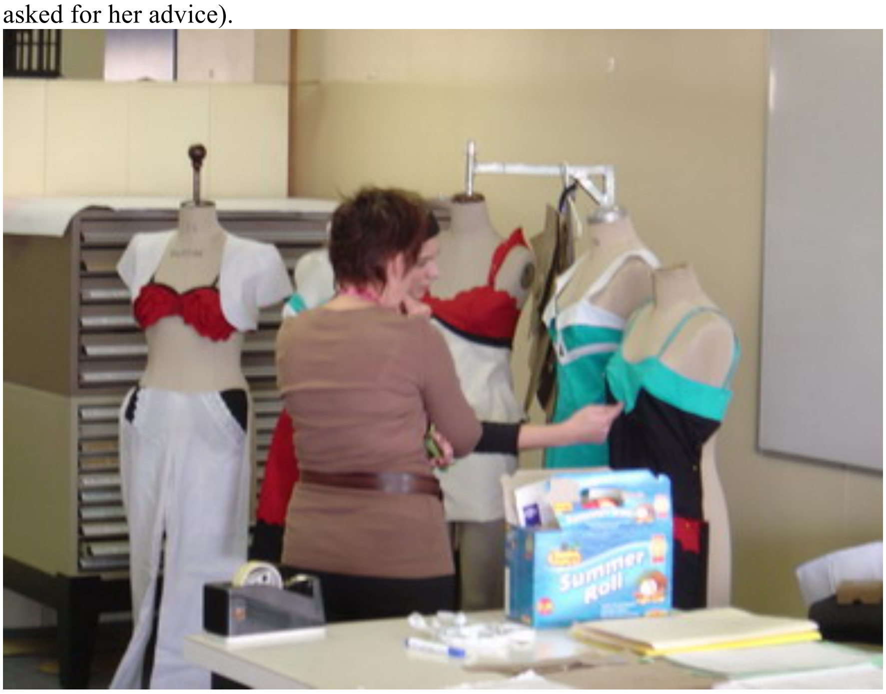
Photo: DSC00018 - DSC00019
Chris double checked again with the retail pants and told Zoe the order of assembly that she needs. For her pocket design also the small details that she needs to be aware of after sewing the main part of the pocket.

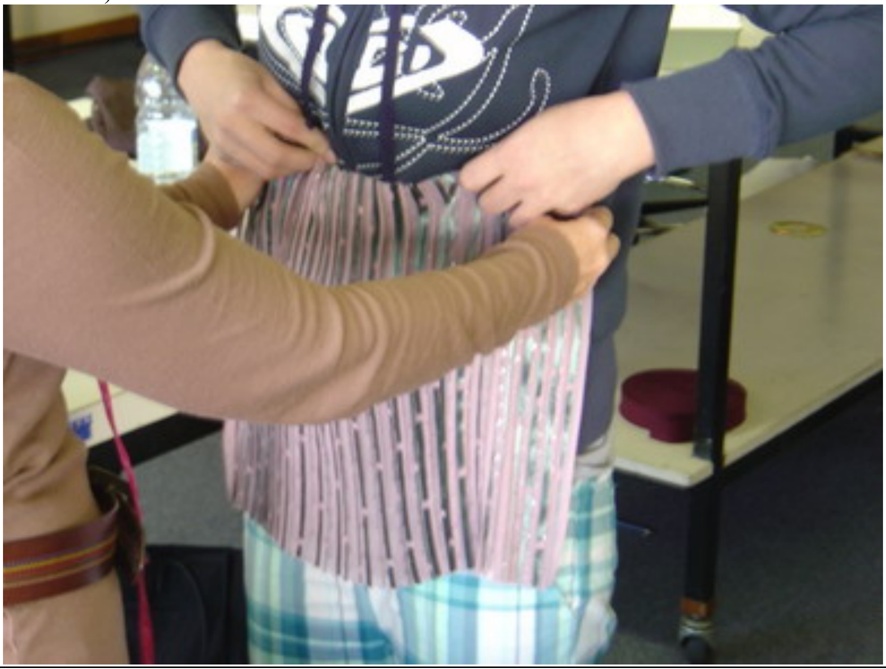
2:00pm	Photo: DSC00020 Ashmita laid out her paper pattern template onto the fabric with pins holding them together and ready for ready to be cut out for assembly.  Photo: DSC00021 Several typical cut pattern templates.  Photo: DSC00064 Ashmita used scissors to trim the outline of the pattern template before sewing.

	
2:20pm	Photo: DSC00025 Chris suggested a few modifications to Zoe's vest design. Also a few sewing adjustment to the back of the vest. (Hand gestures representing the line and direction of sewing). 

<table>
<tr><td>2:48pm</td><td>Photo: DSC00029
Natalie and Chris were discussing part of her design collection.

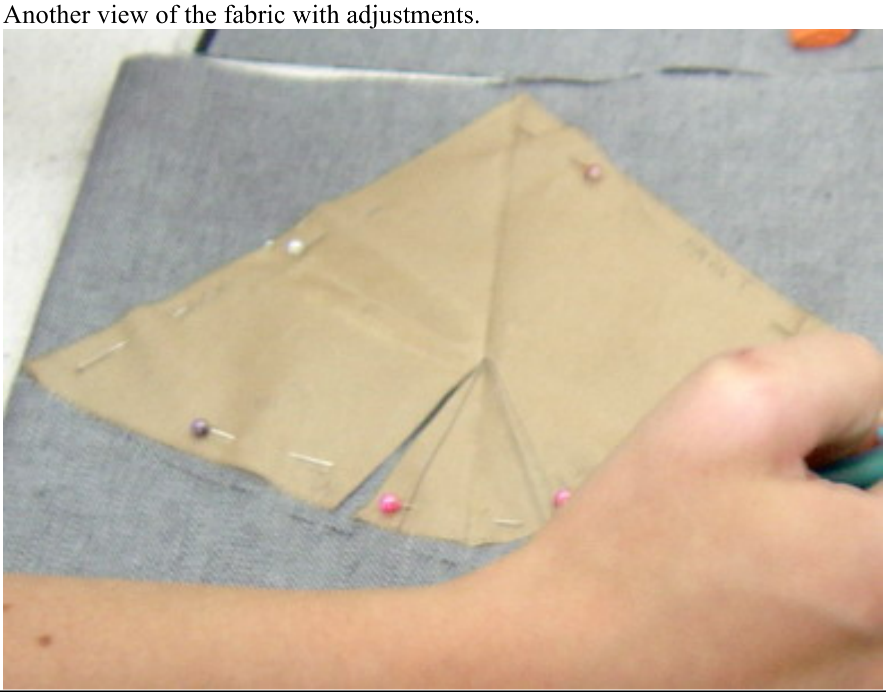

Photo: DSC00033
In particular, Natalie was concerned about the dress on the dummy model on the right. (Hand gesture by Natalie to point out the area she was concerned about to Chris and asked for her advice).

</td></tr>
<tr><td></td><td></td></tr>
</table>

3:01pm	Photo: DSC00034 Alexis showed Chris the fabric that she is intending to use for her dress design. (Hand gesture: picking fabric up using thumbs)  Photo: DSC00045 Alexis asked Chris how she can create a crease effect. Chris explained to her that she can spray some starch on the fabric and iron them to create the crease effect. (Folding gesture with thumbs by Chris)  Photo: DSC00045 Chris showed Alexis an alternative fabric that Alexis can consider. Chris asked Alexis to put the fabric on herself to see the broad picture. (Some hand gestures for holding

<table>
<tr><td></td><td>the fabric)
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>3:07pm</td><td>Photo: DSC00048
Natalie was not sure if she needs to use two layers for her dress design or not. Chris felt the fabric first and then folded the fabric to see the effect of two layers. (Hand gestures: feeling the fabric and also folding of fabric by Chris)
</td></tr>
<tr><td></td><td></td></tr>
</table>

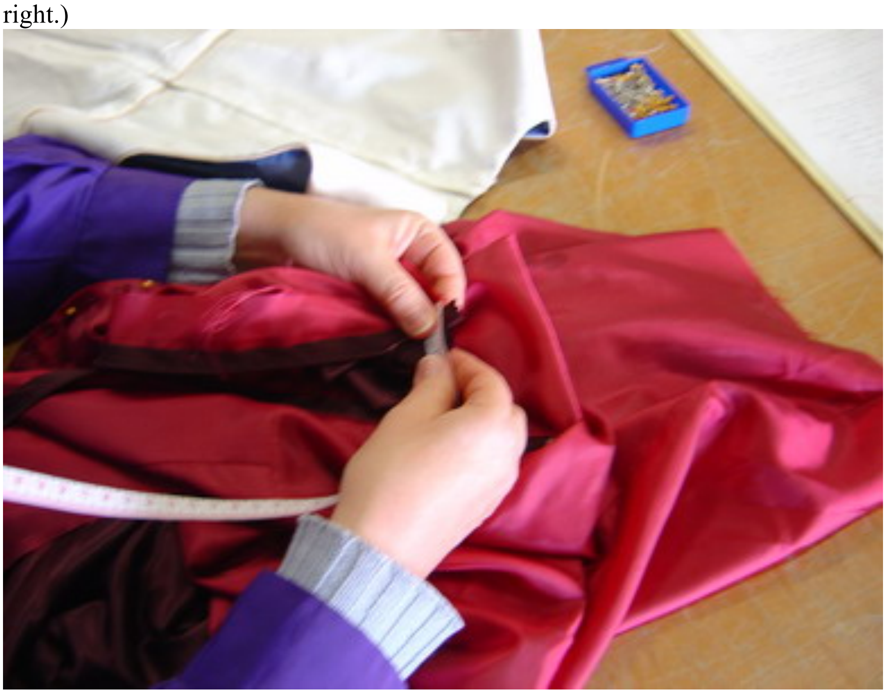
3:10pm	Photo: DSC00055 Misako was getting ready to cut out patterns and to save time she decided to cut multiple layers of the same fabric.  Photo: DSC00055 Misako decided to ask Chris some advice before she proceeded any further. (Hand gesture by Misako: feeling the fabric with her fingers)  Photo: DSC00055 After Chris had examined the fabric, she advised her to go ahead with the cutting.

	 When I went back and ask Misako what they were discussing, she explained that because the weave direction is in 90 degree angles, it is important to align the pattern with the weave and to ensure this applies to all the patterns, so when sewing up the patterns the garment will look even and symmetrical.

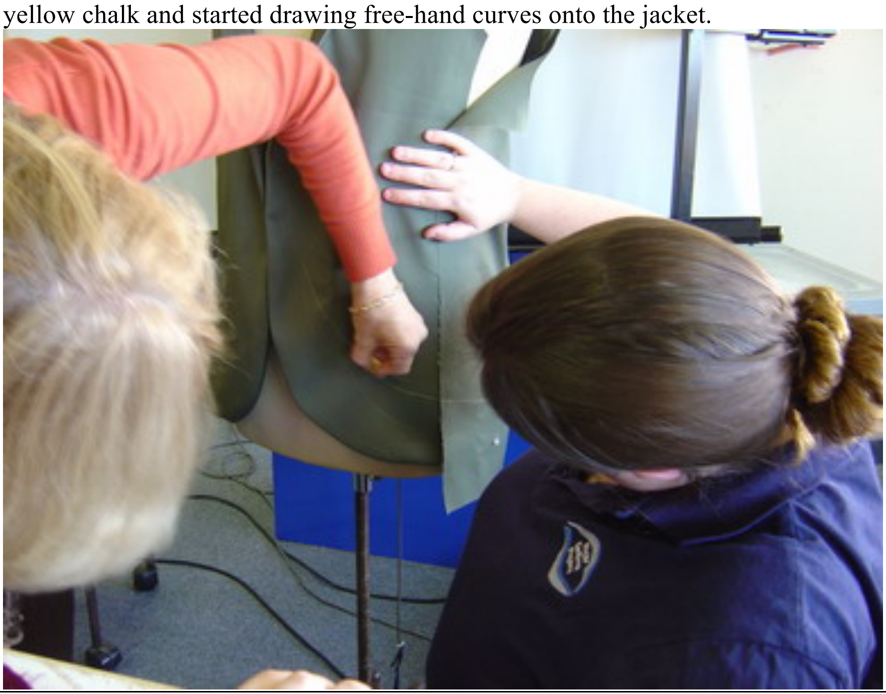
3:23pm	Photo: DSC00073 Alexis had made an error on one of her pattern templates, so rather than remake the paper pattern template, she marked the adjustment straight onto the fabric that she will use. (Hand gesture: used ruler with the left hand to mark the measurement onto fabric.)  Photo: DSC00073 Another view of the fabric with adjustments. 

Observation session 5: 14th-June-06, 1:35pm – 3:20pm (Building G3-9/G3-18)
Advance Diploma Class
Total: 3 students; all 3 students participated.

1:45pm	Photo: DSC00091 Misako asked Wendy (the replacement teacher) her opinion about Misako's dress design. Misako had put all her parts for the dress design onto a dummy model. She was having trouble with the lower part of the dress; she was unable decide the appropriate height and position.  Photo: DSC00092 Wendy told Misako how much she needed to cut out (Hand gestures).  Photo: DSC00096

	Wendy was trying to correct the lower part (green colour) of the dress using pins to attach it to the main dress (pink colour). 
1:59pm	Photo: DSC00101 Aminah was trying to produce a "step" for the zip for her dress design. Aminah explained the "step" is used to hide the zip and it is usually used as "cosmetic effect" in high quality garments. (Hand gestures: tape measure measurement & flipping left and right.)  Photo: DSC00103 Wendy recommended that Aminah press the fabric first (iron them flat) in order to sew

	the "step" part accurately. Wendy also told Aminah to pay extra attention to the top of the zip where the "step" started and finished. Also highlighted the importance of the order of sewing, and to make sure the measurement of the "step" was accurate to make it neat. (Hand gestures by Wendy: holding fabric and the "step" together with thumbs and fingers, also movement along the zip.) 
3:06pm	Photo: DSC00106 Ebony asked Wendy to check the collar of Ebony's male jacket. Wendy first checked if the collar is aligned correctly when the jacket is buttoned (Hand gestures by Wendy: using thumbs to close the jacket mimicking the button up effect.) 

	Photo: DSC00115 Wendy then made a few adjustments to Ebony's collar pattern template.  Photo: DSC00122 Ebony also asked Wendy's opinion about the length of the jacket. Wendy picked up a yellow chalk and started drawing free-hand curves onto the jacket. 

Observation session 6: 21st-June-06, 1:30pm – 3:45pm (Building G3-9/G3-18)
Advance Diploma Class
Total: 6 students; 4 students participated, 2 students had chosen not to participate.

<table>
<tr><td>1:43pm</td><td>Photo: DSC00124
Alexis asked Wendy to help her with the assembly of her dress design. Alexis was not sure specifically about the zip part of the dress due to her choice of fabric.

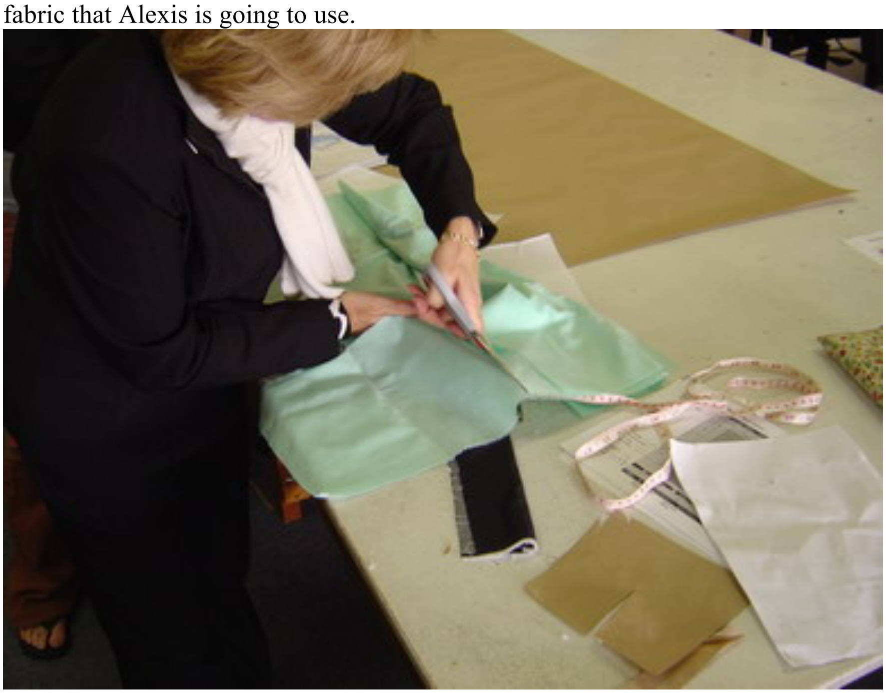

Photo: DSC00125
Wendy began to cut part of the sample fabric as an example instead of using the real fabric that Alexis is going to use.


Photo: DSC00127</td></tr>
</table>

While Wendy was still cutting the fabric, she recommended pressing them (she referred ‘press’ as ironing) before sewing so the pattern/printing on the fabric would line up symmetrically and in the same order. (Hand gesture: right thumb and fingers holding 2 layers of the fabric together)

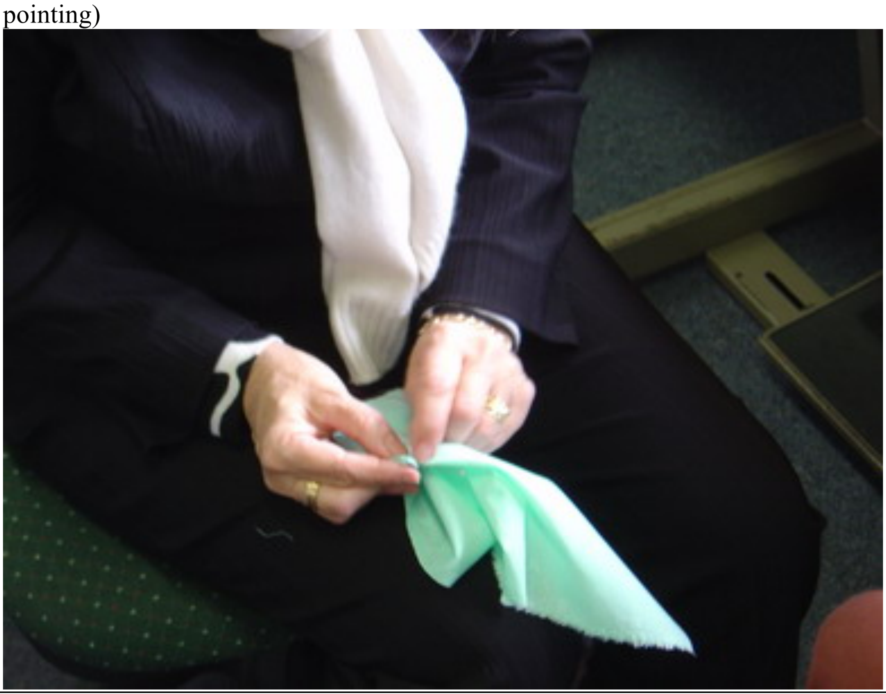
Photo: DSC00124

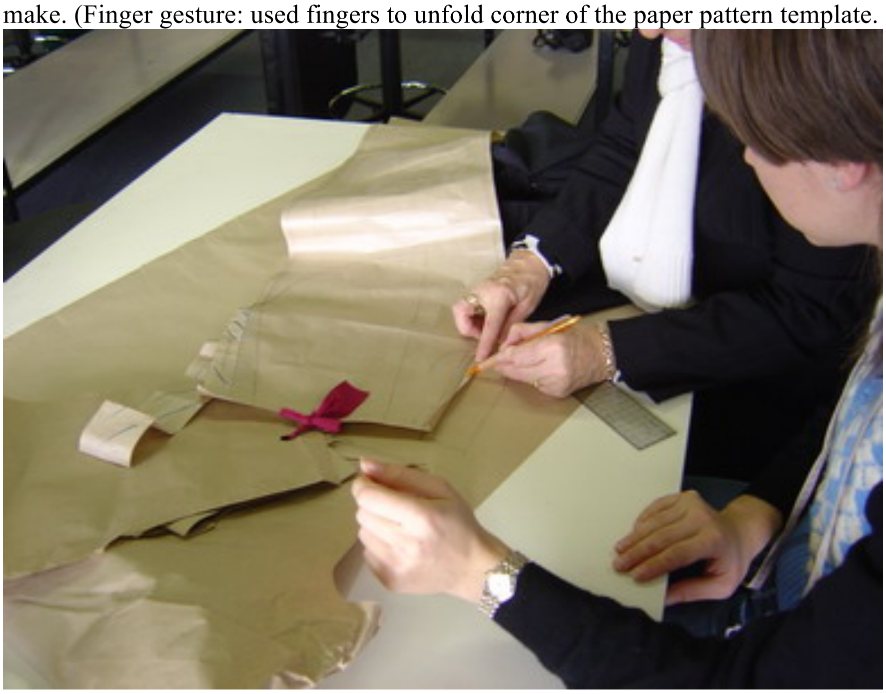
Wendy went to the sewing machine to sew a sample for Alexis and show her the order of assembly. (Hand gesture: fingers pressing down the fabric holding it in place before sewing began)

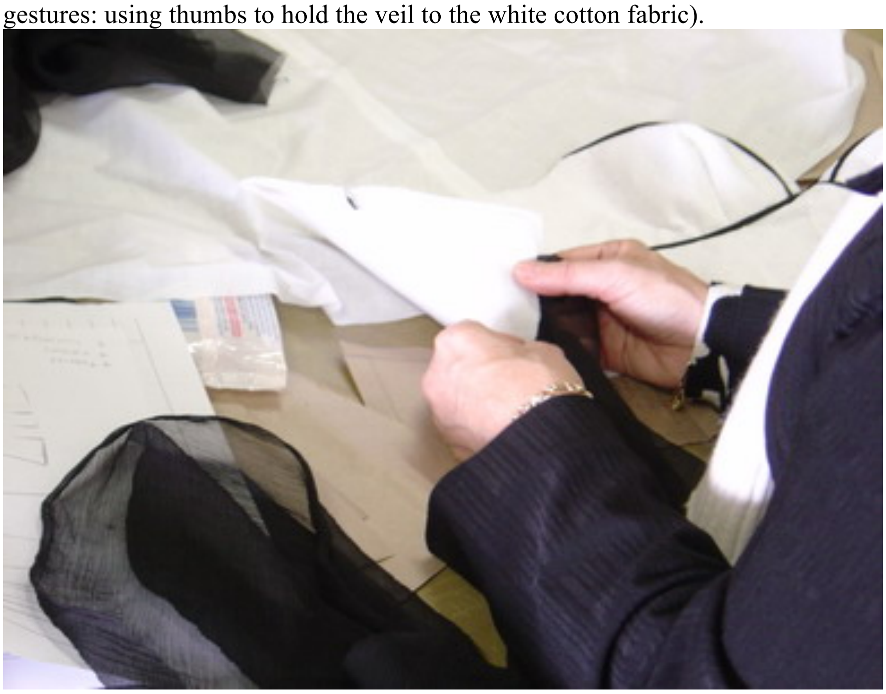
Photo: DSC00134

Alexis took down some notes about the order of assembly.

Photo: DSC00136
Wendy finished sewing and showed Alexis what it will look like for her zip. Wendy explained to Alexis what she area need to take extra care (Finger gestures: finger pointing)

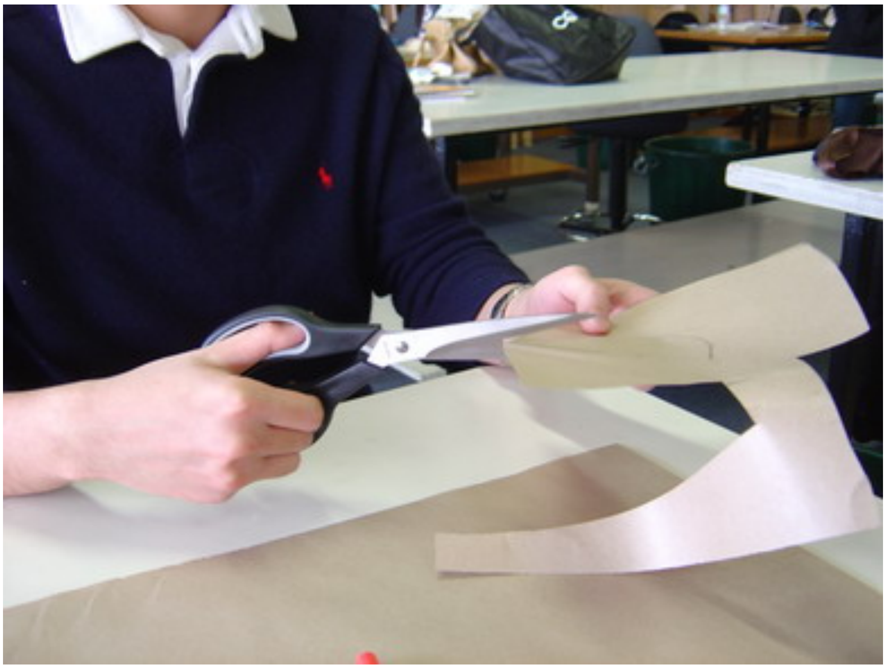
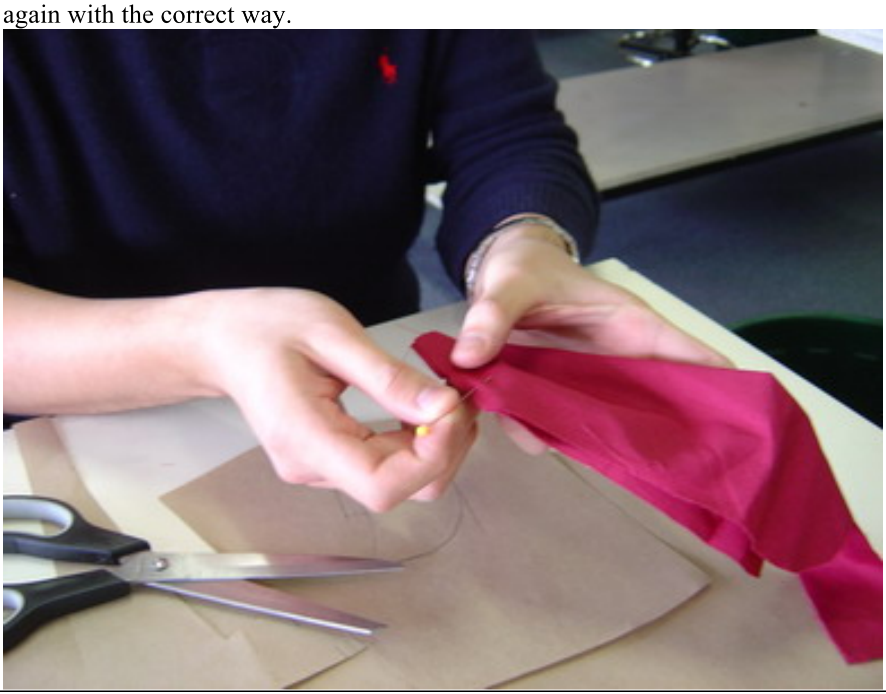


2:08pm	Photo: DSC00137 Zoe asked for advice from Wendy regarding the pockets for her pants design. Zoe said to Wendy that she thought she might have made a mistake with the pocket pattern template, which she had made according to Chris's advice. Wendy spotted the error right away and pointed it out to Zoe - "is that where the problem is?" (Finger gesture: finger pointing). Zoe said 'yes'.  Photo: DSC00140 Wendy started to draw some lines representing the modification that Zoe would need to make. (Finger gesture: used fingers to unfold corner of the paper pattern template.  Photo: DSC00146

	Wendy had a close look at the retail pants that Zoe was referring to before she made her final comments about the modifications that Zoe needed to make. (Hand gestures: using hand to move away the inner pocket away to see the detail of the assembly) 
2:14pm	Photo: DSC00148 Ashmita asked Wendy to help her with her dress design; Ashmita was trying to sew two layers of very thin veil like fabric (black), but she has no idea how to sew them up to her dress. Wendy went to try out the fabrics and figured out a way of sewing them. (Hand gestures: using thumbs to hold the veil to the white cotton fabric).  Photo: DSC00152 Wendy asked Ashmita the length and width of the veil that she is intended to use. Ashmita showed her the size of the veils by laying them out on the table. (Hand gesture by Ashmita: throwing fabric on the table)

	
2:22pm	Photo: DSC00155 Alexis picked up a size 12 dummy model and she started to put her cotton pattern sample onto the dummy model then pinned the fabric that she wanted to ultimately use on top of the cotton pattern sample. (Hand gestures: folding the fabric with fingers on left hand, and pinning it to the dummy model using right hand) 

Master (Zoe) and apprentice (observer) relationship

<table>
<tr><td>2:40pm</td><td>Task 1: Zoe wanted to cut the pattern template. She taught me how and what to cut. Basically what I did was cut the shape of the pocket, which was pre-drawn using pencil.

Task 2: Zoe wanted to fold the fabric and pin it together to prevent the fabric from moving when sewing it up. After I put the first pin onto the fabric, Zoe corrected me and told me not to pin it too close to the area where sewing will occur. I then did it again with the correct way.
</td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><td>2:47pm</td><td>Photo: DSC00162
Aminah put all her design and pattern templates together with the dress she made ready for marking. (Hand gestures: flipping through the pattern templates checking if there is anything missing).
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>3:10pm</td><td>Photo: DSC00165
Alexis needed some help from Wendy with her design. Alexis showed Wendy what sort of ripple or wrinkly effect she wanted for her design. (Hand gestures from Alexis: both hands moving in air across the chest area of the dummy model).

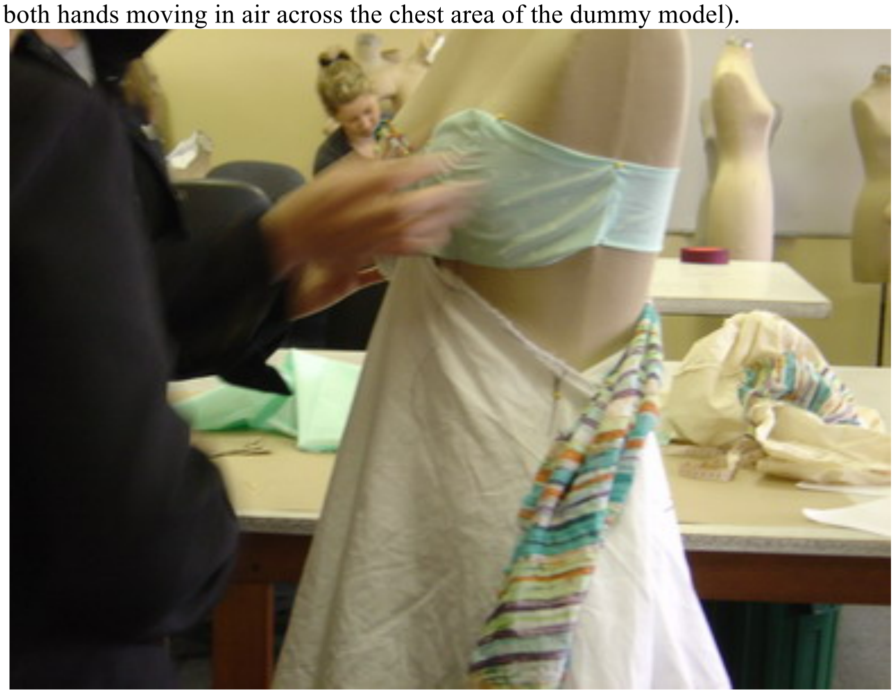



Photo: DSC00167
Wendy demonstrated the effect that Alexis might be after. (Hand gesture: folding the fabric using fingers)</td></tr>
</table>

Photo: DSC00169
Wendy found it difficult to do it by hand, so she took down the fabric and began to fold the fabric on the table. Wendy told Alexis that she will need to 'press it' in order to hold the shape and effect. (iron them flat)

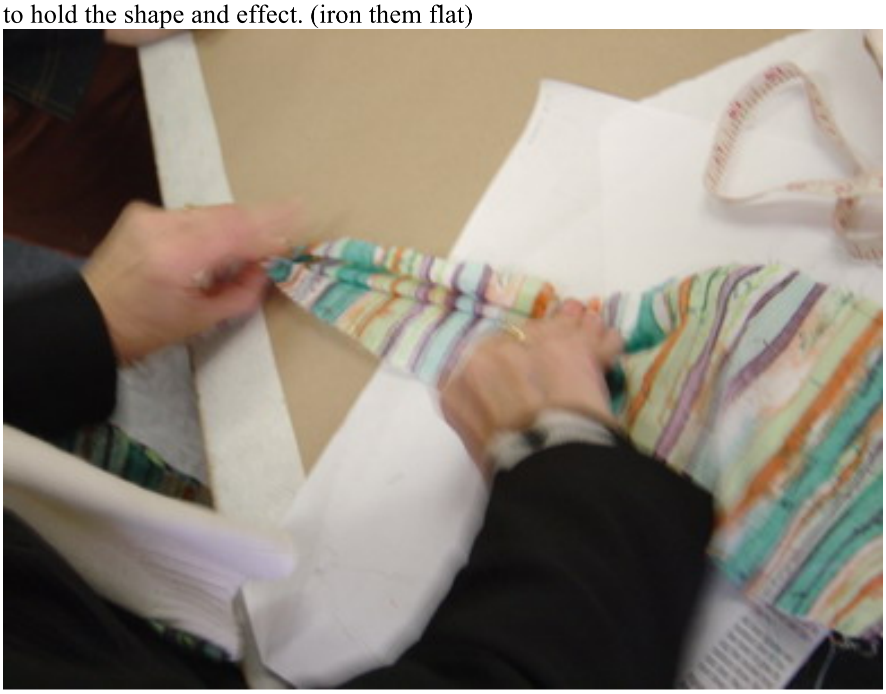
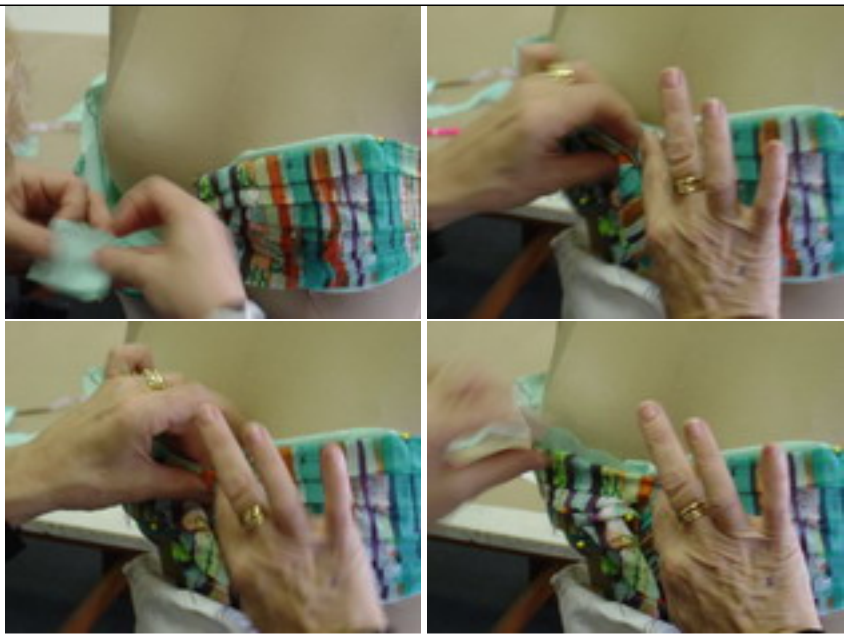


Photo: DSC00173
After Alexis finished 'pressing' the fabric, she returned to the dummy model and started to pining it up

Photo: DSC00182
Alexis found a problem with the joining of the fabric in the middle of the chest area where she will have buttons to join up the piece. She then asked Wendy to help her out on this particular problem.

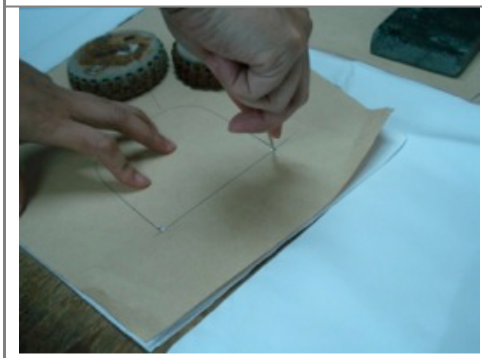
Photo: DSC00186- DSC00189
Wendy showed Alexis how to put a square 'bag' onto one side of the fabric to solve the button problem. (Hand gestures from Wendy: fingers actions mimicking button up actions)



3:40pm	Photo: DSC00190 Alexis found another problem with the assembly of her skirt. She wanted to ensure her skirt design maintained a 3-D look and had volume to it. She asked Wendy to help her out. Wendy checked out exactly what the problem was first.  Photo: DSC00193 Wendy recommended to Alexis that she should "bag it like the jacket" (the same method of assembly as for her jacket). Alexis understood and agreed with Wendy that it will do what she wanted to maintain her design. 

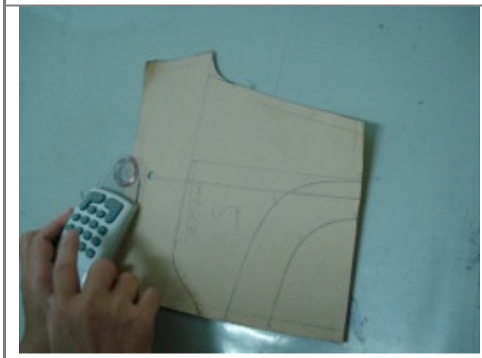
C. Observations And Contextual Interviews At A Fashion Design Firm In Taiwan

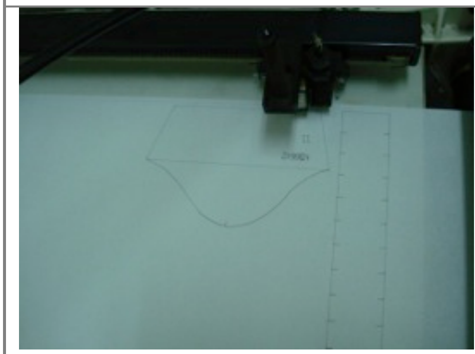
	Description and interview comments:
	<u>*Designer Linda used tape measure to measure the width, of a light pink jacket.*</u> Interviewer: Do you always use a tape measure to take measurement? Linda: Yes, I use a tape measure for fabric and clothes measurements. Sometime I use a ruler if I can't find the tape measure around.
	<u>*Designer Linda used a tape measure to measure the collar of a light pink jacket.*</u> Interviewer: Do you ever use your fingers to take any measurements? Linda: That would not be very accurate especially for the production line.
	<u>*Designer Linda used tape measure to measure the length of a light pink jacket.*</u> Interviewer: Why is that? Linda: It is important to get an exact measurement to give to the manufacturer so the production garment ends up being the same as the prototype.

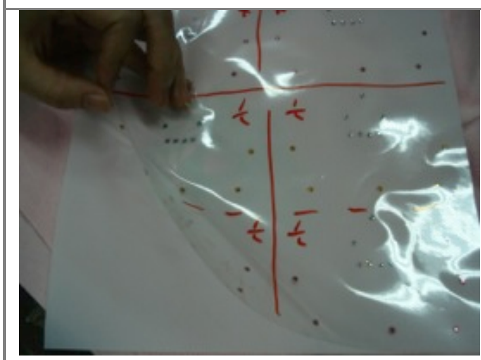
	*Design assistant Mary laid out templates on a white fabric.* Interviewer: Do you always cut out the template by hand? Mary: I am cutting this by hand for a design prototype, so we can try it out and examine the overall look. As for the production line, we have a semi-automatic cutting machine with a laser guide for accurate cutting.
	*Design assistant Mary used a special chalk to mark the outline of the template for cutting.*
	*Design assistant Mary used scissors to cut out the template on the fabric.*
	*Design assistant Mary used a special sharp metal pin to mark two tiny holes on the paper template through the fabric underneath.* Interviewer: Why do you need to make two holes on to the fabric? Mary: I am marking the fabric because there will be a pocket template going on top of this current template.

	*Design assistant Mary laid out a pocket template on the fabric using the two holes as a guide to position it accurately.*
	*Design assistant Mary wrote some notes on the back of the fabric with a pencil.* Interviewer: What sort of notes are you writing on the back of the fabric and why? Mary: I am writing down the template part numbers on the fabric for a particular style of the garment, so it is easier to organise later on.
	*Design assistant Mary overlapped two pocket templates to check for the depth of the pocket.*
	*Design assistant Mary wrote some design notes .* Interviewer: What are you writing and are you sending this via fax or mail? Mary: I am writing down some important design specification notes for our manufacturer in China, and I will be sending

	this together with some fabric samples and the prototype via international mail.
	_Paper Template Developer John laid out templates for a particular shirt design._ Interviewer: What are the small holes on the templates for and how do you organize the templates? John: The templates for each design are labelled and held together using a string. All templates are stored on the walls in the storage room. They are categorised by either “spring/summer” or “autumn/winter”.
	_Paper Template Developer John laid out new templates for a particular shirt design on to a previous season shirt design._ Interviewer: What are you going to do with these templates? John: I am trying to compare some minor adjustments I made to the new templates that I made earlier to the previous design.
	_Paper Template Developer John used special ruler to make the template._

	<u>*These are the typical tools used by the Paper Template Developer John for making paper template.*</u>
	<u>*Digital Template Developer Ellen received a new paper template from John and needed to convert it to a digital template.*</u> Interviewer: How do you convert the paper template to digital form? Ellen: I will lay the paper template down and use this point-capturing device to capture the outline of the template by defining some key points. The computer will immediately pick up the points and I will join the points together to make the digital template.
	<u>*Digital Template Developer Ellen used the point-capturing device to capture the outline of the template.*</u>

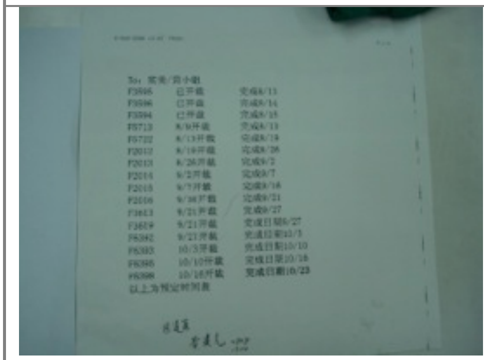
	*<u>Digital Template software used by Ellen.</u>* Interviewer: How do you organise the templates and how do you store them? Ellen: Once I have made the digital templates, they are named exactly the same as the paper templates and they are then categorised into either "spring/summer" or "autumn/winter" folder for the current year. The files are saved on the local hard drive and also backed up on the local server.
	*<u>Digital Template Developer Ellen printed out a template.</u>*
	*<u>Designer Linda compared fabric pattern and colour against the graphic designer's concept by matching paper colour samples to the fabric samples.</u>*

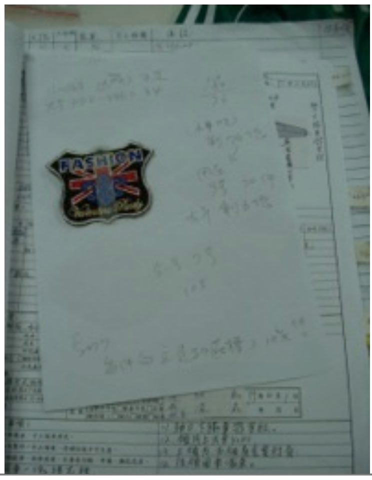
	*Designer Linda received new logo design from the graphic designer.* Interviewer: Do you prefer to see the graphic design on a computer monitor or on paper? Linda: It all depends on the work, if it is the "work-in-progress" designs then I will look at them on the monitor but in most cases the graphic designer will print them out for convenience.
	*Designer Linda needed to add some accessories onto the fabric.*
	*Designer Linda started to place some colour crystals onto the fabric by hand, in accordance with the logo design by the graphic designer.*
	*Designer Linda finished placing the crystals and the next step was for her to make a template by laying down a special sticky transparent plastic over the fabric and crystals to capture the positions of the crystals.* Interviewer: Does this take long to do? Linda: I am only doing a couple for our

	manufacturers. They will have special machine to do that automatically.
	*Designer Linda compared the crystal template carefully against the physical prototype design before sending the crystal layout template to the clothing manufacturer.*

	*Design sketch by Designer Linda.*
	*Graphic designer converted Linda's design into digital format for easy cataloguing.* Interviewer: Why do they need to be converted into digital format? Linda: Once the design sketches are in digital format, we can use them anywhere. For example, we can list them in our workflow chart etc.

	<u>*Workflow chart with design notes.*</u>
	<u>*Workflow chart with design notes.*</u>
	<u>*Design assistant Mary placed the logo onto the paper template to find a suitable position the logo for each size of the garment.*</u> Interviewer: Wouldn't it be easier to do this task by using a computer? Linda: I would use a computer for the final stages of the design process for accuracy, but for the initial stage of "look and feel" I would prefer to do it by hand, working with the physical object because I am used to doing the design work with "tangible" things like this paper template.

	*Once the position of the logo is confirmed, a demo of the design will be produced.*
	*Fax received from the manufacturer.* Interviewer: What are the usual forms of communication? Linda: Mostly telephone, some fax and mail if we need to send/receive any physical objects to and from our manufacturer.
	*Designer Linda received some fabric samples from a textile manufacturer with various choices of individual colours.* Interviewer: What do you need to do next? Linda: I will need to pick the colours that are the closest match to the fabric on the right from the samples on the left, and then call back to the textile manufacture for confirmation.
	*Typical manufacturing specifications (simple).* Interviewer: Will the specification sheet for each design be converted into digital format? Linda: No, at this stage they are stored in

	folders and the previous season's specifications are stored in the storage room. Although if someone converted them into digital format, it would be a lot easier to retrieve or archive them.
	*Typical manufacturing specifications (with alternative fabric colour).*
	*Typical manufacturing specifications (with logo).*
	*Complicated graphic design with layers of real fabrics.* Interviewer: How do you create this particular design? Linda: This is one of our more complicated designs. In this case, we are trying to create a 3-D feel of the skirt and umbrella from a normal 2-D image, so the design stands out

	from the fabric.
	<u>*Complicated graphic design with layers of real fabrics (different stages).*</u>

D. Quick And Dirty User Testing Information Sheet And Questionnaire.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences
& Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(mobile: 0412088029)

The multi-touch designer table is only a proof of concept for my research and is not for commercial production. The user interface is only at a simple and yet basic prototype stage. The purpose of this user testing is to test the concept of my research and it is NOT about testing the hardware technology behind the multi-touch designer table, or a fully developed commercial system. This user testing will help me identify the key aspects of interactions in a collaborative situation/environment. Please do not hesitate to put down your ideas and suggestions in this questionnaire.

Interview/Questionnaires

1. How easy/hard did you find navigating the system?

Very Hard   Average   Very easy

1   2   3   4   5   N/A

If you found it difficult, was it because you were unfamiliar with the process involved in doing it? If so, please describe or give an example of how you would have preferred it to be.

2. How easy/hard did you find browsing images/clothing designs from the database?

Very Hard   Average   Very easy

1   2   3   4   5   N/A

If you found it difficult, was it because you were unfamiliar with the process involved in doing it? If so, please describe or give an example of how you would have preferred it to be.

3. How easy/hard did you find communicating with the other participant using the on-screen keyboard while collaborating on a task?

Very Hard		Average		Very easy	
1	2	3	4	5	N/A

If you found it difficult, was it because you were unfamiliar with the process involved in doing it? If so, please describe or give an example of how you would have preferred it to be.

4. How easy/hard did you find communicating with the other participant using the "pencil" drawing tool while collaborating on a task?

Very Hard		Average		Very easy	
1	2	3	4	5	N/A

If you found it difficult, was it because you were unfamiliar with the process involved in doing it? If so, please describe or give an example of how you would have preferred it to be.

5. How easy/hard did you find the overall communication with the other participant at any time while collaborating on a task?

Very Hard		Average		Very easy	
1	2	3	4	5	N/A

If you found it difficult, was it because you were unfamiliar with the process involved in doing it? If so, please describe or give an example of how you would have preferred it to be.

6. Do you prefer to have telephone communication while collaborating on a task?

7. Do you feel that a basic tutorial/help function on how to use the system would help and why?

8. Do you feel that it was hard to understand how the system was interpreting your interactions?

9. Which features do like best and least?

10. Are there any other features/functions/tools (hardware) that you would like to see in this system?

11. Do you have any other suggestions for improvement for the system?

12. Overall, how did you find the system?

Poor		Average		Excellent
1	2	3	4	5

E. Ethical Clearance, Information Sheet, Consent Form And Gatekeeper Letter For Conducting Research Studies At MIST College In 2009.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Information Technology and Electrical Engineering

Student Research Ethical Review Application Form

Student's Name: Jason Shih Sheng Yang Student ID # 30092824

Student's Email Address: jyang@itee.uq.edu.au Telephone: 0412088029

Degree Program: PhD Status/Year: 3rd year

Supervisor's Name: Dr. Ralf Muhlberger Email: ralf@itee.uq.edu.au Phone: 07 3365 2766

Working title of research: How can computer interfaces support virtual collaboration in the clothing industry

ETHICAL DECLARATION: We, the undersigned research student and supervisor, have considered the ethical issues relevant to this research project. It is our judgement that this research adheres to our own ethical standards, those of the discipline, and *The University of Queensland's Guidelines for Ethical Review of Research Involving Humans – 2000.*

[signature] 20-4-2009 — Student Signature/Date

[signature] 20/4/2009 — Supervisor Signature/Date

OFFICE USE ONLY Date Received in Course Centre 7/05/2009

Reviewed by: [signature] — ITEE Ethical Review Officer

27/5/09 — Date

Clearance Number: 2009/03 **Student/Supervisor advised via email** ☐

Clearance Conditions: None.

Gatekeeper consent

Usability user testing of multi-touch application assisting designer's work

PhD research student: Jason Shih Sheng Yang
Principle Advisor: Dr. Ralf Muhlberger

The above research team from University of Queensland will conduct a usability user testing study involving students and teachers at Metropolitan South Institute of TAFE in Queensland.

The objective of the study is to examine how user friendly and effectiveness of the software application in assisting basic designer's work.

Place and Time frame:
User testing study will be conducted at MSIT fashion department for duration of 2 weeks. My aim is to get minimum of 5 teachers and 5-10 students in total to participate this study.

Activities:
At the start of the activity, there will be a short movie clip explaining the goal of the research project to participants, and also the aim of this user testing. The user testing will be in the form of scenario based activities where participant will have a series of mini tasks to perform using the software. Each mini-task is set to maximum of 5 minuets and the whole user testing per each participant (teacher and student) is no more than 20 minutes. During the user testing, data will be collected in terms of how many correct steps participants takes to perform the task also how many steps participants have trouble completing the task and have to go back or ask for help. There will also be a quick interview for each participant after the activity to ask for any feedback on the usability of the software.

The aim of the study is to investigate if learner-adaptive computer software can be beneficial as a complement in classroom learning for both students and teachers.

The result of the user testing study can help to better understand how designer will adopt new technology in assisting their basic designer work. The result will be made available to the TAFE on request.

I understand that participation in the study is completely voluntary. All participants will be asked to give informed consent and will receive an information sheet detailing the user testing mechanism and procedure.

I fully condone this study.

Supported

Liz Reynolds
Education Manager
6 April 2009

Supported

Jackie McArthur
Faculty Director
6 April 2009

1.	**Briefly state the project aims.**

The aim of the study is to examine the user friendliness and effectiveness of touch based hardware and software applications in assisting basic design work.

2.	**Briefly state methods, measures and procedures.** (List any standard measures & manipulations. Attach details/copies of new/purpose built questionnaires or other materials.)

At the start of the activity there will be a short movie clip explaining the goal of the research project to participants, and also the aim of this user testing. The user testing will be in the form of scenario based activities where participants will have a series of mini tasks to perform using the software. Each mini-task is set to a maximum of 5 minutes and the whole user testing per each participant (teacher and student) is no more than 20 minutes. During the user testing, data will be collected in terms of how many correct steps participants take to perform the task and how many steps participants have trouble completing the task and have to go back on or ask for help. There will also be a quick interview for each participant after the activity to ask for any feedback on the usability of the software.

3.	**Who are the Participants?**

Tick and specify where requested:

- ☐ Volunteer students/members of UQ community
- ☐ Paid participants
- ☐ Special population (specify) ________________________
- ☐ Community Sample (specify age & recruitment) ____________________
- ☑ Other (specify)
  Students and teachers in fashion department from Metropolitan South Institute of TAFE

4.	**State recruitment procedures**

There will be two types of recruitment; one for the teachers in the fashion department, and the other for the students in the fashion department. I will first contact the head of fashion department and request permission to attend some classes. After permission has been granted, I will give a brief introduction about the study and I will hand out the information sheets and consent forms to all the members of the fashion department who wish to participate in my research. I will then collect the consent forms and exchange contact details for those potential participants.

(a) Is consent to participate fully informed and voluntary? Yes/No

(b) Is signed consent to be obtained? Yes/No (If "Yes", attach form)

(c) Is an information sheet to be provided? Yes/No (If "Yes", attach form)

(d) Where applicable, will parental, institutional, and/or gate-keeper consent be obtained?
Yes/No/NA (If "Yes", give details and attach forms/approval).

5.	Describe the procedures for assuring anonymity or confidentiality of data.

Participants will be clearly informed that the data collected from my user testing study will only be used in my research and that their personal details such as name will be de-identified. Recorded data such as paperwork, audio/video clips will be stored in a secure locked cabinet and all digitally recorded material will be password protected

6.	Do the procedures involve any of the following?

- ☐ Potentially noxious, embarrassing or offensive stimuli/procedures
- ☐ Deception
- ☐ Concealment
- ☐ Invasive procedures (e.g. blood or saliva samples)
- ☐ Drugs
- ☐ Data from other researchers

Give details and justification of any of the above:

NO

7.	Describe procedures to allow for participants to withdraw from the study

Should any participant withdraw from the study, any identifiable information about them that has been gathered up to that point will be destroyed. If a participant has decided to withdraw after an interview, all interview data will be destroyed, any user testing notes specifically about that participant will also be destroyed and from that point in time, I will not engage with that individual further about the study.

8.	Describe debriefing procedures. Attach copy of debriefing/information sheet if available.

N/A

9.	**Does this study involve foreseeable risks to participants beyond the risks of everyday living? Yes/No** (If "Yes", describe the nature and extent of risks, along with risk minimisation procedures).

NO

10.	**Does this study involve foreseeable elevated risks to community groups, institutions, the researcher, or the discipline of information technology/electrical engineering? Yes/No** (If "Yes", describe.)

NO

11.	Describe the potential benefits (to participants, researcher, institutions, community groups, and/or society at large) and explain how these are sufficient to justify the following:

(a) The volunteers' time and trouble

Participants will be rewarded a chocolate bar for completing user testing activities.

(b) The risks (if applicable)

N/A

12.	Are any anticipated benefits (e.g. of a technological tool) available to some participants to be made available to all participants in a timely fashion? Yes/No/NA

N/A

13.	Does the supervisor (or others) have current BSSERC approval for research employing essentially the same methods, procedures and participants? Yes/No (If "Yes", please give clearance number and any salient differences).

NO

14.	(Optional) Describe any other salient ethical considerations arising in the proposed research and indicate how these will be dealt with.

N/A

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences &
Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(mobile: 0412088029)

INFORMATION SHEET

Title of Research Project: How can computer interfaces support virtual collaboration in clothing industry

Name of Principal Investigators: Jason Shih-Sheng Yang

My research is focused on designing a computer system that will potentially allow businesses that have manufacturing departments located remotely to function as effectively and efficiently as if they are in the same location. I have chosen to carry out my research in the fashion industry because it is a good example of a distributed manufacturing industry.

I would like to conduct a user testing study to validate my earlier research findings. The objective of the study is to examine user friendliness and effectiveness of the software application in assisting basic design work.

At the start of the activity there will be a short video clip explaining the basic tools and functions of the software application on the multi-touch machine for this user testing. The user testing will be in the form of scenario based activities where participants will have a series of mini tasks to perform using the software. Each mini-task is set to a maximum of 5 minutes and the entire user testing per each participant (teacher and student) is no more than 20 minutes. There will also be a quick interview for each participant after the activity to ask for any feedback on the usability of the software. The interview proceedings will be audio recorded. This will only occur after the user testing has finished so there is no interruption. The information you give will remain confidential. Only the investigator of the project will have access to your responses and also recorded footage. The results of this research will be made available once the study is finished in June 2009. If you would like a copy please contact me.

The participation is completely voluntary and you can withdraw from participation at any time without penalty. If you have chosen not to participate, I will not approach you or observe you at all.

This information sheet is yours to keep. If you have any questions regarding this project I will be happy to answer them. You can contact me on 0412 088029 (mobile) or alternatively email me at jyang@itee.uq.edu.au.

Jason Shih-Sheng Yang
PhD Student
The University of Queensland

This study has been cleared in accordance with the ethical review processes of the University of Queensland. You are, of course, free to discuss your participation with project staff. If you would like to speak to an officer of the University not involved in the study, you may contact the School of Information Technology and Electrical Engineering Ethics Officer directly on 3365 2097, or contact the University of Queensland Ethics Officer on 3365 3924.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences &
Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(mobile: 0412088029)

CONSENT FORM

Title of Research Project: How can computer interfaces support virtual collaboration in clothing industry

Name of Principal Investigators: Jason Shih-Sheng Yang

I agree to take part in the user testing study as explained on the *Information Sheet*.

I have read (or had read to me) and understood the *Information Sheet* that explains the research project.

I am aware that all the data collected will only be used for its stated purpose and my personal details will remain confidential. Should I be quoted in the report, my identity will remain undisclosed.

I am aware that I may not gain anything from taking part in this research. I also understand that I am not being graded on my participation in this study and I will not be affected academically should I discontinue my involvement.

I understand that the participation is voluntary and I am free to ask questions or to withdraw from participation at any time without penalty.

CONSENT BY PARTICIPANT

I have read, or had read to me, and understood all the information provided. I agree to take part in the research as described in this consent form.

Full name	Signature	Date
________________	________________	______________

F. Ethical Clearance, Information Sheet, Consent Form And Gatekeeper Letter For Conducting Multi-Stage Evaluation Study At MSIT College In 2011.

SCHOOL OF INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

ETHICS COMMITTEE

OUTCOME OF REVIEW

APPLICATION DETAILS:

Reference:	EC201106YANG-A (*amended application*)
Name:	Jason YANG
Student Number:	30092824
Project Title:	Video-stimulated recall and video card game user testing
Principal Advisor:	Stephen Viller

Date Received:	30 August 2011 (*original application received 12 August 2011*)
Expedited Review:	Yes – minor amendments
Date Reviewed:	30 August 20111 (*original application reviewed 24 August 2011*)

OUTCOME OF REVIEW:

- ☑ Approved
- ☐ Request Amendment
- ☐ Require Submission to BSSERC/MREC

COMMENTS:

Amended application submitted 30 August has been approved by the acting chair, ITEE Ethics Committee.

Signature: [signature]
Chair, ITEE Ethics Committee

Date: 30/8/11

Gatekeeper consent

Video-stimulated recall and video card game user testing

PhD research student: Jason Shih Sheng Yang
Principle Advisor: Dr. Stephen Viller

The above research team from University of Queensland will be conducting a video-stimulated recall and video card game user study involving students at Metropolitan South Institute of TAFE in Queensland.

Place and Time frame:
The user testing study will be conducted at MSIT fashion department in August 2011 for duration of 8 weeks.

Activities:
The first stage of the study is to observe the collaboration and interaction during mutual critiques of student's design works. The second stage of the study is to conduct video-stimulated recall interviews, consisting of a series of questions, while viewing the recorded footage of the user testing activity. The third stage of the study is to conduct a video card game exercise, which involves sorting some images cards into themes.

The result of the user testing can help to better understanding how designer will adopt new technology to collaborate their design work. The result will be made available to the TAFE on request.

I understand that participation in the study is completely voluntary and participants can withdraw from participation at any time without penalty. All participants will be asked to give informed consent and will receive an information sheet detailing the user testing procedure.

I fully support this study.

Supported

E Reynolds.

Liz Reynolds
Education Manager
9 August 2011

1.	**Briefly state the project aims.**

The project aim is to conduct a qualitative study to evaluate and investigate the use of combined TVTM system[1] and hardware for supporting remote interaction and collaboration in fashion design. This study is about evaluating the TVTM software system and also exploring the phenomenon of the gesture-based interaction around the multi-touch gesture technology.
The evaluation study involves 3 stages (see section 2). Stage 1 evaluates the software with pairs of design students undertaking collaborative tasks. Stage 2 uses video recording from stage 1 to explore and review the interactions in more detail. Stage 3 follows a game playing process to explore common interaction themes in the video data.

2.	**Briefly state methods, measures and procedures.** (List any standard measures & manipulations. Attach details/copies of new/purpose built questionnaires or other materials.)

Stage 1: User testing
Study Participants in pairs are requested to use the TVTM system in order to critique each other's designs. Interactions will be recorded for later use.

1. At the start of the user testing activity there will be a short video clip explaining the basic tools and functions of the software application on the multi-touch machine for this user testing.
2. Two participants are required per session.
3. They will use the software in two separate locations to generate remote collaboration.
4. The user testing will be in the form of critiquing activities, where two participants will have to critique each other's design work using the software.
5. Each participant has a maximum of 10 minutes to critique his or her partner's design work and the entire user testing session is no more than 30 minutes.
6. Each user testing session will be video recorded and will be played back later during the interview stage and selected clips will be used in the 'video card game[3]' stage.

Stages 2: Video-stimulated recall[2] interview
Participants are interviewed in pairs about the use of the TVTM system during the user testing session making use of recorded video to assist recall.

1. Video-stimulated recall interview will only occur after the user testing has finished so there is no interruption during the user testing.
2. Two participants from the same user testing session are required during the interview.
3. The interview proceedings will be audio recorded to assist with transcribing/note taking.
4. Participants will be asked to watch the video footage of their user testing session.
5. The Interviewer will ask a series of questions with regards to the video footage.

Stage 3: Video card game[3]
Four groups of five participants 'play' a creative design game where video clips are use as working material to identify common themes in the data.

1. Twenty participants from the user testing session are required during the video card game and they will be split into four groups.
2. Each participant will be given a set of 10 random photo images cards.
3. Each participant will be given 30 minutes to watch their short video sequences and will be asked to review their cards individually and take notes on the cards based on what he/she observed from the video clips.

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[1] Yang, J, Muhlberger, R and Viller, S (2010) TVTM: A case study and analysis of 3 virtual representations to support remote collaboration within the fashion industry. 470, School of Information Technology and Electrical Engineering, The University of Queensland. http://espace.library.uq.edu.au/view/UQ:217226

[2] PIRIE,S. E. B. (1996) Classroom video-recording: when, why and how does it offer a valuable data source for qualitative research?, Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Panama City, FL, 14 October 1996.

[3] Buur, J. and A. Soenderborg. (2000) Video Card Game: An augmented environment for user centered design discussions, in proceedings of DARE (Elsinore, Denmark,2000), ACM Press,63-69.

4. Participants will be asked to group their cards openly in front of their group and describe their potential themes in terms of interaction activities.
5. Each participant will then be asked to present a theme that they come up with to their group and invite other participants to contribute with their cards which fit into the same theme. The participants have up to 2 hours to finish this task.

3.	**Who are the Participants?**

Tick and specify where requested:

☐ Volunteer students/members of UQ community

☐ Paid participants

☐ Special population (specify) ____

☐ Community Sample (specify age & recruitment) ______________________________

☑ Other (specify)

Students and teachers in fashion department from Metropolitan South Institute of TAFE

4.	**State recruitment procedures**

There will be one type of recruitment; the students in the fashion department. I will give a brief introduction about the study and I will hand out the information sheets and consent forms to all the members of the fashion department who wish to participate in my research. I will then collect the consent forms and exchange contact details for those potential participants.

(a) **Is consent to participate fully informed and voluntary?** Yes/No
(b) **Is signed consent to be obtained?** Yes/No (If "Yes", attach form)
(c) **Is an information sheet to be provided?** Yes/No (If "Yes", attach form)
(d) **Where applicable, will parental, institutional, and/or gate-keeper consent be obtained?** Yes/No/NA (If "Yes", give details and attach forms/approval).

5.	**Describe the procedures for assuring anonymity or confidentiality of data.**

Participants will be clearly informed that the data collected from my user testing study will be used in my research and that their personal details such as name will be de-identified. Recorded data such as paperwork, audio and video clips will be stored in a secure locked cabinet and all digitally recorded material will be password protected. Participants also have a choice whether to give permission for use of video in research process including presenting in conferences or not.

6.	**Do the procedures involve any of the following?**

☒ Potentially noxious, embarrassing or offensive stimuli/procedures

☐ Deception

☐ Concealment

☐ Invasive procedures (e.g. blood or saliva samples)

☐ Drugs

☐ Data from other researchers

Give details and justification of any of the above:

While the process of critiquing one another's work is an everyday occurrence in a design education context, recording and playing video footage of this process has the potential to expose participants to some degree of embarrassment. For this reason, I have given participants the opportunity not only to withhold or withdraw their consent for participating in the study, but also to withhold (initially) or withdraw (at any time during the study) their consent to video footage of them being recorded and/or replayed.

My plan to work around the possible withholding or withdrawing of such consent e.g. ensure that students are organised into pairs where both consent to be recorded, if one of the participants within the pair decide to withhold or withdraw from participation, I will need to make sure not to use or to carefully edit any wider shots that may include people who have not consented or who have subsequently withdrawn their consent. If one person in a pair of participants chooses not to continue with the study, the data for both participants will be destroyed, as individual data is of no use to my study. By ensuring a sufficiently broad selection of participants, the minimal loss of some sets of data should not have an adverse effect on my study

7. Describe procedures to allow for participants to withdraw from the study

Participants are free to withdraw at anytime without penalty during the entire study. Should any participant withdraw from the study including video and audio recording, any identifiable information about them that has been gathered up to that point will be destroyed. If a participant has decided to withdraw after an interview, all interview data will be destroyed, any user testing notes specifically about that participant will also be destroyed and from that point in time, I will not engage with that individual further about the study.

8. Describe debriefing procedures. Attach copy of debriefing/information sheet if available.

N/A

9. Does this study involve foreseeable risks to participants beyond the risks of everyday living? Yes/No (If "Yes", describe the nature and extent of risks, along with risk minimisation procedures).

Yes. Although the exposure to peer critique is a perfectly normal, everyday element of design education and therefore does not expose participants to risks above those of everyday living, the use of video recording and replay within the research process and in later research communication (use in conferences and perhaps teaching settings) has the potential to expose them to slightly elevated risk of embarrassment or personal discomfort. Again, this is managed by ensuring that participants are informed of this risk, and that they explicitly consent to having their image used in this way, and that they understand that they are free to withdraw their consent (either fully or partially) at any time during the study, without penalty of any kind.

10. Does this study involve foreseeable elevated risks to community groups, institutions, the researcher, or the discipline of information technology/electrical engineering? Yes/No (If "Yes", describe.)

NO

11. Describe the potential benefits (to participants, researcher, institutions, community groups, and/or society at large) and explain how these are sufficient to justify the following:

(a) The volunteers' time and trouble

Participants will be rewarded a coffee voucher for completing user testing activities.

(b) The risks (if applicable)

N/A

12. Are any anticipated benefits (e.g. of a technological tool) available to some participants to be made available to all participants in a timely fashion? Yes/No/NA

N/A

13. Does the supervisor (or others) have current BSSERC approval for research employing essentially the same methods, procedures and participants? Yes/No (If "Yes", please give clearance number and any salient differences)

YES, ITEE clearance number: 2009/03

14. (Optional) Describe any other salient ethical considerations arising in the proposed research and indicate how these will be dealt with.

N/A

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Information Technology & Electrical Engineering
Faculty of Engineering, Physical Sciences & Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(mobile: 0412088029)

INFORMATION SHEET

Title of Research Project: Video-stimulated recall and video card game user testing

Name of Principal Investigators: Jason Shih-Sheng Yang

My research is focused on designing a computer system that will potentially allow businesses that have manufacturing departments located remotely to function as effectively and efficiently as if they are in the same location.
I am conducting a quick user testing study followed by a video-stimulated recall interview and video card game study, to validate my earlier research findings. The first stage of the study is to observe the collaboration and interaction during mutual critiques of student's design works. The second stage of the study is to conduct video-stimulated recall interviews, consisting of a series of questions, while viewing the recorded footage of the user testing activity. The third stage of the study is to conduct a video card game exercise, which involves sorting some images cards into themes. The details of each stage are described below:

Stage 1: User testing

1. At the start of the user testing activity there will be a short video clip explaining the basic tools and functions of the software application on the multi-touch machine for this user testing.
2. Two participants are required per session.
3. They will use the software in two separate locations to generate remote collaboration.
4. The user testing will be in the form of critiquing activities, where two participants will have to critique each other's design work using the software.
5. Each participant has a maximum of 10 minutes to critique his or her partner's design work and the entire user testing session is no more than 30 minutes.
6. Each user testing session will be video recorded and will be played back later during the interview stage and selected clips will be used in the 'video card game[3]' stage.

Stages 2: Video-stimulated recall interview

1. Video-stimulated recall interview will only occur after the user testing has finished so there is no interruption during the user testing.
2. Two participants from the same user testing session are required during the interview.
3. The interview proceedings will be audio recorded to assist with transcribing/note taking.
4. Participants will be asked to watch the video footage of their user testing session.
5. The Interviewer will ask a series of questions with regards to the video footage.

Stage 3: Video card game

1. Twenty participants from the user testing session are required during the video card game and they will be split into four groups.
2. Each participant will be given a set of 10 random photo images cards.
3. Each participant will be given 30 minutes to watch their short video sequences and will be asked to review their cards individually and take notes on the cards based on what he/she observed from the video clips.
4. Participants will be asked to group their cards openly in front of their group and describe their potential themes in terms of interaction activities.

5. Each participant will then be asked to present a theme that they come up with to their group and invite other participants to contribute with their cards which fit into the same theme. The participants have up to 2 hours to finish this task.

The information you give will remain confidential. Only the investigator of the project will have access to your responses and also your recordings. Your recordings will be stored on a password-protected computer and in password-protected files. Your recordings will be kept permanently and will only be used for research purposes. In an event where recording are shown to other researchers and audiences in academic conferences, your identity will remain confidential and will be given a false name (e.g. Participant A). Your recordings will never be shown to other general public for commercial gain and will never be given away or sold. The identities of all the participants will be de-identify. If you would like to have access to the results of the study, you may contact me directly to request for a copy of the publication once it has finished in September 2011.

The participation is completely voluntary, if you have decided to participate this study, you will be given a coffee voucher at the end of study. You are free to withdraw at any time from participation in the study. You are also free to withdraw your consent to use the video images (either fully or partially) at any time during the study, without penalty of any kind.

If you have chosen not to participate, I will not approach you at all.

This information sheet is yours to keep. If you have any questions regarding this project I will be happy to answer them. You can contact me on 0412 088 029 (mobile) or alternatively email me at jyang@itee.uq.edu.au.

Jason Shih-Sheng Yang
PhD Student
The University of Queensland

This study has been cleared in accordance with the ethical review processes of the University of Queensland. You are, of course, free to discuss your participation with project staff on 0412088029. If you would like to speak to an officer of the University not involved in the study, you may contact the School of Information Technology and Electrical Engineering Ethics Officer directly on 3365 2097, or contact the University of Queensland Ethics Officer on 3365 3924.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Information Technology
& Electrical Engineering
Faculty of Engineering, Physical Sciences &
Architecture (EPSA).
PhD Student: Jason Shih-Sheng Yang

The University of Queensland
Brisbane, QLD 4072.
Australia
Contact: jyang@itee.uq.edu.au;
(mobile: 0412088029)

CONSENT FORM

Title of Research Project: Video-stimulated recall and video card game user testing

Name of Principal Investigators: Jason Shih-Sheng Yang

I agree to take part in the user testing study as explained on the *Information Sheet.*

I have read (or had read to me) and understood the *Information Sheet* that explains the research project.

I am aware that the entire participation will be video and audio recorded, and I hereby consent to the videotaping and audio recording of myself.

I am aware that all the data collected will only be used for its stated purpose and my personal details will remain confidential. Should I be quoted in the report, my identity will remain undisclosed.

I am aware that I may not gain anything from taking part in this research. I will only be rewarded a coffee voucher after I have completed all three stages of the study. I also understand that I am not being graded on my participation in this study and I will not be affected academically should I discontinue my involvement.

I understand that the participation is voluntary and I am free to ask questions or to withdraw from participation at any time without penalty.

CONSENT BY PARTICIPANT

YES ☐ I DO give consent for the video recording being shared with other researchers and/or shown in academic conferences as part of the research analysis process. I understand I have the right to withdraw my consent to the use of my video recorded image at any time during the study, without penalty

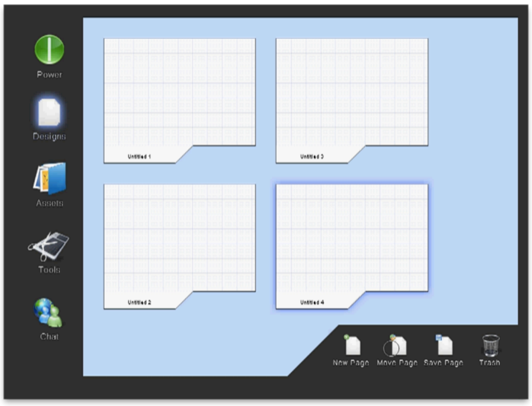
NO ☐ I DO NOT give consent for the video recording being shared with other researchers and/or shown in academic conferences as part of the research analysis process.

I have read, or had read to me, and understood all the information provided. I agree to take part in the research as described in this consent form.

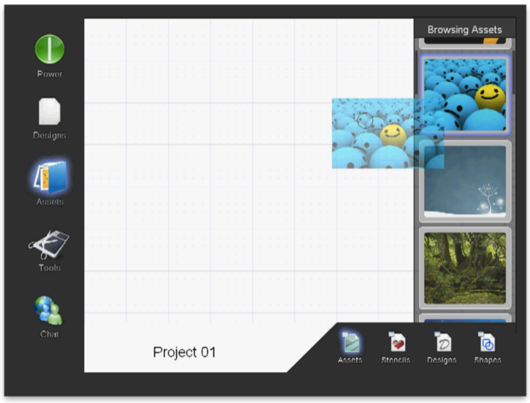
Full name Signature Date

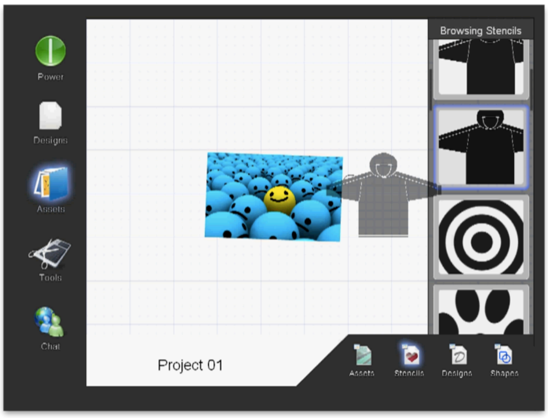
G. TVTM User Interface (Screen Captured)


Power


Power
Designs
Assets
Tools
Chat
New Page
Move Page
Save Page
Trash


Power
Designs
Assets
Tools
Chat
Untitled 1


Browsing Assets
Power
Designs
Assets
Tools
Chat
Project 01
Assets
Stencils
Designs
Shapes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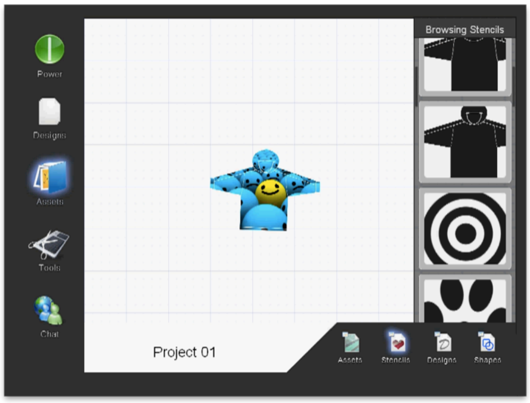
Project 01
Assets
Stencils
Designs
Shapes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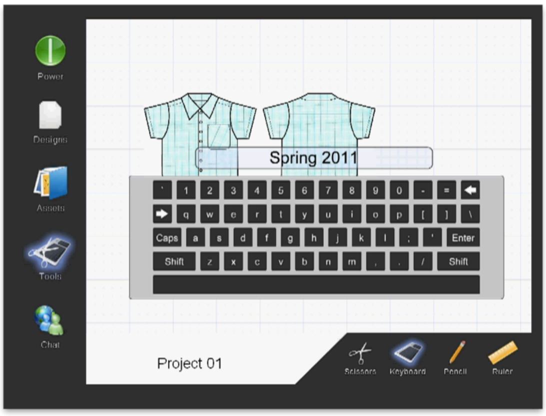
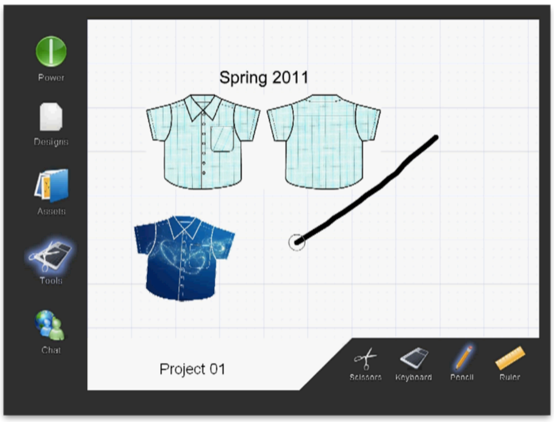
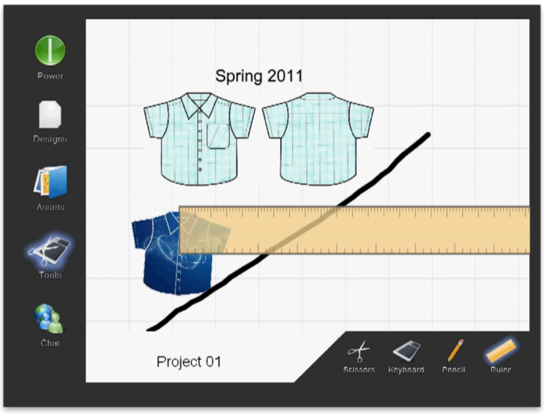
Project 01
Assets
Stencils
Designs
Shapes


Power
Designs
Assets
Tools
Chat
Spring 2011
Project 01
Scissors
Keyboard
Pencil
Ruler


Power
Designs
Assets
Tools
Chat
Spring 2011
Project 01
Scissors
Keyboard
Pencil
Ruler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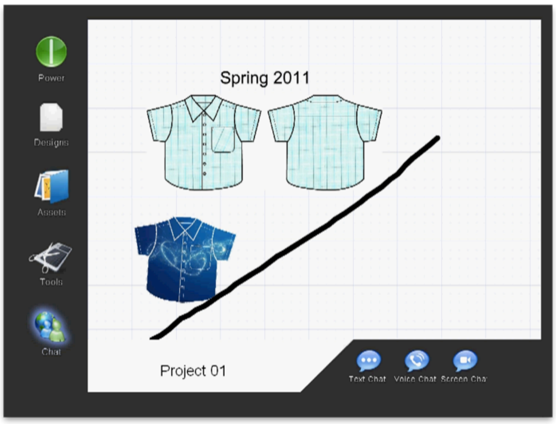
Assets
Tools
Chat
Spring 2011
Project 01
Scissors
Keyboard
Pencil
Ruler


Power
Designs
Assets
Tools
Chat
Spring 2011
Project 01
Text Chat
Voice Chat
Screen Cha

H. Transcripts for chapter 5, section 5.3

Transcripts for section 5.3.1:

Interviewer: *How does this prototype compare to the FTF communication?*

Quote 1:

Bree: *It is a bit hard to use this technology, but if this is the only option then you would find a way to learn how to use it. And it doesn't have all the ideas that you have in the system so it makes it harder.*

Quote 2:

Elle: *It is good that you can have the system in front of you and you can both interact with it.*

Faye: I like to use hand gestures to show people what I am thinking.

Quote 3:

Dani: *I think FTF is easier to hear and see. I think the biggest problem for me is not being able to manipulate so I did not have the normal flow of the conversation. So I was more focusing on trying to get the touch screen to work rather than talking about the design problem. If the system is fully functional then it would definitely help.*

Quote 4:

Gail: *Obviously you still have the audio component, but you know we are so used to the paralinguistic gestures that you do miss out on that extra level of communication. So it would help if the system had similar visual function to let users see each other as well.*

Transcripts for section 5.3.2:

Quote 1:

Interviewer*: I can see your hand (Faye) trying to swipe up and down over the touch screen when trying to assist your partner (Elle) in finding an alternative fabric and were you (Faye) wanting to take over the control at the time?*

Faye*: Yes, I saw one that she (Elle) had passed that I liked and it was like an automatic thing to use finger gestures. But I knew if I touched the screen again it would interrupt the system and cause the system to crash as you can't both interact at the same time.*

Quote 2:

Interviewer*: When your partner (Hana) was taking about her jacket design, did you (Gail) want to see more about her design?*

Gail*: No, I was just trying to hear what she was saying. It is like I am talking to you and you can't hear what they are saying is really frustrating.*

Hana*: You can't hear or was it because you don't understand?*

Gail*: I couldn't hear what you (Hana) were saying at all.*

Quote 3:

Interviewer*: You (Gail) made a comment that you couldn't see the design of the jacket very well on the screen, did you at that point want to interrupt your partner to clarify about this issue?*

Gail*: Yes I did. I couldn't hear what she (Hana) was saying. I was just wanted to make sure that we were on the same page.*

Transcripts for section 5.3.3:

Quote 1:

Interviewer: *When you were describing the 'pink and roses', you were using hand/finger rolling gestures, why did you do it like that?*

Dani: *It is part of the conversation just like in FTF conversation.*

Quote 2:

Interviewer: *When you were describing your design earlier, I saw you making hand gestures over your chest to present the height of the dress you were describing. What was the intention there?*

Faye: *Yes it is like an automatic thing using the hand/fingers gestures thing.*

Interviewer: *Would you use the same gestures or movements if you were chatting FTF?*

Faye: *Yes.*

Quote 3:

Interviewer: *I noticed that you (Hana) have used your hand gestures to represent long sleeves, would you use the same gestures if you were having a FTF conversation?*

Hana: *Yes I would.*

Transcripts for section 5.3.4:

Quote 1:

Interviewer: *How did (Faye) you figure out how scrolling works?*

Faye: *It is basically like an Apple product, so it is very straightforward.*

Interviewer: *And how did you know you could resize the images using two fingers?*

Faye: *Yes, I remembered you could do the resizing like iPhone and iPad etc.*

Quote 2:

Interviewer: *You (Dani) made the comment in the video about how you (Dani) are used to touch screen technology like iPhone. What sort of features are you familiar with?*

Dani: *Yes, the touch inputs are very similar although the screen (TVTM prototype) is much 'heavier' to use and not very responsive.*

Transcripts for section 5.3.5:

Quote 1:

Faye: *It would be good if the system could support sketching,*

I guess to change some of the details I would use keyboard or pen tool to help each other out with the details that you can't do verbally.

Quote 2:

Elle: *Also a better webcam would be good.*

Quote 3:

Dani: *I think the system is good; it builds on the technology that we are pretty familiar with like the touch phone and touch screens. So I think that making the functions more like what we are using already would be good. So it doesn't require too much learning to use the system. With regards to remote collaboration, it would be really good to have split screens function so that we could both see what we were working on at the same time and also an area where you can present your ideas and designs. So for example, I can work on the alternative design or solution to a design problem when she was presenting her design problem and vice versa.*

Quote 4:

Cleo: *It would be good if the system supported cloud storage and a sharing facility like Dropbox so we could share files in the design firm's database.*

Quote 5:

Bree: *Make it faster, easier to use, more editing functions, webcam images are not very clear and very small too. It would also be good to have an individual workspace and share workspace on the system.*

Quote 6:

Gail: *It is kind of hard and difficult to work with but once I have became familiar with it, it would be just as easy to navigate.*

Quote 7:

***Hana**: The program is a bit slow and also it is hard to get a common understanding.*

Quote 8:

***Gail**: Yes, if we were both very skilled users of it, it would be a great tool.*

Quote 9:

***Gail**: It would be good to have a colour palette and basic graphic editing tools. Also some sort of magnifying functions that focus on what the other user is talking about or where their attention has been directed on the screen, so you know instantly where to follow and know what they are saying using something like an eye tracking device.*

Quote 10:

***Hana**: Maybe split the screen into two; one is for individual working space and one to share while collaborating.*

I. Example of cards generated for each individual theme by the fashion design students during the Video Card Game study

Theme: Selecting

Gwenneth selects an image by tapping on the screen.

* Trying to select the icon on screen.

Clip 26

Lizzie selects the new fabric.

selecting fabric & putting on screen

Clip 41

Theme: Navigating Systems And Changing Orientation

Elana magnifies the image.

woman navigating through system.

Clip 2

Tamarra shrinks the image down on the screen.

* fixing the icon on the screen. Rotating & sizing.

Clip 24

Theme: Pointing At Screen During Conversation

Jenni points and confirms the specific image with her partner.

Pointing to designs

Clip 16

Jenni describes different colours for the swimwear.

detailing of the design.

Clip 20

Theme: Choosing /Conversing

Katarina wants to change the pattern on the fabric.

Seems to be looking at the fabric beside it for idea's to change the fabric pattern.

Clip 59

Katarina selects another fabric.

choosing fabric putting on screen

Clip 65

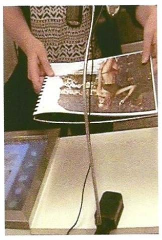
Theme: Asking Advice And Seeking Confirmation

Katarina asks her partner if she likes any other fabric.

Asking for other ideas & seeing what her partner likes/ dislikes.

Clip 64

Lizzie shows her design to her partner on the webcam.



She describes her dislikes of the design and raises the booklet to visualize this to her partner.

Clip 39

Theme: Showing And Explaining

Tamarra confirms the choice of the new fabric with Jenni.

* looking for a colour. discussing & choosing with jenny.

Clip 23

Jenni describes the print design in detail.

talking about the detail of design.

Clip 19

Theme: Drawing

Lizzie tries to draw on top of the fabric.

trying to draw on design

Clip 48

Lizzie draws the shape of the swimwear.

Drawing the swimwear

Clip 50

Theme: Looking And Searching

Gwenneth wants to look for an alternative design.

Looking for alternative design trying to manipulate screen

Clip 30

Gwenneth cuts fabric with a heart shape stencil.

She was looking for patterns

Clip 32

Theme: Communication With Partner

Gwenneth confirms what she sees on the screen with her partner.

Confirming that her & her partner understand eachother.

Clip 29

Jennis suggests waist heights for the swimwear.

trying to explain the design idea.

Clip 21

Theme: Changing Designs

Lizzie talks about the t-shirt design.

It looks as if she is attempting to show changes on the programme but has difficulty so she goes back to the visual.

Clip 52

Lizzie talks about her new design.

Changing the design of the bikini top.

Clip 45

Theme: Scrolling Selections

Katarina looks for an alternative design.

She is trying to find different ideas for the fabric.

Clip 60

Chung-Fu looks for an alternative fabric.

Scrolling selecting

Clip 33

Theme: Putting Fabric Onto The Screen

Gwenneth points at the new fabric.

Showing a new fabric

Clip 28

Amy agrees with the choice of the pattern.

checking the pattern.

Clip 69

Them: Choosing Shape And Putting Shape Onto Fabric

Clave talks about two alternative print designs.

using a shape tool on a print.

Clip 10

Lizzie uses stencils to cut the new fabric into a flower shape.

choosing shape to put on fabric

Clip 43

Theme: Resizing

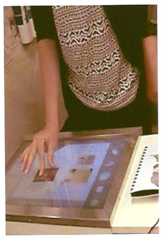
Elana magnifies the image.

~~About the Price?~~

Resizing.

* Clip 2

Lizzie resizes the new fabric image.



Zoom out / in Pattern

* Clip 42

Theme: Searching For Pattern

Amy looks for an alternative fabric.

scrolling looking for fabric

Clip 66

Gwenneth looks for an alternative design.

Looking through patterns

Clip 31

Theme: Asking Questions About Design

Clip 29	Clip 46
Gwenneth confirms what she sees on the screen with her partner.	Lizzie confirms that her partner can see what she is doing.
 Confirming that her & her partner understand eachother.	 Making sure / questioning if her partner can see her.