Investigating the Impact of Proximity and Visual Conation Modes on Enhancing Engagement with Public Large Interactive Displays

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Deployment of large interactive displays (LIDs) to public spaces has provided new ways for passersby to gain information. This medium plays the role of transmitter for information visualizations designed to communicate certain messages or provide specific digital experiences. However, prior research has shown that these forms of interactive surfaces are often highly underutilized, even unnoticed, when installed in public spaces. When LIDs are unnoticed, or fail to sufficiently engage passersby, the intended message(s) cannot be transmitted or perceived successfully. To mitigate this problem, this research leverages empirical and theoretical frameworks from the field of Communication Studies, and from the subfield of Symbol Interaction as well as various message functions. Accordingly, we generated several animated visual cues to examine the impact of proximity and conation (persuasion) modes. We also ran a field study to evaluate the interface design.

Through implementing of the data analysis, we learned that animation effects are useful assets in order to obviate the conative function of communication (persuade passersby to become engaged with the LID). Our findings emphasize that self-revealing systems design may encourage the user to become engaged with the LID. It was also revealed that randomized animated visual effects had more impact on the passersby touch behaviour.

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List of Acronyms

AIGA: American Institute of Graphic Arts (the professional association for design)

DOT: United States Department of Transportation

HCI: Human Computer Interaction

LID: Large Interactive Display

UI: User Interface

Chapter One

Introduction

Large interactive displays (LIDs) are becoming ubiquitous due to their capability of delivering dynamic content to broad audiences. This new technology Is beginning to replace traditional signs in public areas (Müller, Michelis, & Schmidt, 2010). However, it is argued that most multimedia systems are designed for personal devices or are used in familiar environments such as home and the specific issue of encouragement in public areas has received insufficient attention (Müller, Michelis, & Schmidt, 2010). For the purpose of using such new electronic technologies in unfamiliar environments (such as libraries, airports, museums, etc.) the domain of multimedia design needs to be broaden (Müller, Michelis, & Schmidt, 2010).

Moreover, LIDs in public settings have to compete for the audiences' attention. There are numerous visible and audible elements in public environments which can easily grab the attention of targeted audience (passersby) and disrupt interaction. Also, LID technology is relatively novel and an unusual phenomenon and this may cause the passersby to resist engaging with the device. Therefore, a main challenge to designing interaction for LIDs is to successfully persuade the passerby to engage or interact with the LID and also remain engaged with the LID interaction until the intended message is fully transmitted and understood.

In this research, our first challenge was that, in contrast with other forms of computing technology, the passerby/user (audience) of LIDs does not own the device. Therefore, the showcased content with the LID in public setting needed be to be visibly salient enough to gain a passerby attention. We knew that if the public LID failed to gain sufficient attention, the message would not be transmitted properly. Thus, one of our key concerns was how to deliver information in an already crowded setting. Although current findings from Human Computer Interaction (HCI) studies are applicable for interaction design for public displays, we still needed more than mere traditional display characteristics such as usability, learnability, and likeability. Therefore, dealing with the issue of engaging passersby was our central research challenge for designing LIDs for public settings. To address these issues, we investigated the notion of persuasion and designing different layers to reveal interactive information in a, hopefully, engaging manner. Our major research question was that how could we leverage the concepts of persuasion and engagement from Communications theories in the design of LIDs for enhancing attraction and engagement in public spaces. The study relied on the distance of the user from the display and various visual cues which are explained descriptively in the following chapters.

1.1 Motivations

There is a main factor that motivated the work within this thesis which is relating the body of HCI studies to other tangential disciplines such as Communication Studies.
To the best of our knowledge the existing interaction design techniques has minimal focus on the persuasive function of communication. Hence, we were interested to extend the boundaries of HCI studies by investigating different communication functions. Our focus was on designing more intuitive and persuasive meaningful messages.

1.2 Research Objectives

The overarching goal of this research is:

- Investigating potentially relevant concepts on “persuasion” and “engagement” from the field of Communications Studies
- Utilizing the identified concepts from the related literature to design potential LID interfaces to attract and engage passersby in a public setting
- Validating our design by running a field study in a public setting.

We also put an effort on the process of designing interaction for public settings from a visual-communication perspective. To fulfill this aspect of the study, we adopted notions of “Symbolic Interactionists” from the body of Communication Studies. This helped us to inject appropriate contextual references to the “UWaterloo Community Application” which been designed specifically for this research. Also, we investigated different “communication functions” in order to become capable to design different visual modes for this research.

1.3 Thesis Organization

This thesis is organized into the following chapters:

- **Chapter 1, Introduction:** contains the motivation and main research objective of this thesis.
- **Chapter 2, Background:** contains a background literature review, main challenges of designing interaction for public LIDs, related researches, and the motivational study.
- **Chapter 3, Theoretical framework**: explains the adopted notions from the body of Communication Studies. It details different aspects Symbolic Interactionists notion, various communication functions, and main focus of this research. Moreover, related research study which guided us through this research are provided.
- **Chapter 4, UI Design:** describes the design approach and the iterative process we went through in designing the interaction modes, various layers of visual feedback. Starting with the identification of variables in the research and goes through listing the physical characteristics of the deployment environment. It continues with designing the low-fidelity wireframe, animation effects, and direct or indirect visual cues.
- **Chapter 5, Study Methodology:** Describes the main study design as well as independent variables in detail. Also, it provides an overview of the data collection techniques and the implementation process used to test the main objectives.
- **Chapter 6, Results**: includes the empirical findings, encompasses the results from the quantitative and qualitative data analyses.
- **Chapter 7, Discussion**: Discusses the findings from a broader context, and how they can be used to better design interaction for public LIDs.
- **Chapter 8, Conclusion and Future Work**: summarizes the main findings of this thesis and describes future direction by recommending some future steps that assist latter studies to build upon these findings.

Chapter Two

Background

This chapter provides detailed description on background literature of previous related work, and elaborates on how the current study provides a novel contribution to the domains of interaction with large interactive displays in public settings.

In this chapter, a brief definition of the term "interaction design" and its history is provided. Afterward, we briefly review the main aspects of interaction design for LIDs in public settings, as well as related studies which encompass challenges in this specific branch of interaction design. The main focus of this review is to provide detailed description on the following items: social configuration, users' expectations, and public attention.

Finally, a key motivating study is overviewed, which investigates engaging passersby in the public setting. The mentioned study been implemented by Cheung and Scott (2013). This master's thesis builds on and extends that prior study.

2.1 Interaction Design

Dan Saffer, a well-known interaction designer and author, mentions in an interview with AIGA (the professional association for design) that Bill Moggridge and his colleague Bill Verplank realized in the late 1980s that they were involved with a novel branch of design which was traditionally called "graphic design" or "industrial design". So, they tried to generate a novel term which could successfully describe this new branch of design. Between "interaction design" and "SoftFace" they chose the former and coined the term interaction design (Saffer, 2016). According to Saffer, designing for interaction is something that people were doing since before recorded history such as using smoke signals to communicate certain pre-defined messages over long distances. However, the main difference in our modern era is that, microprocessors are now embedded into all sorts of objects. Thus, objects are now capable of providing all sorts of behaviours. Very simply, Dan Saffer defines the term interaction design as a discipline which is capable to make technology useful, usable, and fun to use (Saffer, 2016). He also emphasizes the difference between good engineering which is something that let the technology to happen and good interaction design which is something that let the technology to becomes approachable for people to use (Saffer, 2016).

With the recent unprecedented growth of technology, interaction design has taken many different forms and, through digital immersion, many interactive screens and public displays have been deployed in urban environments, malls, shop window, inner city areas, airports, train stations. (Muller et al, 2010). These deployments have sparked increased interest in designing interactions and information visualizations that can better facilitate user engagement. However, it is argued that within early stages of deploying LIDs in public settings, researchers discovered that the pattern of using this novel technology is quite different from existing computing paradigms (Cheung & Scott, 2013). Within a public setting, a variety of social configurations, social behaviours, and public attention been seen. While inspiring for designers, the diversity of the ways that the public start to interact with LIDs, provides various challenges in term of designing an effective interface. Therefore, it is crucial to learn about various behaviour patterns in order to successfully address the design challenges.

2.1.1 Variations in Social Configurations

Since LIDs are large in size and are more accessible and available to the public, their different possible usage patterns such as single or collaborative use is debated. The range of usage paradigms and social configuration may encompass a wide range from individuals to couples, families, and strangers (Cheung & Scott, 2013; Marshall et al. 2011). Due to the diversity of possible social configurations, designing a UI (user interface) as well as interaction for public LIDs differs from personal computing paradigm. The designer has to learn and foresee different social configurations in order to manage the content being delivered to the public.

In a study conducted by Peltonen et al (2008), the authors presented data from a detailed observation of a multi-touch display called CityWall. In the study, the researchers installed a LID in a central location of Helsinki in Finland for eight days. During the study period, it was reported that 1199 people interacted with the LID. The authors presented data of a video analysis that revealed crowding, massively parallel interaction, teamwork, games, negotiations of transitions and etc. The observed results suggest several social configurations that lead to social learning due to the public use of LIDs (Peltonen et al., 2008). Here, the term "Social learning" explains a public situation in which people are capable of learning from one another by observation, imitation, and modeling (Bandura, 1977). It is debated that most of the human behaviours are learnt through observation and modelling. The observational data can provide an idea of how new tasks or behaviours can be performed. In another occasion, the coded information can be used as a guideline for action (Bandura, 1977). The concept of social learning can explain how human behaviours spread from one person to another and is the result of the interaction between human cognition as well as environmental influences (Bandura, 1977). Here in the context of LID's research, the term social learning means that people successfully learnt to implement needed tasks by looking at each other, interacting in parallel, or working together in a team. The authors argue that the main features that contributed to such a variety usage pattern include the multi-touch feature, gesture based interaction, and the physical display size (Peltonen et al., 2008).

2.1.2 Variation in Social Behaviours

In addition to variation to social configurations (individuals versus groups), there is a variety of possible social behaviours that lead to different methods of interaction. In a public setting, we expect a heterogeneous audience in terms of general knowledge of digital technology, education, age, gender, etc. Through varied demographics, the users' responses to the system might be difference. For example, elderly people or people with limited technological knowledge may be uncertain or reluctant to approach LIDs and be more interested to learn by looking at the others.

Russell et al (2010) explored the social effect of shared LIDs. The authors presented data from a field study held at IBM Almaden site. Within the study, the researchers studied the BlueBoard LID, which was a 1.3-meter plasma display (XGA) with a resistive touch screen. The device offers fast access to personal information, let small groups work and collaborate side-by-side. The researchers conducted observations of both group use and individual use to learn about use pattern and users' behaviours.

The reported findings on "group use" emphasizes on social effect of LIDs in public settings. Amongst various effects on social behaviours, uncertainty of usage, individual leaders, working collaboratively, and group sharing of information were dominant (Russell et al, 2010). The researchers observed the impact of social learning through group interaction. As some participants were unsure (uncertainty of usage) about the instructions or particular functions, they had the chance to watch and learn from other participants who were implementing certain tasks (learned about the display by observing and imitating others). It is reported that picking up a behaviour by seeing other participants have occurred many times during the study. It was also reported that in many cases when a group was using the device, other participants were uncertain about appropriate behaviour in order to engage or disengage with the device (uncertainty of usage).

Another interesting observation through group usage was that one person was usually leading and dominating the interaction (individual leaders). And in cases that nobody was leading the interaction, the participants started to respond to BlueBoard by using turn-taking behaviour (working collaboratively and group sharing) due to the device limitation of handling only one touch at a time (Russell et al, 2010).

In another in-the-wild study, Ojala et al (2012) used several double-sided hotspots along walkaway and in a market area as well as six single-sided indoor hotpots. The study findings suggest that many people were hesitant to use the technology. They were afraid to either break the device or to displease others. The authors compare it to a situation that someone may want to turn up the TV volume or change its channel in a crowded cafe. It is reported by the authors that people carry such entrenched inhibitions into the display experience. Such mental attitudes are called a "formidable interaction obstacle" (Ojala et al, 2012). Being unfamiliar to some users and not knowing about the mechanisms of device could also introduce additional barriers.

There were also cases where some people did not interact due to the inability of recognizing the interactive capabilities of the device which led to “interaction blindness” (Ojala et al., 2012. Houben, & Weichel, 2013). This “blindness” refers to occasions when the display was recognized by someone but might not be engaged because of lack of information about the potential interactivity of the content.

2.1.3 Public Attention

One of the main observed challenges in terms of deploying LIDs in public settings is enticing public attention (Cheung & Scott, 2013; Brignull & Rogers, 2003). Although, LIDs are increasingly being placed in public spaces to support various activities and their content is often animated, a major problem that been observed is resistance by the public to engage with these devices (Brignull & Rogers, 2003).

A source of public resistance to not engage with LIDs can be generally rooted in the feeling of social embarrassment (Brignull & Rogers, 2003). However, there is evidence that reveals part of the resistance is also due to audience expectations (Müller et al, 2009). In a study conducted by Müller et al (2009), it was found that for most public displays passersby tend to ignore them because they expected to encounter boring advertisements. However, replacing display content with shopping coupons or learnable information for students led to more attention to public displays in their research.

There are a couple of “blindness” terms that been attributed to LIDs. In addition to “interaction blindness” there is fair chance of occurrence of “display blindness”. The term display blindness describes the occasions in which the public fail to notice the presence of a LID in a public setting even if the LID is in close proximity (Müller, Wilmsmann, et al., 2009).

2.2 Systems Design Issues in Interacting with LIDs

Alongside the design challenges which has been observed in the prior research discussed above, several systems design issues have been discovered which may cause difficulties in the process of interaction with LIDs. Cheung and Scott (2013) identified the following list of commonly reported interaction issues or design considerations for touch-based LIDs:

1- Reachability issue: the issue occurs when the size of the screen is too big and certain areas are not reachable for the user (Shoemaker et al., 2007)
2- Gorilla arms: causes fatigue in the user's arm due to mid-air gestures (Hincapié-Ramos et al., 2014).
3- Territoriality issues: refers to the spatial ownership when several users are interacting with the LID (Azad et al., 2012; Scott et al., 2004).

Although much of the active research on LIDs is focused on these interaction design issues, this thesis research focuses on the challenge of enticing passersby attention towards the display and persuading them to go through physical interaction with it. For the purpose of facilitation, we looked for some motivating research to inspire us in term of interface design.

2.3 Visual Stimuli to Drawing Passersby Attention

For the purpose of designing UI for the LIDs, the impact of several types of visual stimuli are investigated. They are typically categorized as "low level" and "high level" visual stimuli (Cheung & Scott, 2013).

Low level stimuli refer to basic visual elements that the human visual system can process quickly, with little higher-order cognitive processing. These visual elements include colour, text (typeface, size, angles), animation (motion) and icons (size, shape) which amongst them, colourfulness been identified as one of the most evoking visual element (Cheung, 2016; Ojala et al., 2013; Müller et al. 2010).

In contrast with low level stimuli, high level stimuli are more complex visual elements that require some cognitive processing to interpret and understand. Therefore, high level stimuli are more likely to play a role in persuading a passerby to interact with the LID (Müller et al. 2010). In a study conducted by Michelis and Müller (2011), different digital augmentations of a mirror image of passersby were investigated to evoke passersby curiosity. Through investigating different aspects of such visual stimuli, the researchers compared the impact of a realistic image of the user versus a silhouette-style user shadow. The results showed that both design approaches were effective at drawing a passerby's attention (Müller et al., 2014, 2012).

In more recent work, Cheung and Scott (2013) combined this user silhouette approach with the proxemics interaction design pattern proposed by Ballendat et al. (2010). Using this approach, they varied the visual design of the silhouette based on the proximity of the user to the display (the silhouette grew larger and more visually salient as the user approached the display). They used the user silhouette to draw the users' attention and encourage them to remain in the course of interaction. Their study inspired this current research study in many ways. Hence, more detailed information is provided next to provide more context for the research conducted in this thesis.

2.3.1 Motivating Study: Cheung and Scott's LIDs Studies

The research focus of this thesis was inspired by the study conducted within differently extends by Cheung and Scott (2013) and Cheung (2016). Their work focuses on the effect of different visual cues including animation and user silhouette to attract and engage passersby with LIDs in a public setting. In two separate studies, a laboratory-based and field-based study, they investigated various animation feedback concepts.

The researchers of the study initially argue that animated content such as floating images or popping-up menus have been examined in the previous studies and has shown their effectiveness to draw passers-by attention. Also, it is argued that the animated visual elements had significant effect on guiding users' interaction and made a "lively and engaging experience" (Cheung & Scott, 2013; Seto & Scott. 2012). Accordingly, the designed study by the researchers take advantage of the **proxemic interactions design approach (**Ballendat et al. 2010). Here the term proxemics refers to the advanced sensing technologies which are used to track user's movement and providing more elaborate information based on the user's distance, orientation, identity and location (Figure 2-1) (Cheung & Scott 2013; Marquardt et al. 2011). This distance-based approach to interaction design is based on "proxemics" research from the 1960's by anthropologist Edward Hall, and others, on the role of space in interpersonal communication (Hall, 1963). Accordingly, four different zones include public, social, personal, and intimate are attributed to interpersonal communication where decreasing in levels represent reduction in distance ranges.

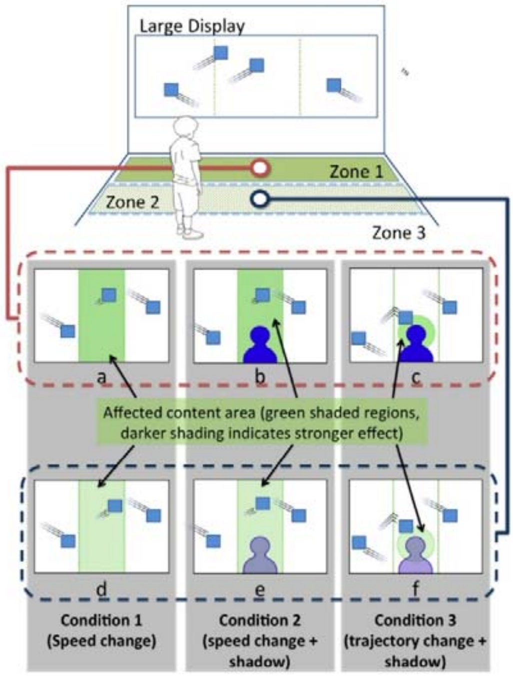

Figure 2-1. Three identified zones in front of the display (Cheung, 2016)

Based on the Hall's theory, it was proposed by Marquardt and Greenberg (2012) to correspond the tracking information with the proxemics theory for designing proxemics-based interaction (Cheung & Scott, 2013). In the proxemics-based interaction, the system adapts its behaviour based on the user's distance, for instance, changing the size and/or shape of a user silhouette based on how close a user is to the display screen (Cheung & Scott, 2013).

Cheung and Scott (2013) adapted different visual cues based on the proximity of the user to the LID. They focused on three main visual concepts which consist of 1) adaptive shadow 2) adaptive speed 3) adaptive trajectory (Cheung & Scott, 2013; Cheung, 2016). In the proxemics-based interaction designed by Cheung and Scott (2013), they take advantage of three identified distance zones: the first zone is the closest and lets the user have an intimate interaction with the display (~.05 m). The middle zone represents a personal interaction (1.2 m) while the third zone is the farthest and represents public interaction (3m). Each of their studied visual concepts (adaptive shadow, adaptive speed, and adaptive trajectory) were changing according user's movement from one zone to another zone (perpendicular to the LID).

The first visual concept –adaptive speed- was designed to demonstrate a decrease in speed in a stepwise fashion. Thus, as the user walks closer to the display, the adaptive speed would decrease the speed of the animated content to let the user look at and then touch the content. The second visual concept –adaptive trajectory- was similar to adaptive speed. As the user was crossing from the farther zone to closer ones, the content gravitated towards the user's location. The third visual concept was adaptive shadow which refers to displaying a silhouette projection of the user as a part of the display. Although it is similar to the silhouette used by Müller et al. (2012) to increase the attraction power of displays, Cheung and Scott's design (2013) adopted the opacity of the shadow based on users' proximity: as the user was walked towards the display, the opacity of shadow would increase. The intention of using adaptive visual content was to invite the user to get close to the display in order to enable the system to reveal more information.

In this thesis, the three identified zones and the rationale of revealing information based on a user's proximity to the display, are key aspects that have been adopted from Cheung and Scott's work (2013). Accordingly, the focus of this thesis was to design adaptive visual content in the context of a library application which is explained in the following chapters.

Another key concept that was adopted from Cheung (2016) was the novel LID interaction model that they proposed inside their study and was called the "Discover Model" (Figure

2-2). This model represents the sequence of a user's cognition state when encountering LIDs in a public setting. A key concept of this model is that it reveals the continuous process that a user may go through from first becoming aware of the presence of the LID to collecting information about the LID and engaging with it.

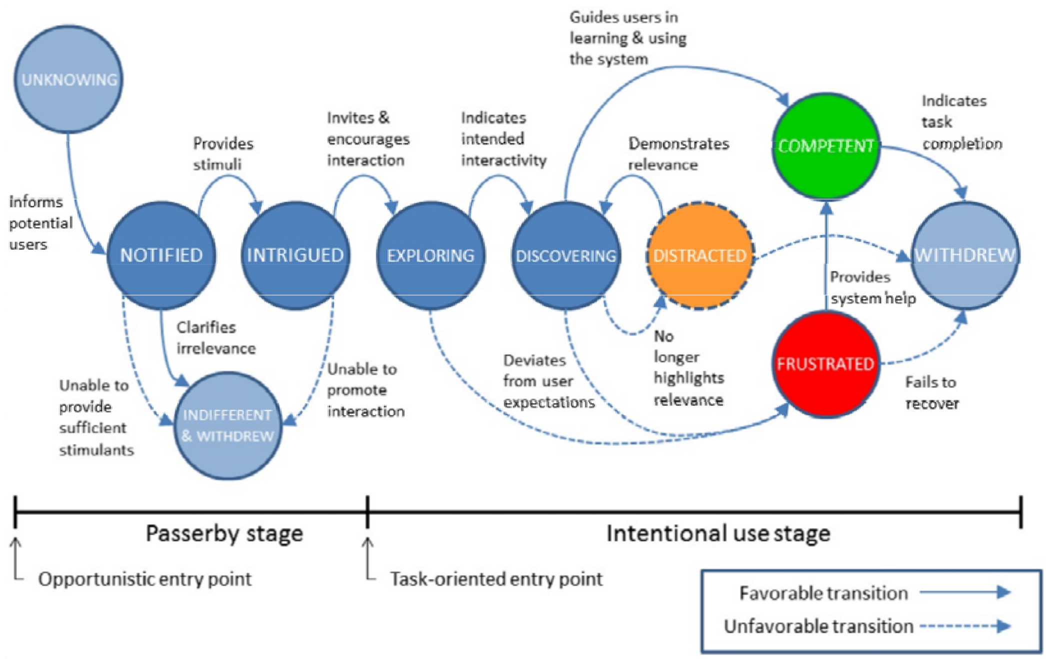

Figure 2-0-1. "Discover Model", The novel LID interaction proposed by Cheung (2016)

The model encompasses five different main states which demonstrate a novice user's interaction with a LID in a public setting and focuses on the discoverability process (Cheung, 2016). The main states include notified, intrigued, exploring, discovering and competent. Also, there are some sub-states before/after or in the middle of these main states. It is argued that when a person passes a LID in a public setting, they are initially unaware of the presence of LID and its functionality. Once the passerby becomes aware about the presence of LID, without even entering direct interaction with it, then they have entered the first main state of the discoverability process, being notified. In case the user finds a tendency to interact with the discovered system, then they become intrigued just by the system itself. At this stage, the user starts to generate certain expectations from the system based-on their understating of a system that looked interesting. In contrast with a user who is intrigued by the system, the passerby may not show any interest to the system and may withdraw from the on-going process of discovery. If the passerby does not withdraw, then, they enter into the next state, and may start exploring the system and intentionally interacting with the LID. In this state the user would expect to collect more information about the system and if not distracted by anything else inside the environment, the user may move into the next state, that is discovering different features of the system and purposefully become engaged in the process of interaction. It is worth noting that there is always a chance that the user may pay attention to an external stimulus and get distracted from the process of discovering different aspects of the system. Finally, if the user spends sufficient interacting with the display and learning about all the guidance provided by the display, it is expected that they become competent the LID and successfully complete all the desired tasks. However, if the system's feedback or responses do not correspond with the user's expectations, the user may become frustrated and withdraw before becoming competent (Cheung & Scott, 2013).

As mentioned above, this thesis builds upon the Discover Model and preserves the same sequences for delivering proxemics-based information. We also focused on the early stages, up to Exploring. However, we also looked at different design approaches to facilitate the transitions through the early stages of the Discover model. Detailed description about design solution that been proposed based-on the three identified zones and the discoverability model will be explained in the following chapters.

2.4 Chapter Summary

In this chapter, we briefly reviewed the background literature and various interaction design paradigms. Then, we overviewed some of the main related studies to learn more about major challenges of designing UI for LIDs. We encompassed from various social configurations and behaviours to the systems design issues which should be foreseen by the UI designer. Finally, we provided detailed information about the main motivational study and explained the adopted aspects. In the next chapter, we will provide detailed explanation about adopted notions from the field of Communication and how they might be related to this current research study.

Chapter Three

Theoretical Framework

The main objective of this chapter is to provide detailed information about the adopted theories from the body of Communication Studies. We start by overviewing the main developed questions. Then, we look at some of the recent communication models and related theories and try to create a bridge to the body of HCI studies. In the next step, we briefly review the main message components and their functions and mainly focus on the conative function of the communication. The main goal of this chapter is to explain the persuasive aspect of the messages which can be delivered to the publics via LIDs. We also provide instances from related studies which can guide the reader through perceiving the study implementation methodology in the following chapters.

3.1 Drawing on Communications Theory for LID design

One of the main goals of this research was to look at the process of designing user interfaces for public LIDs by taking advantage of specific Communications approaches. The major rationale is that by building the research upon theories in tangential disciplines such as Communication Studies, there is a chance that we can generate novel questions that can be answered inside HCI research. At the beginning stages of the research we were interested to benchmarking natural human interaction to learn about the main reasons that different persons in a conversation may stay engaged with interaction. Thus the following questions were developed:

1. How enticing users' attraction and convincing them to engage with the LID can rely on interpretable verbal and non-verbal animated feedback of the UI?
2. What sorts of information from deployment environment can elicit users' attraction?

The main goal of exploring these questions was to put purposeful effort on understanding communication patterns that are adopted through human interaction and inject them to the UI design process for LIDs. We also tried to suggest new questions for HCI studies. For these reasons it was expected that Communication Studies be a good supplement for exploring interactive information transmission process because in the context of Communication Studies, the interactive display plays the role of the transmitter of the message which deliver the information to the random users.

Accordingly, specific theories from Communication Studies were adopted and we tried to relate them to this current research. In the following paragraphs, each of the chosen theories as well as their relation to this study are explained.

3.1.1 Symbolic Interactionism

One of the main aspects of every design project that should be identified within early design stages is communicators of the message. Here in this context, we consider the communicator as a person who tries to send a specific information (message), and the receiver as a person who tries to understand and receive the sent message. When the receiver tries to generate some related responses based on the perceived message, then a meaningful interaction takes places which is built upon common meanings that can be understood by both sides of the interaction.

This notion is the very basic rationale behind many communication models that are conceptual models for explaining the process of human interactions. One of the earliest models was generated by Claude Elwood Shannon (Shannon & Weaver, 1949). The model which was published for Bell Laboratories contained an introduction that was written by Warren Weaver who was an American scientist and mathematician who widely known as one of the pioneers of machine translation (Piore, 1979). Consequently, the model was known as the Shannon-Weaver communication model (Shannon & Weaver, 1949). The Shannon-Weaver communication model was designed to reflect the functioning of radio and telephone technologies and within this initial communication model three primary parts were included; the sender, channel, and receiver. The channel was the telephone itself, through which the sender was part of the telephone that one could speak inside it and the receiver was the part of the phone where one could hear the other person (Shannon & Weaver, 1949). This model is mostly focused on the channel and the communicators' role as well as the idea of transferring information. Although this model is the foundation for all later models, it is not comprehensive, especially regarding the active role that the receiver plays in successful communication.

A more recent interactive model, based on the Shannon-Weaver communication theory is called “Symbolic interactionism” (Braun, 2015). This thesis research draws on this model due to its relevance for public relations (Braun, 2015). Braun (2015) argues that symbolic interactionism is more a paradigm rather than a specific theory. This approach was first developed by a group of sociologists and philosophers (Braun, 2015; Solomon, 1983). Solomon (1983) in his article “*The role of products as social stimuli: A symbolic interactionism perspective*” describes that:

> “Similar approaches were developed independently in Germany by George Simmel and by Max Weber, the latter's version being known as "action theory." Some versions of symbolic interactionism are known as "role theory," while others simply refer to this work as the "Chicago tradition, "reflecting the dominance of the University of Chicago faculty in the theory's dissemination (e.g., Mead, 1934)” (319-329).

Symbolic interactionists mostly focus on a family of theories that looking at humans as creatures of intentions and motives. Accordingly, development of meanings is the very basic element that spark social interactions (Hall, 1972). A core premise of symbolic interactionists is that people need to “co-exist” in the same context within a society to become able to interact. Also, another key feature is that people inside a specific society can generate meanings for all the signs and symbols that are surrounding them and react accordingly (Hall, 1972). Here the term sign refers to any object, quality, event, or entity which given its presence can indicate a probable presence of something else (merriam-webster.com, 2017). For instance, in public areas, traffic signs provide information and warning for both drivers and pedestrians. However, a symbol can be any mark, sign, or signifiers which stands for or can be interpreted and linked to a specific idea by reason of relationship (merriam-webster.com, 2017). It can take the form of a word, a gesture, a sound, or an image. For example, by convention the colour red can be a symbol of danger and in cases where it is embedded into a sign, the sign can be understood as a warning.

As soon as a person starts to assign meaning to any of the recognized signs or symbols, then the person has entered into a process that is called the interpretative process (Braun, 2015; Hall, 1972). Based-on the meaning that are assigned to each signs and symbols, the receiver of the message may generate a response. Therefore, within the notion of symbolic interactionism, an action is the meaningful response that is the direct result of going through an interpretative process (Hall, 1972). As soon as the sender of the message acknowledges that the other person is going through the same process, then interaction takes place. Philip Lesly, an early pioneer of public relations and the first creator of public relation handbook (Braun, 2015) argues the importance of co-existing in the same context by the following statement:

> “Public relations started as publicity… because, as it became harder for people with different backgrounds to understand and know about each other, the first necessity was for one group to tell others about itself (Lesly, 1967, p.3)

Another key concern of symbolic interactionists is the pivotal role of signs and symbols within intentional interactions. They argue that a human is a symbolic creature who possesses language skill (Braun, 2015). Thus humans are capable of choosing and delivering words in a meaningful manner. On the other hand, exposure to meanings and phrases that are loaded with certain symbols can trigger a range of behaviours and are also able to elicit a desired response (Braun, 2015). Hence, we can infer that for designing an intentional and strategic interaction for LIDs, we have to rely on the information that is retrievable from the specific public area in which we want to set up the LID. Also, for eliciting users’ responses, we need to be concerned with generating meaningful messages that lead the user to go through the interpretative process.

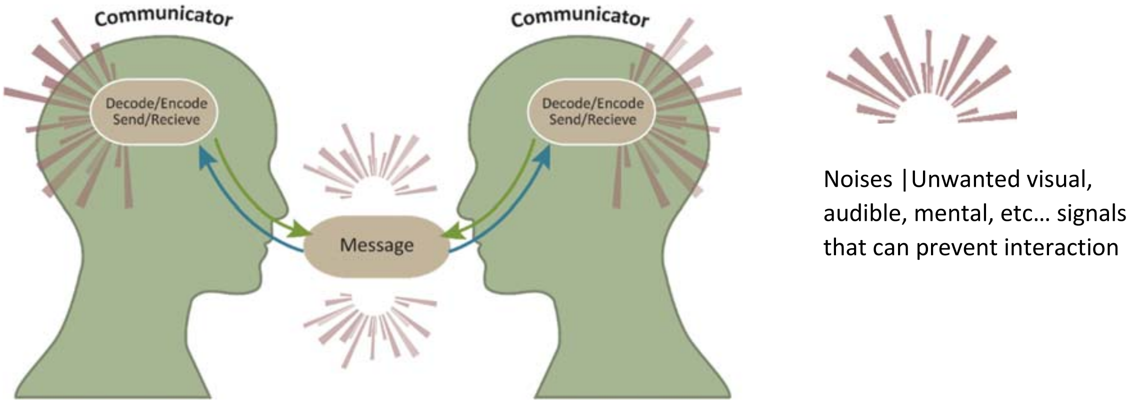

Figure 3-1. An intentional interaction; communicators on the both sides are equipped with language skill.

Figure 3-1 demonstrates the theoretical aspect that been explained above. As it is shown, during an intentional interaction, communicators on the both sides are equipped with language skill and can generate meaningful messages. Once one of the communicators decides to send a meaningful message that contains signs and symbols, they have to encode them in a manner that is understandable for the other communicator. The other side has to then decode the message and at the same time provide another encoded response. So, one of the main differences of the symbolic interactionism model in comparison with traditional communication models is that both communicators have to generate meaningful messages to elicit responses and to let the interaction continue successfully. Another key difference is that within this model both communicators are assumed to be inside an environment which contains many distracting elements called noises (unwanted signals). Within Communication and HCI studies, a noise can be undesired random signal which can lead to disturbance by avoiding the useful information to be transferred. It can also influence the interpretation of transferred meaning and lead to misunderstanding (Rothwell, 2004).

Here in this research, while there was an effort made to adopt symbolic interactionism concepts, we had to put an effort into generating an upgraded model in order to take into account the role of message transmitter which is the LID.

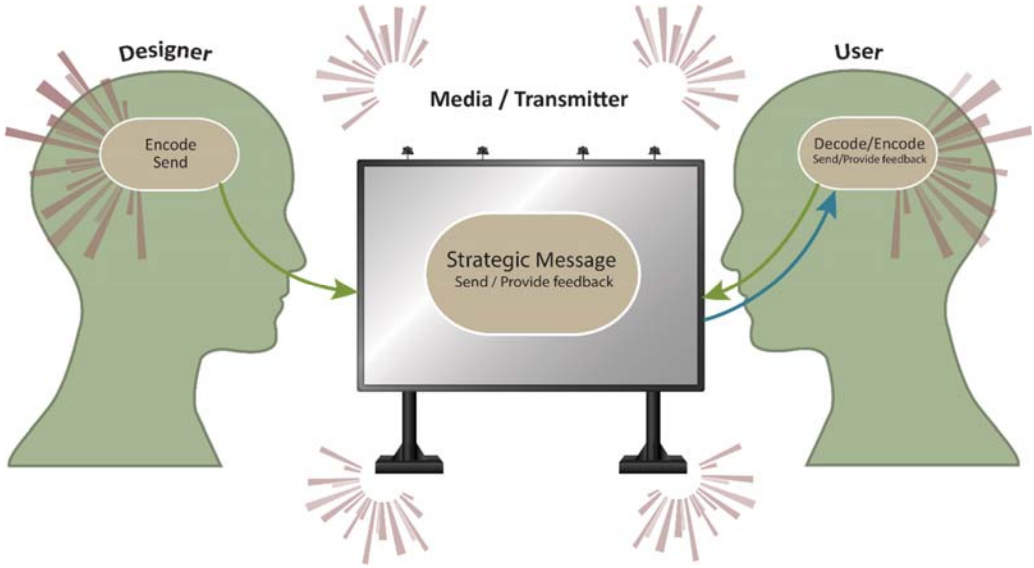

Figure 3-2. LID in public interactions.

Figure 3-2 illustrates how adding the LID to public interactions can change the role of message communicators. In the scenario of establishing an interaction via public LIDs, the designer is an indirect communicator that has the chance to encode an "adoptive and strategic message". by the term adaptive we mean that the LID interface can change automatically based on the users' distance from it. The designer can send the message via chosen a media/transmitter. In contrast, the other participants in this interaction who are the receivers/users of the message, can still perceive meaning (decode) and at the same time generate meaningful responses accordingly (encode). Hence, by relying on symbolic interactionism, the designer has to 1) find basic and common contextual social and cultural information to share with the receiver/user and to 2) foresee the receiver/user responses in order to prepare correspondingly meaningful responses that let the interaction continue.

3.2 Message Components and Their Functions

After identifying the main communicators of the message and their roles, we now discuss different message components and their communication functions.

It is argued that all forms of communications and interactions basically consist of the same components:

1) the sender, who is the person that tries to deliver some information (In HCI design context, the designer and encoder are equivalent to the sender).
2) the message, which is the information that the sender wants to transmit.
3) the channel, which is the either auditory, visual, etc. medium through which it the message reach the receiver; and 4) the receiver is who the sender tries to deliver the message to and who goes through the interpretative process to decode the message (Segel, 2010). In the HCI design context, user and decoder are equivalent to the word “receiver”.

Russian-American Linguist Roman Jacobson further identified two additional components that impact communication and interaction: “context” and the “code”. He argues that each participant of communication is able to maintain communication or interaction when they use common codes in the same intellectual context (Jacobson, 1956 & 1960).

Jacobson distinguished six functions that each refer to one component of communication and interaction. He believed that fulfilling at least some or all of these functions based-on the “intention of message” is necessary for communication to occur (Jacobson, 1960). Although the focus is mainly on verbal communication, these functions can be generalized to non-verbal communications as well. These functions can be summarized as follows (Jacobson, 1960; Herbert, 2011):

- The emotive or expressive function: the function, relates to the sender (the designer in the HCI context), and relates to the effort by the sender of message to demonstrate their internal purposes.
- The referential function, relates to the context of the message and it can be a situation, an object, or a specific mental state.
- The conative function; relates to the receiver (the user in the HCI context), and deals with influencing the receiver/user’s behaviour and hence, relates to the idea of “persuasion”.
- The phatic function; relates to the channel/media in which the message is transferred and it serves to establish, prolong or discontinue communication. As an example, the short question of “Hello?” is about to confirming that a call

contact is still there and tries allows the communication to continue by assuring that the channel is not blocked. So, the question “hello?” is serving the phatic function.

- The metalingual function; relates to the codes (signs and symbols that either directly or indirectly represent a concept). This function is mainly concerned with establishing mutual agreement on the codes to enable the sender and receiver to go through the process of encoding and decoding.
- The poetic or aesthetic function; relates to the message itself and the way that the codes are used. This operative function is mainly concerned with how a verbal or non-verbal combination of signs and symbols might be positively experienced by its users.

Figure demonstrates that how each message component is linked to a corresponding function. Also, that the red outline highlights that in this current research our purpose is to examine the conative function in terms of influencing passersby behaviour.

This research builds on the prior work generalize these specific concepts to other forms of communication beyond verbal communication.

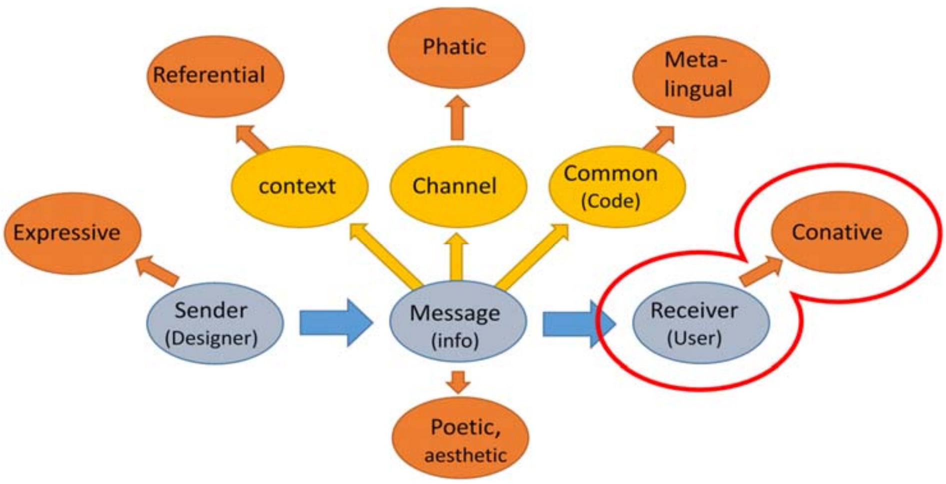

Figure 3-3. The message components and their corresponding functions

For instance, Hébert (2011) applied the same concept to a design of a poster advertisement that was part of a series of 1989 advertising campaigns with the common slogan "If you drink, then drive, you're a bloody idiot". To visualize the slogan, the designer took from the vantage point of someone (presumably dead) lying within a grave looking out towards the sky. The shape of the grave's hole and the alignment of blue and white colours in the sky resemble a glass of beer. Hebert (2011) applied the Jacobson's communication functions to the advertisement shown in Figure 3-4 in order to analyze it from the perspective of this theory. The author argued that the advertising message had to accomplish the following, in three successive stages; first, it had to establish a channel (the phatic function) in order to make a bridge through its audiences' mind, second, it had to convince its audiences that the message was true by considering message references which is an inside grave view of a dead person (referential function), and third, it had to get people to act by influencing their behaviour (conative function). He argued that the third objective is clearly the most important one, and the others are subordinate (Herbert, 2011).

Figure 3-4. Reproduction of Poster advertisement which been analyzed from the perspective of Jacobson's communication functions, Hébert (2011).

A key question for this thesis research was that how to take advantage of these functions for two different purposes: 1) convince users to approach the LID and start interaction (conative function); 2) convince users to stay in communication by the time the message is fully understood. Due to the boundary limitation of the research, we decided to focus and investigate different aspect of conative function as one of our main independent variables.

3.2.1 Conative Function of the Message

By considering the conative function of the message, we were trying to find subtle ways to influence the LID users' behaviour by means of contextual references inside the environment.

Traditional psychology studies three key components of the mind which include cognition, affection and conation (Huitt & Cain, 2005; Hilard, 1980.) (Figure 3-5). The first component refers to the process of coming to know and understand; also encoding, perceiving, storing, processing, and retrieving information" (Huitt & Cain, 2005). This process is typically associated with the "what?". For example, inside a public setting when a passerby visits a LID for the first time, they may ask the questions "What is this display? What does it do? What kind of information does it provide? What is the meaning of this information? etc." By asking these questions the passerby attempts to learn about the nature of LID.

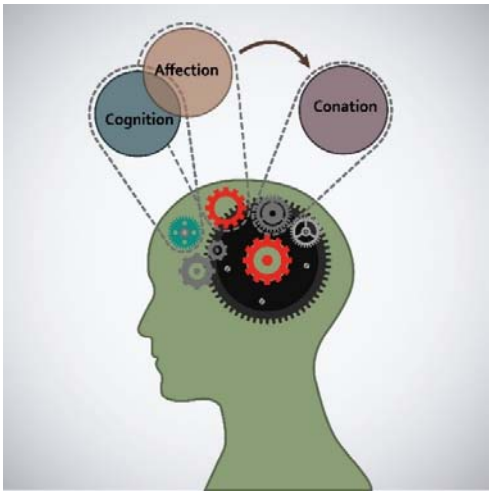

Figure 3-5. Three key components of the mind.

In the next step after perceiving information, psychologists believe that the second component of the mind that is used is affection. Huitt and Cain (2005) identify affection as the process of providing emotional interpretation for information and knowledge and is generally associated with the question of “how”. For instance, if the passersby learn about the LID, they may go through this process very intuitively and ask “How do I feel about it?” the response to this question is quite crucial because it can define the positive or negative feelings that one may attach to the perceived information. If the answer to the question is that “I feel scared of this technology” or “I feel reluctant to engage with the provided information”, then it means that convincing the passersby to start interaction will be more difficult. Finally, the last component used is conation. The term conation refers to the connections that human’s mind builds between perceived knowledge and sparked feelings in order to elicit corresponding behaviours (Baumeister, Bratslavsky, Muraven & Tice, 1998; Huitt & Cain, 2005). Baumeister, Bratslavsky, Muraven & Tice (1998) argue that conation is “the personal, intentional, planful, deliberate, goal-oriented, or striving component of motivation, the proactive (as opposed to reactive or habitual) aspect of behaviour” (1252- 1265). This term is generally associated with the question “why?”. Within the context of this research, the passerby may ask “why should I respond/ interact with this display?” and there should be a reasonable answer in order to influence the behaviour of the passersby and convince them to approach and engage with the display. Hence, in this context the conative function of a message refers to successfully persuading the receiver of the message (passerby/ user) to approach the display, start interaction, and continue the course of interaction for some reasonable amount of time. The process of influencing the users’ behaviour can be either “explicit or direct” by providing direct, clearly expressed, readily observable signs and symbols or “implicit or indirect” by expressed the message indirectly or implying information (McQuarrie & Phillips, 2005).

Based on the reviewed theoretical framework, we concluded that a LID should include three main features:

1) It should contain contextual inferences related to the deployed environment
2) It should provide positive impression of the device in order to affect the feelings of the passersby, and

3) It should be persuasive which means that by taking advantage of either direct or indirect sign and symbol manipulation, it should convince the user to engage with the LID.

3.3 Related study Investigating Direct and Indirect Conative Function

Advertising researchers McQuarrie and Phillips (2005), investigated the role of direct versus indirect persuasion in advertising. In their study, *"Indirect Persuasion in Advertising: How Consumers Process Metaphors Presented in Pictures and Words"* they argue that using indirect metaphors (symbols that refer to something else rather than themselves) would cause audiences to be more receptive to the message of an advertisement. Their rationale was that consumers could provide more positive and spontaneous inferences about the advertised brand at the time of advertisement exposure. The authors built their assumptions upon prior work arguing that indirect claims in advertising are capable of eliciting beliefs which lead to constructing multilayered meanings (Smith, 1991). However, McQuarrie and Phillips (2005) as well as MacKenzie & Lutz (1989) argue that the way that the message is manipulated visually or verbally, can heavily influence the effectiveness of the persuasion results. To validate the idea, they measured the participants' response latency by providing both direct and indirect claims in the custom advertisements designed for their experiment.

For the purpose of constructing the experimental stimuli, the authors did the followings: 1) examined advertisements of popular magazines 2) chose an initial set of 12 products 3) asked a professional artist to extract all images which included visual metaphors related to the chosen products. In the next step, the authors provided fictitious brand names which carried neutral or vaguely positive connotations and combined each name to one of the product categories. For example, "plus dishwasher" for detergent. Finally, they manipulated direct verbal claims (Figure 3-6) (A) (called verbal literal) which was a combined a product photo with the brand name on bottom as well as a direct claim on the top of the advertisement. Then, they compared this constructed direct claim with a visual metaphor (B) and a verbal metaphor(C) (McQuarrie & Phillips, 2005).

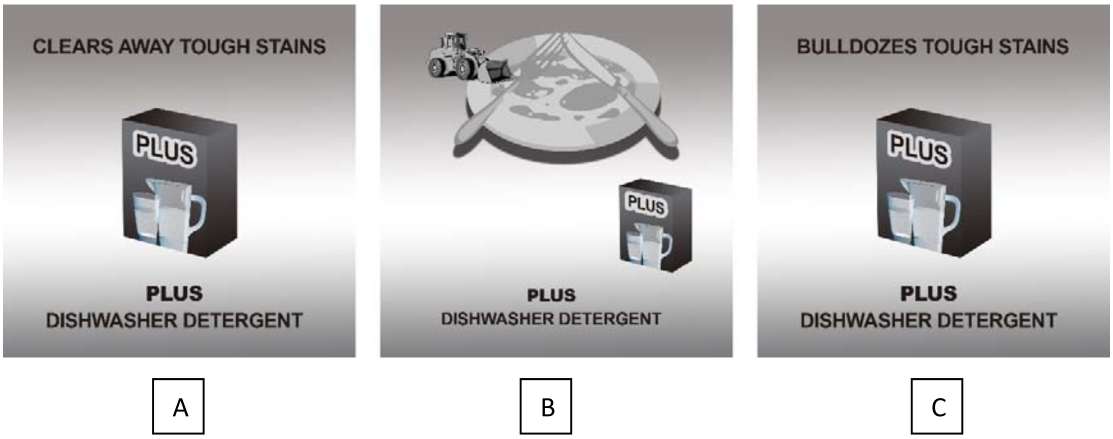

Figure 3-6. Investigating the impact of Verbal literal versus visual and verbal metaphor (Reproduction of advertisements used by McQuarrie & Phillips (2005)).

The authors reported that using pictorial metaphorical claims (pictorial symbols) provided a chance for participants to go through multiple positive inferences spontaneously. In contrast, participants who were exposed to the verbal literals (direct claims) and to the verbal metaphors (symbolic wording) tended to generate additional inferences in case they were asked to provide their interpretations from the advertisement (McQuarrie & Phillips, 2005). Their study suggests that people are more receptive to visual metaphors due to their open-endedness and lack of constraints on they can be interpreted (McQuarrie & Phillips, 2005).

In this thesis research, McQuarrie and Phillips (2005) research motivated us to design different sorts of visual stimuli. And by considering the DISCOVER Model which was proposed by Cheung and Scott (2011) various direct and indirect visual and verbal stimuli were designed for different levels of proxemics-based interaction with LID. We went through several brainstorming sessions and discussion of the possible meaning implications with research peers. This process resulted in a set of 18 visuals for direct persuasion as well as an equal number of visuals for indirect persuasion. These visual and verbal stimuli are explained in detail in the next chapter.

3.4 Chapter Summary

In this chapter, we reviewed the main adopted Communication theory which is called “Symbolic Interactionism”. We also argued the role of LID as the message transmitter and the way that it can alter the role of the user in the process of decoding and encoding messages. Afterward, the main message components and corresponding communication functions were explained and conative function was chosen as one the key aspect of this thesis research. Finally, some related research examples were reviewed in order to provide a guidance for the study design and its implementation. In the next chapter, we will explain how we embedded the chosen variables (proximity and conation modes) into the process of UI design.

Chapter Four

The UI design

The main objective of this chapter is to explore the different steps of user interface design. The interface was specifically designed for the educational environment as an example of public setting. We named the interface “UWaterloo Community Application”. The previous chapter elaborated on various adapted related works which could bring novel perspective to this area of study. Following on the requirements gathered from the background research, this chapter expands on the process of interface design for the LID. The ultimate design used in this study was an interactive interface that included contextual references of the deployed environment. For this purpose, an experimental application was designed which allowed us to look at differences between displays with proxemics-based animation as well as persuasive visuals. This chapter describes the iterative design process to get to the final visualizations used in our experiments. Providing a reasonably effective interactive interface which be able to successfully elicit passersby attention was the main goal of the whole design process.

4.1 LID Installation Site/ Setting Considerations/ Design Requirements

From the very beginning of the design process based on the planned study design, environmental characteristics of the LID installation site were considered. We already knew that within a crowded area, the content shown by the display should be salient in order to win the competition with other visual stimuli inside the environment. The selected field study site was a hallway and foyer area in the Engineering 5 (E5) building at the University of Waterloo, Canada, near the main office of the Mechanical and Mechatronics Engineering (MME) department (Figure 4-1). Given this selected location, we started listing the main visual characteristics of this area by gathering some physical information about the wall colours at this building as well as light/reflection direction (Appendix A).

Figure 4-1. Engineering 5 (E5) building at the University of Waterloo and the entrance hallway (photo taken by Victor Vucicevich).

4.1.1 Informative Frames/ DOT Pictograms and Icon Design

Nowadays, all around the world a set of 50 signs which is called DOT (United States Department of Transportation) pictograms are used for the purpose of conveying useful information to people. These set of signs are designed to be simply perceivable by heterogeneous audiences who have different cultural background or languages (Figure 4-2, Figure 4-3). One of the main physical characteristics of the indoor area of E5 building is also the presence of DOT pictograms. We considered signs and symbols which been used

inside the informative frames.

Figure 4-2. DOT pictograms: A set of fifty pictograms used to convey information that are useful to travelers without using words

Figure 4-3. DOT pictograms translation: From left, "Escalator (up)," "Nursery" and "Ground transportation”.

The major consideration about the design of these signs is that the use of words is avoided and still they can be understood very fast and more simply than words (Figure 4-4). Since they are designed for public spaces and work well for conveying information to multi-cultural areas, they are used on campus at the University of Waterloo as well (Figure 4-4).

Figure 4-4. DOT pictograms in E5 building

Given that these pictograms are learnt world widely, we decided to apply the same simplified fashion for using pictograms inside the information visualizations used in the study. Henceforth, we initially simplified all the pictorial elements to the point that they resemble the DOT pictograms and then, tried to add more contextual meaning and expression to them.

4.1.2 Environment Dominant Colours

We considered the whole environment of the MME department very neutral. The reason is that almost all the surfaces in the department from the walls and the floor is covered with gray colour. Through sunlight reflection on the wall or floor, the passersby can just see different shades of gray colour. The only exception is the entrance hallway which its walls are all in red. Since the large interactive display was supposed to be installed in a totally neutral area which is full of light/dark gray colours, we inferred that using more colours for designing the information visualization can increase the contrast and also make the interface visually salient. Based on the high levels of ambient and reflective light in the study environment, the base experimental application utilized very bright, contrasting colours for better visibility and salience in the study context (Appendix A).

4.2 Content Development Based on the Deployment Context

For designing an information visualization that is appropriate and related to the context of a university campus and that contains contextual references, we chose to embody the desired visual effects in the framework of a three-story library shelf. Since an object such as book can carry different meanings in an educational context, we expected that passersby could relate the showcased information visualization with themselves.

It was also expected that all the university staff and students would already be familiar with the concept of studying in a library or borrowing books from a library within an educational establishment. Accordingly, this familiarity could help the passersby to avoid retreating or withdrawing as result of encountering with something that is unknown to them. Also, this interface could subtly imply the idea of a digital library which can provide information in a faster fashion. Although, we did not tend to deliver any information about the library activities, we chose this general symbol for in-campus activities.

In the next step, a low fidelity wireframe of the library shelf was designed in order to check necessary information visualization requirements (Figure 4-6).

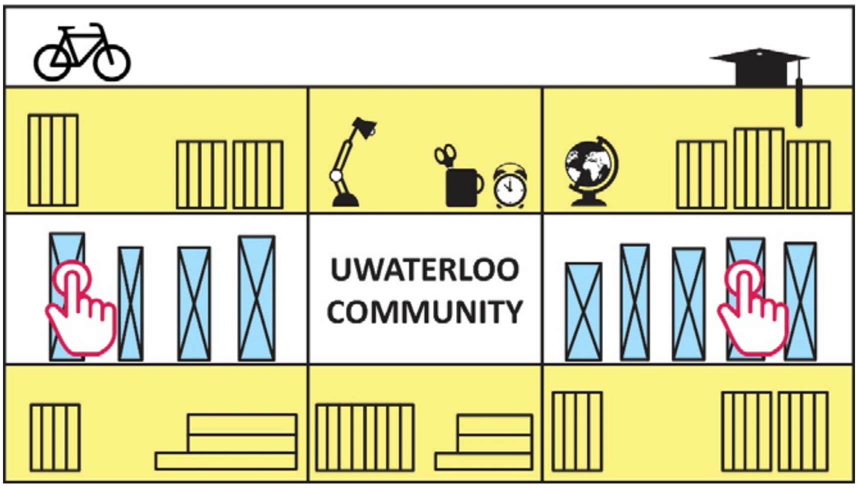

Figure 4-6. low fidelity wireframe of the LID interface/
The blue boxes represent the touchable areas inside the interface.

Inside the top and bottom shelves that are shown with yellow colour, some educational visual elements are used that are related to the idea of studying. The whole surface is divided into four sections. The top section, contains an interactive stimulus. The only interactive stimulus in this section is a moving bicycle in the left side which is not touchable. The reason for using this visual element is that this transportation device becomes commonly welcomed during the summer time. We inferred that a simplified bicycle can represent something familiar and also symbolize sunny days and good times in the summer. The interactivity of this pictorial element is limited to synchronized movement with the passerby alongside and in parallel with the display from left to right. The bicycle movement has an automatic time-out function and after a while it goes back to its first position. We intended to imply a sense of playfulness and intrigue the passersby to move back and forth to make the bicycle to follow them. At the right side of this section, there is a graduation cap which is visually simplified to be as simple as DOT pictograms and represents the idea of ending education successfully. Although we initially intended to add animation effect to the graduation cap as well and make it to jump and react to the presence of the passerby, the final decision was to avoid this effect and let all the animation effects occur in parallel with the length of the display.

The top and bottom shelves have the same size and are filled with non-interactive elements. None of the books or other educational visual elements in these two shelves are labeled. In contrast, we labeled all books in the middle shelf (blue boxes) with explicit or implicit pictorial and textual elements (depending on the conative mode). Accordingly, it was expected that the educated in-campus passerby who daily uses website pages, would be able to transfer their background knowledge from webpages and infer that only the books in the middle shelves are interactive. To provide more visual cues to these button shaped books, we also planned to enrich the spine of middle shelf's books by adding texture and more background shadow. Moreover, we decided to use the "bevel and emboss" effect to let the books in the middle shelf be more prominent.

4.2.1 Background Design

In the process of converting low-fidelity wireframe to a high-fidelity prototype, a wooden shelf by means of Adobe Illustrator CC 2015 was designed. Then, the schematic shelf was replaced with it (Figure 4-7). In the next step, different visual elements were designed and placed inside the library shelves. In order to be able to apply animation effect on the interactive elements inside the library, their place inside shelves were kept empty. For interactive elements, we initially had to decide about their animation effect. After that, we used both Adobe Illustrator and Photoshop CC 2015 to generate frame by frame animations that were then displayed in the application

Figure 4-7. High-fidelity digital wooden shelf designed to be used as the background of LID interface

The reason for applying interactivity to the middle shelf is that the average human eye level was considered. So, the focal point of the screen is about 1.5M above the floor which is expected to be the main part that the viewers' eyes will discover first (Figure 4-8).

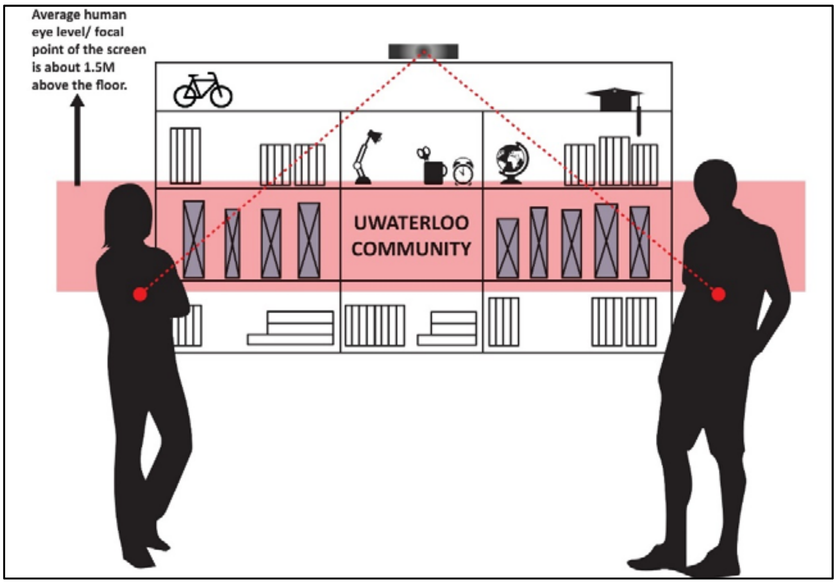

Figure 0-2 Average human eye level and main focal point of the screen

4.2.2 Proxemics-based Animated Visual Effect

Relying on the previous related works which mentioned in section **2.3.1**, we decided to compare proxemics-based animation with random animation as one of our main independent variables. Hence, we had to generate three basic animation effects for the three identified zones and fit them to the interface design.

For the proxemics-based experiment conditions, it was expected that the LID would be capable of responding to the presence of the users corresponding to their proximity to the LID. In contrast, for the random animation, all the animation effects were activating randomly and had specific automatic time-out function.

4.2.2.1 Zone 3 Animation Effect

Due to the nature of our experiment, we started with generating a basic animation effect for the third zone (the furthest one).

We tried two various animation effect and used a combination of both in our final UI design. The first one was "changing angle" in the visual elements that been used inside the interface (Figure).

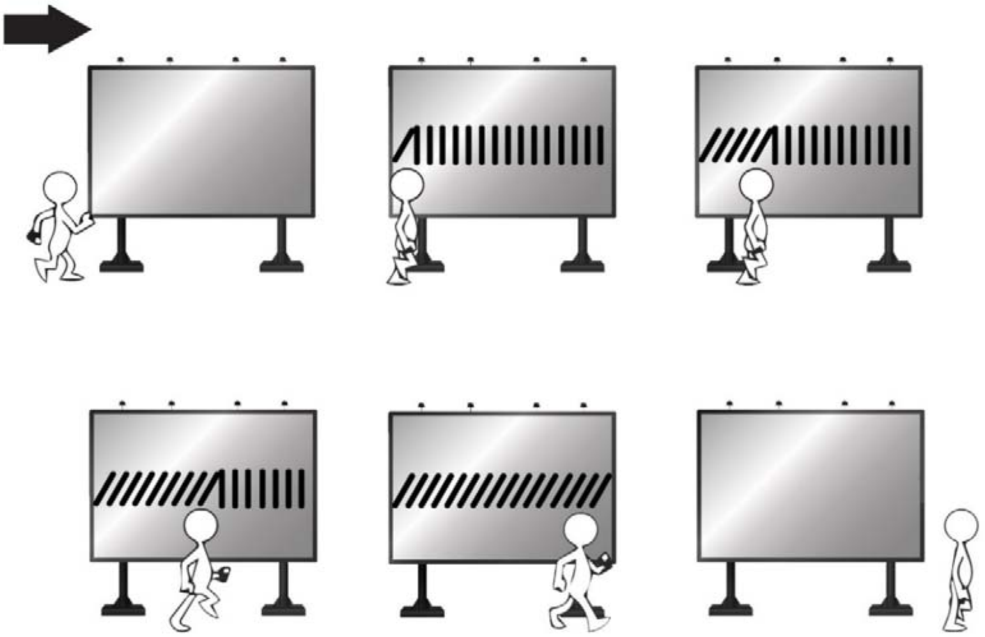

Figure 4-9. Changing angle effect: Implying sense of motion and instability by means of diagonal lines

The rationale behind developing such visual effect was the function of diagonal line in eliciting human's eyes attention. Diagonal lines always suggest a feeling of movement and direction. A line which is neither vertical nor horizontal, suggests sense of instability in relation with gravity and carry the idea of falling down. Thus, it implies sense of motion. Since, we wanted to fit the animation to the library interface, we concluded that the changing angle animation is a good match because we had the chance to replace the moving lines with the books.

The second animated visual effect we tried out, was a bidirectional animation which would let the visualized information to appear on the screen while two users were moving in parallel with the display from two opposite directions (Figure).

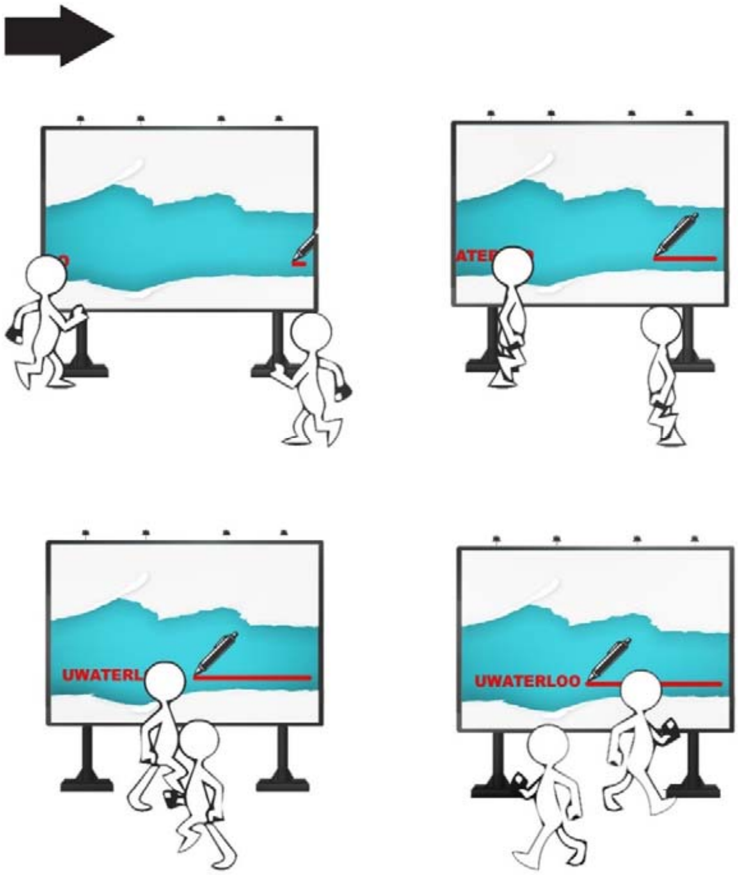

Figure 4-10. Bidirectional visual animation effect

Since in a crowded area such as E5 building, there is a reasonable possibility that passersby move from different directions in front of the LID, we combined the first effect (changing angle) with the second effect (bidirectional animation) and made a "bidirectional changing angle animation effect" for the cases that the user moves in parallel with the display in zone 3.

As explained in section 4.2, the LID was able communicate information through the changes which were occurring in the middle section of the library interface. Accordingly, the user could activate these animated and interactive button-like books by corresponding body movement because the Kinect was capable to detect the top spinal center point of the user (red dots in the Figure 4-11). We provided enough space between books in the middle shelf to let that an individual become able to activate desired button/book (Figure 4-11).

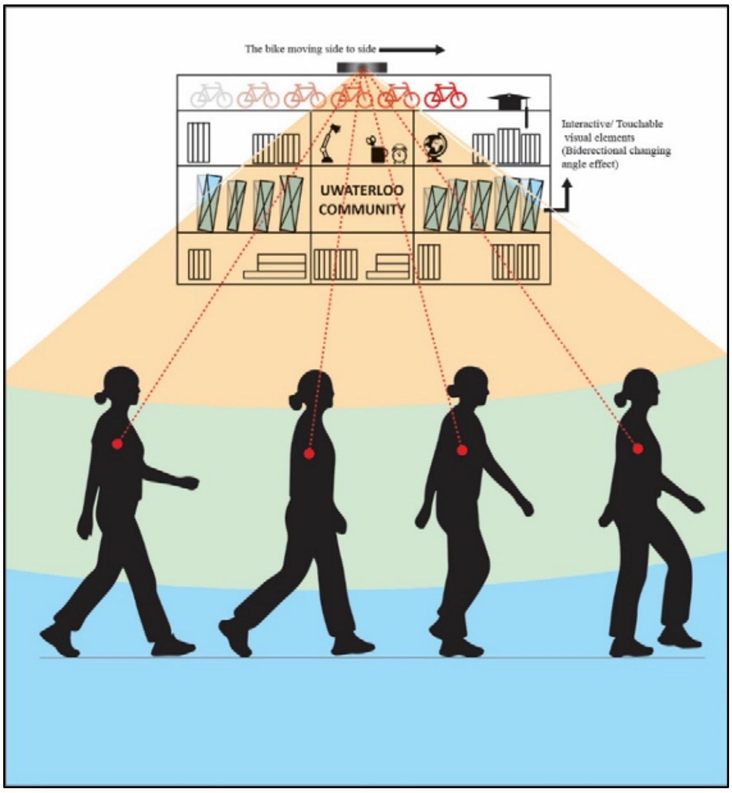

Figure 4-11. Combination of bidirectional changing angle animation effect with the library shelves for zone 3

As it is shown in Figure 4-11 the books in middle shelf can respond to the users' presence while user walks in parallel with the display in zone 3. In order to imply interactivity during the time that the proxemics is activated, the books in the middle shelf tilt to the direction that the user is moving in zone 3.

In case that another user enters to the third zone from the opposite direction, the same effect will react to the presence of second user while the effects that are related to the first user are still active. We expected that this technique helps to draw the user's attention and convince the user to stay and even enter to the course of interaction. Although this interference has done very subtly, we also expected that the users provide an explicit signal such as body gesture about their ambition to discover more information or wishing to be left alone. We also expected that the tilt effect of the books in middle shelf intrigue the passersby to react playfully to the interface that is moving back and forth in parallel with the display to activate more books to tilt.

4.2.2.2 Zone 2 Animation Effect

The visual feedback was planned to be different based-on the zone that users move through. We assumed that those passersby who are moving in parallel with the LID in zone 3, should become aware about the display by seeing the changing angle (tilt effect) on books. However, same animation effect cannot work on zone 2 and zone 1. So, we decided to generate new animation effects for the case that the users move perpendicular to the display (move between zones).

For zone 2, we planned that the books open when the user moves from zone 3 to zone 2. This visual effect could benefit in term of implying the idea that there is more information that can be revealed. Moreover, opened books could provide more space for delivering new visuals for the purpose of message transmission.

Figure 4-12 shows that while the users move perpendicular to the display, the tilt effect in zone 3 replaces with the opening book effect in zone 2 in order to demonstrate the idea of interactivity and revealing more information for the users.

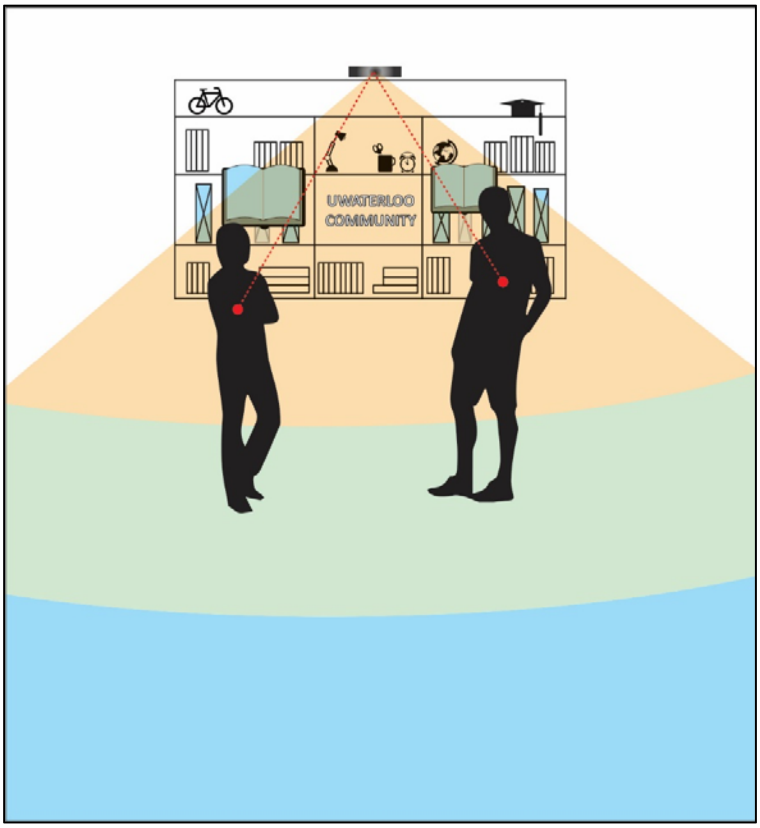

Figure 4-12 Opening book effect for zone 2.

4.2.2.3 Zone 1 Animation Effect

In case the users who moved towards zone 2 are attracted and convinced to engage more with the LID, there is a possibility that they pass zone 2 and enter the closest zone which is zone 1. For this zone, as it is detected the user is close to the display, an icon appears in order to encourage the user to touch the display (blue triangle in Figure 4-13).

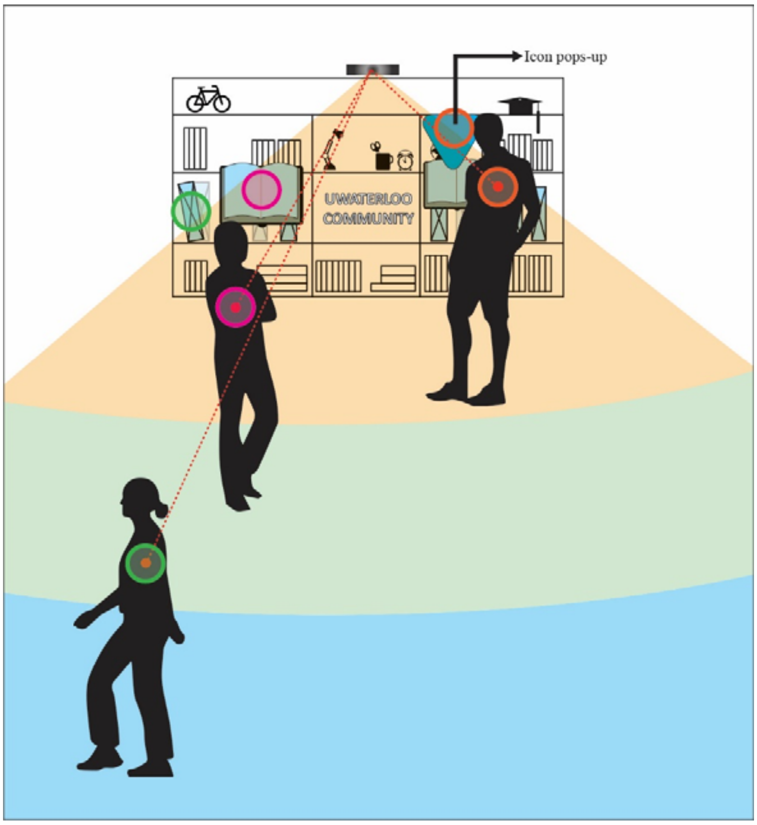

Figure 4-13. Different proxemics-based animation effects for three identified zones in front of the display

Figure 4-13 demonstrates how different proxemics-based animations could work together simultaneously. The purpose of providing these step by step proxemics-based animations can be summarized as below:

1) Letting the user learn that the LID interface is interactive
2) Letting the user learn about different layers of information which could be revealed according to the user's body movement
3) Encouraging users to stop by or move towards the display

4.2.3 Communicating Direct and Indirect Meanings to Fulfil Conative Function Modes

Inspired by the study of McQuarrie and Phillips (2005) which was explained in section 3.3, we planned to investigate two different conative function modes (persuasion techniques) which included direct and indirect visual cues. The purpose was to lead the users through an interpretative process. Hence, we decided to design and use meaningful icons and place them on the spine of the books of the middle shelf. As explained earlier, the icons were inspired by DOT pictograms and they could be used either in the spine of books (in zone 3) or on the books inside pages (zone 2 and zone 1).

4.2.3.1 Designing Ideographic Icons for Indirect Conation in Zone 3

We initially started with designing ideographic icons for indirect persuasion mode. Here, the term ideographic means that we used visual symbols instead of words for the purpose of transmitting our intended messages.

In the earlier stages of design, the icons that are shown in Figure 4-14 were designed. From left to right, they were representing the following subjects: art gallery, student club, health services, physical activity center (PAC), bus stop, game, coffee, study rooms, and campus tours. All the items were chosen through doing research about university in-campus related subjects. At this stage our understanding was that these icons are capable to deliver indirect information about the named subjects.

Figure 4-14. Ideographic icons for indirect conation mode

We also assumed that replacing generated icons with their titles can help us to compare direct vs. indirect conative function. However, during the process of design we perceived that both verbal and non-verbal information are representing same thing and they cannot persuade users indirectly to touch the display.

At the second attempt, we tried to generate different sets of icons for the book spines. This set of icons would change if the user was entering zone 2 by the time the books open. This changing of icons helped us to follow the rules that were gathered from the literature. We kept the basic characteristics of DOT pictogram and tried to add more humanistic feeling to them. The basic difference between generated ideographic icons and DOT pictograms was that human figures in DOT pictograms can imply merely no feelings in terms of sadness, happiness, dizziness and etc. In contrast with them, we tended to inject more humanistic feelings into our human figures. Thus, ones by looking at human figures can perceive different feelings such as power- while the icon is related to physical activity- or sense of humor -while the icon is designed to demonstrate the term “game”. Since we wanted to showcase the interface inside an educational environment, we decided to keep the human figure generally young which is wearing simplified modern and colourful clothing.

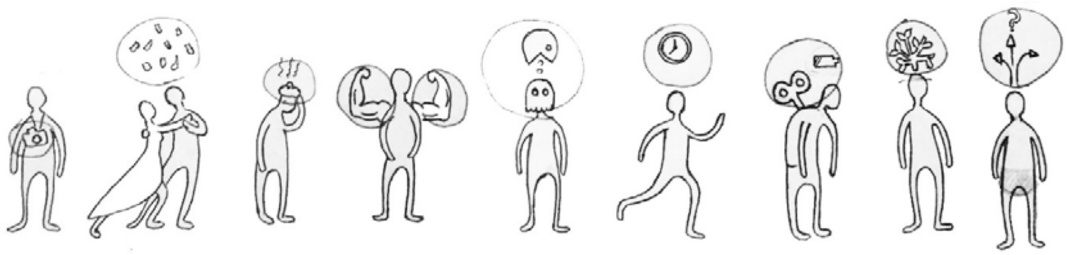

Figure 4-15. Early stages of designing ideographic human icons for the interface based-on DOT pictograms

Figure 4-15 demonstrate early stages of ideographic human icons which tended to be use in the spine of middle shelf books. Through an iterative design process, we also decided to add facial expressions to the ideographic human icons to explicitly emphasize humanistic features. Also, we replaced student club with nightlife to let the visual representation be more specific. The ideographic icons shown in Figure 4-16 were used to examine indirect conation mode in zone 3.

Figure 4-16. Finalized ideographic human icons for the LID interface in zone 3

The message that each of these ideographic icons tend to communicate is as below (from left to right):

- **Art gallery:** a smiley person who can take advantage some artistic materials to generate artworks.
- **Health center:** a sick person who suffers from headache and has fever.
- **Nightlife:** a person who has soda in his hand and colourful sparkles can reveal some information about being in party or club.
- **Physical activity center (PAC):** a person who want to strengthening his muscles to look more powerful.
- **Games institutes:** a person who playfully put on a Pac-man mask.
- **Bus stops:** a person who is running and implies the sense of being late.
- **Coffee:** A person who looks tired and discharged.
- **Study rooms:** a person who looks upset or nervous and has an exam.
- **Campus tour:** a person who looks confused in terms of finding ways.

4.2.3.2 Icons for Indirect Conation in Zone 2

As the passerby may move towards the display (passes from zone 3 and enters to zone 2), the books open and it is necessary to reveal more meaningful information. As it is shown in Figure 4-17, a new set of ideographic icons were designed to be used on the inside pages of books.

Figure 4-17. Ideographic icons for inside pages of books in zone 2

The purpose is that the user relates the icons in zone 3 with the icons in zone 2 and go through the interpretative process. As an example, as the user see the icon of a de-charged and tired person in zone 3 (Figure 4-16), and the icon of coffee and charged battery Figure 4-17) in zone 2, should infer that coffee can energize a tired person and makes him/her to feel more lively. Or a person who is confused and cannot find his/her way should infer that activating the compass icon can provide information about way-finding and taking a campus tour.

4.2.3.3 Direct Conation

For the purpose of direct conation, a different set of visual feedback was designed.

For direct conation in zone 3, the book spines were showing the title of each subject. Figure 4-18 demonstrate that how ideographic icons in zone 3 for indirect conation, are replaced with textual information for the purpose of direct conation.

Figure 4-18. Direct conation in zone 3 (top) versus indirect conation in zone 3 (bottom)

In case the user who is exposed to direct conation condition pass zone 3 and enters zone 2, the photographic images will pop-up inside the opened books (Figure 4-19).

Figure 4-19. Photographic images for zone 2, top row were placed in the left side of the interface and the bottom row icons were placed in the right side of the display.

Figure 4-20 demonstrates different visual modes in zone 3 and 2 based-on the various conation modes. On the top row, the ideographic icons versus the textual information are showing the different visual modes for indirect and direct condition in zone 3. In the bottom row the indirect versus direct conation on zone 2 been shown.

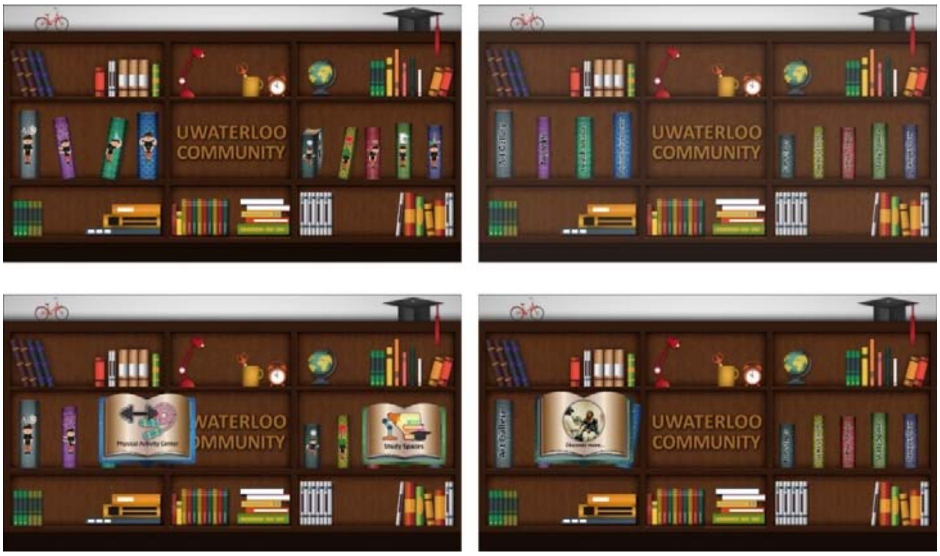

Figure 4-20. Left: Ideographic icons for indirect conation mode in zone 2 and 3. Right: Ideographic icons for direct conation mode in zone 2 and 3.

4.3.3 Indirect versus Direct Signifier for Zone 1

As the user leaves the second zone and enters the first zone (the closest zone to the display), the system provides two different signifiers based-on conation mode (indirect or direct) which tends to invite the user to touch the display. For the indirect conation mode, a magnifier will pops-up which imply the idea of searching for new information. For the direct mode, a hand gesture pops-up which explicitly shows the touch-area inside the interface (Figure 4-21).

Figure 4-21. Direct signifier (left) for zone 1 versus indirect signifier (middle) in the same zone are inviting passers-by to touch the display. The speech bubble (right) helped us to ask users to fill out questionnaire.

Figure 4-22. The blue speech bubble which would pops-up in case the user touches the display

In case the user gets convinced and touch the display in the areas which are interactive, then a speech bubble pops-up showing this message: “Thank you for touching the display! Please pick up your prize from the desk with red ribbon on it!”. This speech bubble was designed to help us specifically for the purpose of asking users to fill out a short online questionnaire on SurveyMonkey (Figure 4-22).

In order to avoid any confusion, the following visuals demonstrate different visual modes related to different proxemics and conation modes in a simple and straightforward way.

For both direct or indirect conation mode, in case the proxemics is “ON”, visual feedbacks will be provided based-on the proximity of the user to the display. And if the proxemics is “OFF”, the visual feedbacks will be provided randomly during the time span that the condition is showcased (Figure 4-23, Figure 4-24).

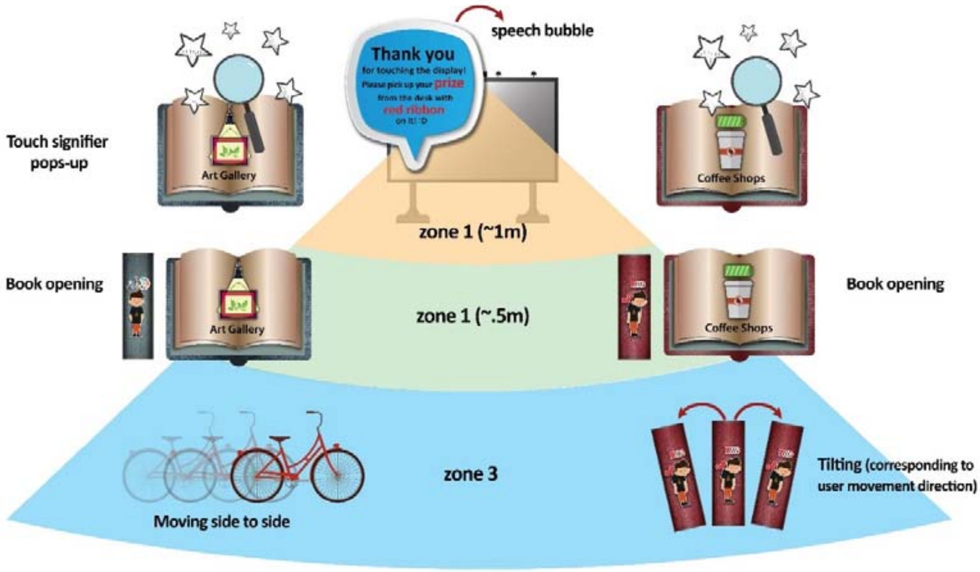

Figure 4-23. Proxemics-based visual feedback for indirect conation

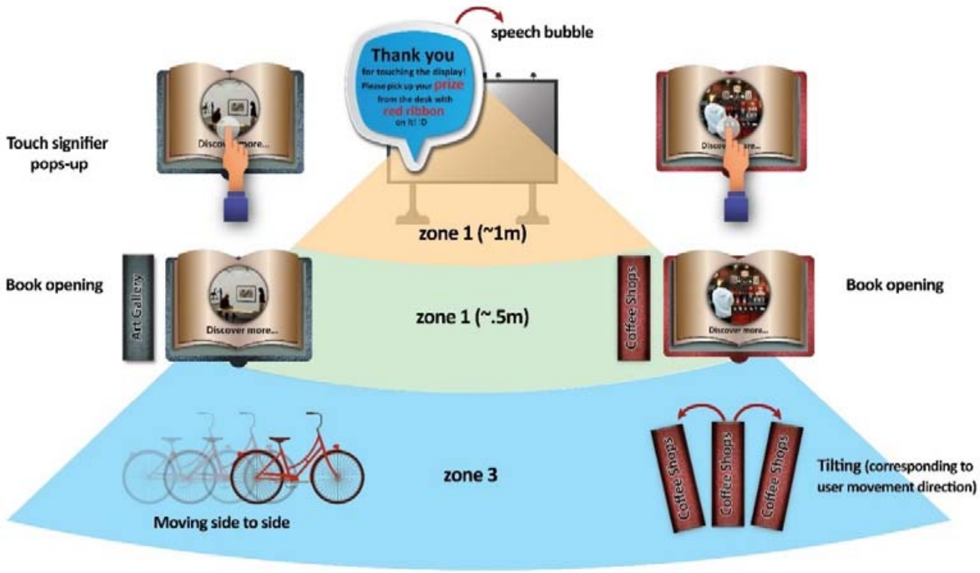

Figure 4-24. Proxemics-based visual feedback for direct conation

4.4 Chapter Summary

In this chapter, we reviewed the iterative process of UI design. We started by looking at various aspects of installation site as well as setting requirements. We continued with the process of content development from the background to various proxemics-based as well as conative-based animation effects and visual cues. We finally summarized the provided information into the last two figures to help the readers to learn about different UI modes.

Chapter Five

Study Methodology

This chapter describes the methodology used in our field study that examined the effectiveness of different animated visual feedback introduced in the previous chapter. In this chapter, we will describe the study design, study variables, procedure and some practical and ethical considerations regarding the study side. Finally, we discuss the data collection techniques

5.1 Study Design

In order to investigate the impact of proximity as well as conative communication with LIDs (persuasion mode), a 2x2 between-subjects field experiment was designed in order to measure the effectiveness of independent variables: Conative mode and proxemics (summarized in Table 5-1). We wanted to investigate the effect of each variable on enticing users' attraction and convincing them to stay in the course of interaction.

Table 5-1. 2x2 between-subjects field experiment to measure the effectiveness of various modes of conation and proxemics-bases animation

	Proxemics	
Conative mode	**OFF**	**ON**
Direct	1-Photographic images + direct textual descriptions	3-Randomly timed photographic and direct textual feedback
Indirect	2-Ideographic icons + titles	4-Randomly timed ideographic icons and titles

As explained in section 4.2.3, for designing the UI, we were inspired by the research conducted by McQuarrie and Phillips (2005). Therefore, for the purpose of taking advantage of visual stimulus, we used a similar strategy in order to combine images with textual information. For the first independent variable which was the conation mode two factor levels were used, direct and indirect (explained in section 3.3), to measure the impact of various persuasion techniques on enticing the users' attention. The second independent variable was whether the displayed animations responded to the proximity of the users to the LID or whether the animations were randomly shown. We intended to observe the impact of revealing different animated visuals with (proxemics-ON) or without (proxemics-OFF) proxemics-based animations on enticing and engaging passersby. This aspect of this research was inspired by Cheung and Scott (2013) and Cheung (2016). Hence, we used the same identified three different zones in front of the LID. As explained in the previous chapter, in case of the presence of proxemics-based revealing information technique, the visual information was revealed corresponding to the distance of the user from the LID based-on the one of the three identified zones and conative mode condition. So, the type of the visuals which were shown inside the display were changing according to the distance of the user from the display. In the proxemics-OFF condition, there was a set ordering of animation events (e.g. an animation sequence) that could appear in random times. In summary, we were looking at the impact of distance, conative mode and their interaction on users' attraction and engagement with the LID.

5.2 Dependent Variables

The application was designed in a way that was capable of detecting the location of the user in front of the display, and the exact coordinates of any touch interaction (saved in an interaction log) according to the condition of experiment. To study the impact of the proxemics and persuasion techniques on enticing passers-by attention a mixed-method study methodology (combining quantitative and qualitative data analysis) was utilized. The quantitative data collected through keeping the record of body log and touch data.

The qualitative data covered items such as initial impression of the LID, the impression of visual content of the display such as the interactive objects and etc. The data collection methods consisted of closed/open-ended survey questions and video-recorded data.

5.3 Experiment Technology

For the purpose of investigating the phenomena of public interaction with LIDs, the "UWaterloo Community Application" was designed (explained in section 4.2). The application was developed to run on a 164cm (64.5")-diagonal interactive display manufactured by SMART Technologies (Figure 5-1).

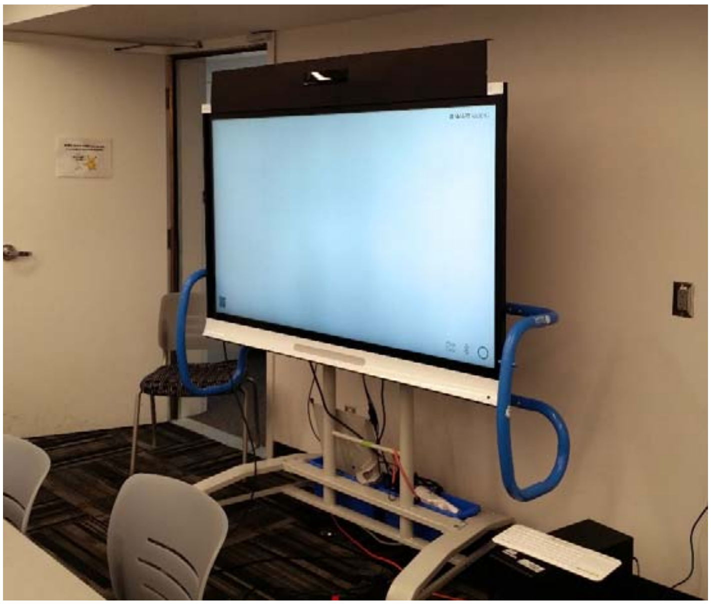

Figure 5-1. The large interactive display which was used through the experiment

This board takes advantage of "Digital Vision Touch" (DViT) technology for detecting and responding to touch (Figure 5-2) and is capable of recognizing up to four multi-touches and report them to the touch event of the connected computer (Cheung & Scott, 2013). This camera-based touch technology also takes advantage of a combination of digital camera, proprietary software, and firmware in order to detect the exact coordinate of touch on the outer surface. The digital whiteboard can also be connected with a laptop/PC to run the UWaterloo Community application.

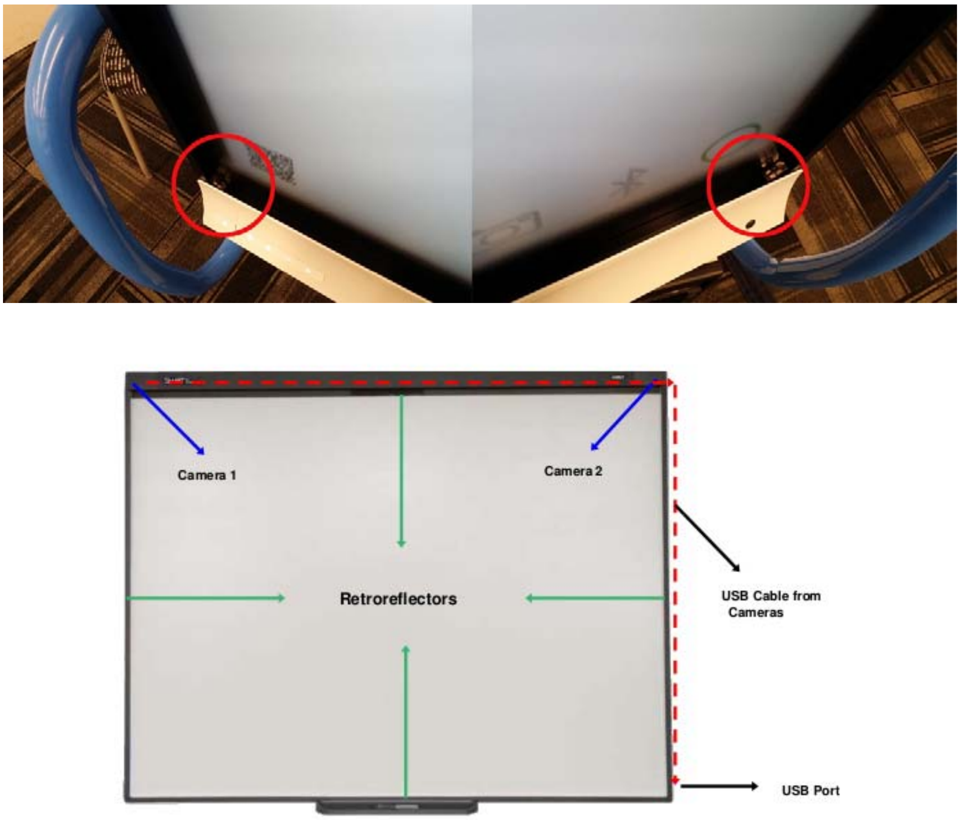

Figure 5-2. DViT (Digital Vision Touch) technology use digital cameras to track objects that interact with the interactive whiteboard. Each camera is calibrated to recognize the position of a pen tray tool or users' finger on the whiteboard surface and to translate that position to a coordinate recognized by computer.

The display was mounted on a mobile stand of adjustable height. The display was connected to a Windows 8 PC (3.5GHz CPU, 16GB RAM, NVDIA Quadro K2200 display card) displaying content in 1920x1080 pixels resolution (Cheung & Scott, 2013).

A Microsoft Kinect V2 was mounted to the top of the display with the help of "4 in 1 Universal Kinect Move" (Figure 5-3). This enabled us to track users in front of the display. By using the Kinect, six passersby could be tracked simultaneously to a distance of 4.5m. User proximity data were used by the application which developed by Unity 5[1] to let the adoptive visual feedback change based-on users' responses to the LID.

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[1] http://unity3d.com/

Figure 5-3. Microsoft Kinect V2 on top of the display

5.4 Study Location (Environmental Characteristics)

As mentioned in section 4.1, a hallway in an engineering building 5 at the University of Waterloo was chosen for the purpose of semi unobtrusive field observation. The location was chosen for the following reasons (Cheung & Scott, 2013)

1) The area has enough foot traffic for three interaction zones
2) The area has enough space either for the passersby to stay for a while and also for the researchers to perform unobtrusive observation
3) There are several power supplies in the area that let the display to operate during the observation
4) The area was legally accessible for the researchers
5) This current study is the expansion of the study been implemented by Cheung and Scott in 2013. Hence, we tried to be consistent in some aspect of the test such as location and identified zones in front of the display.

The location has an above-ground pedestrian pathway on the west-side which is a frequently commuted area. Also the students always use this area between classes. On the east-end there are staff offices. Thus staff members are also commuting in the area and use it for the between meeting hours.

The experiment was performed in the winter time and a couple of weeks before midterm reading week. Hence, we were expecting that the students traffic may increases due to colder seasonal weather and students' preparation for the midterm exams. Finally, there are several sitting areas in the examination site which students usually use for doing their class work. The sitting area could give the researcher the chance of being stationed while have a full view of the display and passersby interactions (Cheung & Scott, 2013).

5.5 Getting Ethics Clearance

For the purpose of performing field study we had to obtain clearance from the University of Waterloo's Research Ethics Office. There are several reasons that can be enumerated as follows:

1) Intervention of public space: we intended to place several equipment inside the experiment environment which could alter the space for short period of time.
2) We intended to record users' reaction, their interaction with the display
3) We intended to invite specific users to fill out online questionnaire

As the study was the expansion of the experiment been performed by Cheung and Scott in 2013, we provided modified information for the ethics office. Hence, we provided information about modifications that include the implementation procedure, a list of the questions we intended to ask from the users via an electronic device (tablet), and the electronic consent and verbal recruitment script for the survey (Appendix C).

5.6 Research Procedure and Anomalies in the Set up Site

The study ran in the mid-February within four days just before the reading week. We set up the equipment in the site. While we observed unobtrusively and recorded the event, an experimental assistance was also onsite and waited for the passersby who started to engage with the device and touch it. When the passersby were looking for the "red ribbon" which was mentioned in the interface, one of the assistances had to verbally recruit the passerby to join the study. It is worth noting that the "red ribbon" was not close to the display area so the passersby who joined the study, had to leave the display site. After listening to verbal recruitment script, if they were interested, the assistance would ask them to read the cover page of electronic survey as well as the information consent. The participant had to explicitly confirm his/her agreement by answering electronic questions in this regard. If the participant would disagree, they were asked to return the tablet to the experiment assistance.

The observation period was from 11am until 3pm on each day. The order of presentation of the four experimental conditions was counter-balanced across the four days, as follow:

Day one: C2, C3, C4, C1

Day two: C3, C4, C1, C2

Day three: C4, C1, C2, C3

Day four: C1, C2, C3, C4

Where C1= direct conation/ proxemics off, C2= indirect conation/ proxemics off, C3= direct conation/ proxemics ON, and C4 = indirect/ proxemics ON.

The reason for changing the order of conditions on each day was that we wanted attempt to provide similar levels of foot traffic across all four conditions during the entire study. We expected that during the morning times time the area would experience less foot traffic and this may introduce inconsistency to the study. However, it turns out that many graduate and undergraduate students in the site and were getting themselves ready for their midterm exams, and accordingly the observation site was more crowded than we expected during certain time. Moreover, there were groups of undergraduates who had to attend exams in a room which was next to the display during all four days of the study implementation. An important anomaly which was observed was the crowd who were in a line in front of the display before the exam starts. A long line of students tended to be distracted by side-talks about the exam (Figure 5-4). Hence, they usually were reluctant to pay attention to the equipment which were quite close to them and was altering the building space.

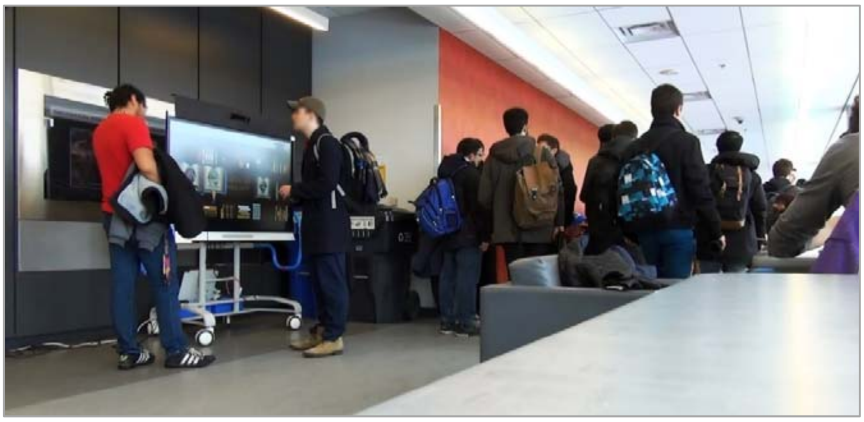

Figure 5-4. The West-wing of the E5 building, two students are talking together in front of the display and many are gathered next to the display.

The important thing that should be considered is that the Kinect was keeping record of passersby who were in its detection area. Hence, this situation created a large number of body logs during the study.

5.7 Data collection and analysis

During the experiment implementation, data were collected from three different sources:

1) Computer logs: The application was capable to assigning a unique ID number to any person who was entering one of the identified zones in front of the display. Moreover, the touch coordinates were recorded automatically. So, for the purpose of quantitative analysis, we had access to the number of who entered in one of zones, the condition, number of touches, coordinated of touch area, coordinates of non-touch area, time and date.
2) Video records: We utilized a Sony HDR-MV1 handheld video camcorder with a wide-angled lens to capture foot traffic and passersby interaction with the display. The data was used to confirm findings from log data.
3) Online survey: Used to elicit feedback from passersby to examine their perception of the display. It was implemented by Surface Pro tablet via SurveyMonkey which is a free online survey software and questionnaire tool.

For the purpose of running data analysis, several steps were taken. Initially, two different tables were created; 1) body log: the log data which was created by the Kinect any time a person entered a zone and included an identification number which allocated to any individual who passed from any of the zones, date, condition, and zone number. 2) touch log: the log data which were created by the display any time a person touched the display. The log data included: touched books name, date, and condition. More detailed information about running data analysis is provided in section 6.2 (Conversion Analysis).

5.8 Chapter Summary

In this chapter, we reviewed the 2x2 between-subject field experiment design. We covered various conditions within the experiment and explained our dependent variables. We also looked at the experiment technology and the deployment location. Finally, we provided information about research implementation and the process of data collection.

Chapter Six

Results

This chapter first reports on the quantitative analysis of participants. We start by reviewing the body and touch log data and the methodology which was used to condense data. In the next step, we argue the conversion analysis for three categories of passersby which include: 1) users who passed by, 2) users who explored the display, and 3) users who touched the display. This classification helped us through measuring the display attraction power, engagement level and holding power which all are explained in detail in this chapter. We will move through the touch analysis and testing the main independent variables which contributed in various touch behaviours. In the second half of this chapter, we will review the qualitative analysis of survey data. We provide an overview of initial impressions and the main detected interactive elements. Finally, we provide data of icon touch analysis.

6.1 Study Participation

During the 4 days of the field study, 35 (9 females, 25 males, 1 other) passersby accepted to answer the online survey. The participants mainly were in the group age of 18-24 (33 participants). Based on the reported data, 88.57% participants had experience of using LIDs in public settings. According to the collected log data, the number of people who passed by the display as well as the number of touches on the display are provided in the Table 6-1 and Table 6-2. More detailed log data is provided in Appendix D.

Table 6-1. Body log raw data for 4 days of field experiment

Condition	**Zone**		
	Zon1	Zone 2	Zone 3
C1 (direct conation/ proxemics off)	523	586	516
C2 (indirect conation/ proxemics off)	581	686	746

C3 (direct conation/ proxemics ON)	518	630	648
C4 (indirect/ proxemics ON)	489	563	554

Table 6-2. Touch raw data for 4 days of field experiment

Condition	**Touch**	
	Touch area	**Non-touch area**
C1 (direct conation/ proxemics off)	208	265
C2 (indirect conation/ proxemics off)	200	326
C3 (direct conation/ proxemics ON)	35	7
C4 (indirect/ proxemics ON)	57	36

6.1.1 Participation Results

Since any individual or group could touch the display dozens of times, two different steps were taken in order to estimate the number of participants in each condition as well as condensing the number of touches.

For the purpose of estimating the number of participants, we assumed that if the time intervals between each touch was more than 30 seconds and the number of touches were less than 25 touches, then an individual person had touched the display. However, if the time interval between touches was less than 30 seconds and number of touches was more than 25 touches, then a group of people had approached the display and touched it several times. In the next step, we supported the estimated numbers by running video analysis. Through the video analysis, we analyzed the number of people who touched the display.

Finally, due to the categorical nature of the data, a chi-squared test was chosen to be performed. The test provided us the opportunity to determine how the frequencies of the observed behaviour occurred by chance or may differ significantly from our expected frequencies.

6.2 Conversion Analysis

By taking advantage of the collected body log data, we categorized passersby into three different groups: 1) passed by: those who spent less than 4 seconds in the area 2) explored: people who stayed in front of the display for more than 4 seconds through all days and in any condition. 3) touched: those passersby who approached the display and touched it. The data for each of these three types of passersby is summarized in Table 6-3 and Table 6-4.

Table 6-3. Conversion analysis raw data by condition and by the three conversion goal categories (passed by, explored, and touched).

Condition	Passed by (number of people)	Explored (number of people)	Touched (number of people)
C1 (direct conation/ proxemics off)	705	101	18
C2 (indirect conation/ proxemics off)	868	138	23
C3 (direct conation/ proxemics ON)	742	95	6
C4 (indirect conation/ proxemics ON)	686	108	9

Table 6-4. Conversion analysis percentage data by condition and by the three conversion goal categories (passed by, explored, and touched).

Condition	Passed by (%)	Explored (%)	Touched (%)
C1 (direct conation/ proxemics off)	100	14.32	2.55
C2 (indirect conation/ proxemics off)	100	15.89	2.64
C3 (direct conation/ proxemics ON)	100	12.80	0.80
C4 (indirect conation/ proxemics ON)	100	15.74	1.31

6.2.1 Attraction Power

For the purpose of measuring that how much the UI design was effective in terms of drawing an unknowing person’s attention (attraction power), we analyzed data based on the number of touches. However, we did not explore the data for glances and assumed that the glances information is merged into explored touch data. Henceforth, we interpreted the attraction power as the conversion from passed by to explored. This gave us the opportunity of three different chi-square tests while the condition 1 (direct conation/ proxemics off) is considered as control group. None of the conditions shown significant impact on the attraction power. The results are as below:

- C1 (direct conation/ proxemics OFF) Vs C2 (indirect conation/ proxemics OFF): χ^2= (1, N=196)=0.55, p=0.45.
- C1 (direct conation/ proxemics OFF) Vs C3 (direct conation/ proxemics ON): χ^2= (1, N=196)=0.54, p=0.46.
- C1 (direct conation/ proxemics OFF) Vs C4 (indirect conation/ proxemics ON): χ^2= (1, N=196)=.404, p=0.52.

6.2.2 Engagement Level

The engagement level in the context of our experiment means how the passersby stayed connected with the UI design. Our interpretation from the engagement level is the conversion between people who explored and people who touched the display. This provides us three tests which compares the explorer and touch data in condition 1 versus all the other three conditions. The test result is consistent with the previous findings in our study and shows that only condition 3 had an impact on engagement level, χ^2=(1, N=196)=4.74, p=.02 where significantly fewer people in Condition 3 (Direct Conation / Proxemics ON) were found to touch the display after stopping to explore it then in Condition 1 (Direct Conation / Proxemics OFF).

6.2.3 Holding Power

The holding power in the context of this research is interpreted as the length of time that each passerby spent in the area of the display. The holding power of each condition was measured by examining the timing data from the body logs collected from the Kinect tracking device. We were only interested in staying occurrence which could be tracked inside log data (Table 6-5). Therefore, no video analysis was done for measuring the holding power.

Table 6-5 Length of stay data for display visitors across conditions.

Condition	Mean length of stay	Standard error	75^{th} percentile
C1 (direct conation/ proxemics OFF)	15.56s	1.29s	21s
C2 (indirect conation/ proxemics OFF)	14.61s	1.05s	18s
C3 (direct conation/ proxemics ON)	18.45s	1.60s	27s
C4 (indirect/ proxemics ON)	18.28s	1.65s	22s

A 2-way Analysis of Variance (ANOVA) was conducted on the timing data across conditions. The test found a main factor effect for Proxemics, as shown by Table 6-6 and Figure 6-1.

Table 6-6. The 2-way ANOVA Test Result

Df	Sum Sq	Mean Sq	F value	Pr (>F)
1	1153	1153.2	5.894	0.0156*

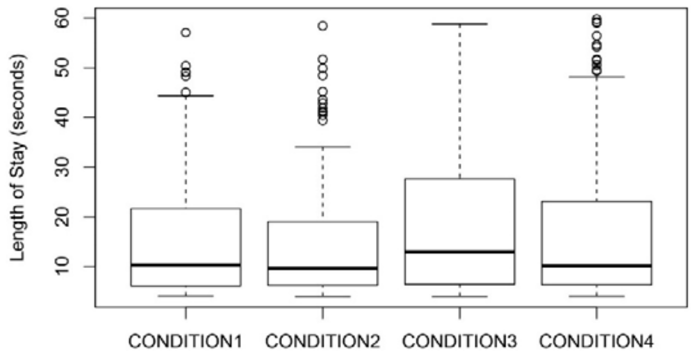

Figure 6-1. Length of stay data for display visitors across conditions.

6.3 Touch Analysis

For the purpose of calculating that how many people were exposed to a certain condition and also had the potential opportunity to touch the display, we took advantage the body log data and the extracted information from video analysis. The results are provided in the Table 6-7.

Table 6-7. Processed number of touch data by the number of people who exposed certain conditions

Condition	Touched	Not-touched
C1 (direct conation/ proxemics OFF)	18	687
C2 (indirect conation/ proxemics OFF)	23	845
C3 (direct conation/ proxemics ON)	6	736
C4 (indirect/ proxemics ON)	9	677

A chi-square was performed and revealed that the choice of condition had an impact on the number of people who touched the display, χ^2=(3, N=56)=10.41, p=.015.

6.3.1 Pairwise Tests

In order to determine which experimental factors influenced touch interaction, we conducted a number of pairwise comparisons with Condition 1 (Direct Conation and Proxemics Off) as this condition represents the common status quo in interaction design for LIDs in public displays (i.e. most LIDs do not respond to proximity and common attempt to entice interaction with direct textual messaging (e.g. Touch Me, or Textual labels on buttons and interface menus). We set up the pairwise Chi-squared tests to determine whether being in Condition 1 or not impacted the touch behaviour. The following three pairwise tests were conducted:

C1(direct conation/ proxemics off) Vs C2 (indirect conation/ proxemics off)
C1 (direct conation/ proxemics off) Vs C3 (direct conation/ proxemics ON)
C1 (direct conation/ proxemics off) Vs C4 (indirect conation/ proxemics ON)

The pairwise chi-square test revealed that only Condition 3 (Direct Conation / Proxemics ON) was found to have a more significant effect on touch behaviour compared to the Control (Condition 1) (χ^2=(1, N=56)=6.7456, p=.009), with passersby being less likely to engage in touch interaction in Condition 3. Other results showed either less significant effect as below:

C1 Vs C2: χ^2=(1, N=56)=0.0142, p= 0.9.
C1 Vs C4: χ^2=(1, N=56)=2.814, p= 0.09.

6.3.2 Testing the Experiment Independent Variables

As it was revealed that being in condition 3 had a significant impact on touch behaviour, we wished to learn the impact of proximity modes (ON/OFF) versus the conation (persuasion) modes (direct/indirect). As proximity was "Off" in conditions 1 and 2 and was "ON" in conditions 3 and 4, therefore, we grouped conditions according to proxemics mode in order to run another pairwise comparison. The test showed that proximity mode had a significant impact on touch behaviour.

However, by grouping condition 1 and 3 (direct conation) and comparing them with conditions 2 and 4 (indirect conation), no significant impact was shown through the chi-square test while χ^2=(1, N=56)=0.65, p=.41.

6.4 Qualitative Analysis of Survey Data

As this current research builds upon the work of Cheung and Scott (2011) and Cheung (2016), we provided our interpretation of the various stages of the discover process by the user.

- **Noticed:** The passersby attention drew to the LID. The characteristic of this state is the user's obvious visual focus, turning head, turning body, continue looking at the display without stopping . Identification of this state is based on the researcher's field notes.
- **Intrigued:** The passerby became curious about the system itself. The characteristics of this state is that the user demonstrates certain reactions to learn about the LID. Such as taking picture and walking around the display. Identification of this state is based on the researcher's field notes.
- **Approached:** The user physically approaches the LID. The characteristic of this state is the user's physical approach to the LID. Identification of this state is based on researcher's field notes.
- **Explored:** The user started intentional interaction with the LID. The characteristics of this state are user playful movement in front of the display, showing different hand gesture to the Kinect, touching different areas which may or may not be touchable, and trying to gather more information about the LID. Identification of this state is based on researcher's field notes.

Part of the information about users who went through initial stages of Discover Model are provided by considering the researcher's field notes as well as online survey results. No deeper analysis including the video analysis was done in order to support these reports.

During the 4 days of field study, the following behaviours were more dominant:

1) Supporting the previous related works, people in group were more interested to approach the display.

2) Although we tried to cover the Kinect by means of black cardboard, users tried to demonstrate various body and hand gesture to in front of the display (Figure 6-2). It seemed that some users were able to detect the Kinect and knew about its function. There were also examples of the users who the checked the technology by walking around and taking picture from it. In many cases, these users did not touch the display and just tried to gather more information about it (based-on the field notes).

Figure 6-2. Some example of users' body and hand gesture in front of the display during the 4 days of field study

3) While all the 35 participants (those who completed the study survey) approached the display, many people did so because of seeing other people were using the display (37 % of participants who answered the survey reported this reason). This shows that LID usage has an impact on social learning which means that people can observe the other people who are using the display and learn how to accomplish certain tasks. This observation may work as an ice breaker activity and also help the LID usage to increase. More information in this regard are provided in Appendix E.

5) In many cases through group exploration, an individual leader would start different movement (body and hand gesture) and other users tend to observe the visual feedback. However, where group of people included just two persons, they would either touch the display simultaneously or invite each other to touch the display and explore possible feedback.

Below, the video data of two male users' conversation is provided. These users were uncertain about the LID function and started to invite each other to explore the display:

"touch it! No…you touch it!"
"I did"….is it a Kinect? Playing with bike…?"
"what is in the screen?"
"Touch it! I pressed the night light!"
"I pressed the PAC! Did you press the bus? No I didn't…wait…"

6.4.1 Initial Impression

One key aspect that we wanted to learn about was about the initial impression of the display. It can be interpreted about the first important piece of the information which may attract the passersby to stop by or start exploring the provided data. As reported in the online survey, most of the participants had a background knowledge about LIDs, it is not surprising that 18 participants reported the physical display device caught their attention. As we expected, colourfulness was another key factor which could work effectively in the neutral space of the E5 building and 14 of the participants were attracted to the display due to the colourfulness of visual content. Other ranked elements can be found in Appendix E.

An interesting finding is that some of the participants were attracted to the display because the display looked unfamiliar in the E5 setting. For instance, participant 9 and 28 reported noticing the display because the of the placement of LID which looked very unusual to them.

Participant 9: "Not normally placed here".
Participant 28: "It was not there yesterday".

6.4.2 Detected Interactive Elements

As the interface design was included various signifiers to imply the sense of interactivity, it is reported by 94.29% of the users that they successfully recognized the interactivity of the display. The remainder of participants were not sure about the display responsiveness and interactivity.

Within the interface design framework in this research, it was expected that the moving objects would be the key element that imply the idea of interactivity. However, based on the reported answers, button-like objects were ranked first (51.43%) in term of delivering this message. This can indicate that 1) participants were able to recognize the button-like objects which looked like books inside a library shelf and 2) the participants have transferred their knowledge from graphical user interfaces (GUI) on personal computers in order to read the interface or explore the information visualization. Other ranked items are provided in Appendix E.

It is worth noting that participant 14 had learned about the display interactivity as the books were responding to his presence. In order to answer the question: "What interface element(s) made you think the display was, or might be, interactive?" He explained his experience as below:

> **Participant 14:** "books opened when I walked by".

This suggests that participant recognized the interactively by means of moving objects. However, his explanation indicates that during the proxemics condition, he was able to relate the corresponding movement of the moving objects to his own body movement in front of the display.

The participants were also asked to explain certain movements to which they thought the display was responding. Amongst the 21 responses to this question, the animation effect (tilt), pop-up bubble, and buttons were reported. Some of the open-ended answers that are provided by the participants are as below:

> **Participant 14:** "books opened when I walked by"
>
> **Participant 16:** "touch, responded by opening a link"
>
> **Participant 17:** "pressing the button. it opened a pop-up when I pressed the button."
>
> **Participant 19:** "With a pop-up box"

Participant 20: "the books tilted in my direction"

6.5 Icon Touch Analysis

Although it was not in the scope of our study, we were interested to learn more about symbol touches. As each of the chosen visual symbols were drawn from the contextual references from the experiment environment, we investigated the symbol touches to learn about possible behaviours of passersby in the public spaces. Therefore, the following symbols touch table was provided (Table 6-8).

Table 6-8. Number of Touches by Icons

Art gallery	**Nightlife**	**Health services**	**PAC**	**Bus stops**	**Game events**	**Coffee shops**	**Study spaces**	**Campus tour**
59	44	53	83	61	70	61	51	35

The goodness –of-fit revealed that the number of touches is not equally distributed. Hence, we investigated if passersby touched symbols based on their placement in the middle or the edges of the screen. This was called central/ peripheral effect. Since there were 5 symbols on the middle books and 4 on the edges books, we assumed that 5/9 of the touches were in the centre of the display and 4/9 of the touches were in the edges. The test result showed that passersby touched the symbols (books) in the centre more while χ^2=(1, N=517)=13.02, p=.0003.

6.5.1 Regression Analysis of Touches on the Coffee Icon

Through the analysis, we tried to explore data about the association of time and touching certain symbols. For instance, we were wondering about touch paradigm of coffee symbol before and after noon. Hence, we grouped all the touches on the coffee ideographic icon as well as photographic image based on the experiment timing. As mentioned earlier, the first hour was from 11:00am until 12:00. The second hour was from 12:00 pm until 1:00 pm and so forth. For this purpose, we just took advantage from the touch log data (touches on coffee) and no further video analysis was done for this test.

The regression analysis shown no significant association between time and symbol touches.

An observational study was conducted to impact of proxemics mode (ON/OFF) versus various conation mode (direct/ indirect) on enticing passersby's attention. Based on analysis of this study data, our interpretation from interaction model proposed by Cheung and Scott (2013) and Cheung (2016) provided which outlining the states that study participants transitioned through. Data analysis focused on testing the independent variables and their impact over the users behaviour as well as their transition through different stages of discover model. This analysis revealed differences across proxemics modes over the engagement level of the participants. By analyzing the results of online survey it revealed that the physical display device ranked first amongst all other factors which enticed the passersby attention. Also, the button-like objects was the most important cue that communicated the concept of interactivity.

6.6 Chapter Summary

In this chapter, we reviewed the quantitative and qualitative analysis of collected data during the 4 days of field experiment. We explained how we classified the passersby and condensed body and touch log data. We provided results conversion analysis, touch analysis and various pairwise tests which helped us to learn about the impact of independent variables. In the second half of this chapter, we explained about the analysis of survey data. Finally, we focused on other findings such as icon touch analysis. In the chapter, we will argue our main findings and discuss about the main things which we learned through this research.

Chapter Seven

Discussion

This chapter summarizes the results and discusses the findings which were presented in the previous chapter. We will argue how we addressed different communication function through taking advantage of animated visual effects. We also provide some of the lessons that we learned which might be helpful for the future UI design for the LIDs.

7.1 Addressing the Conative Function through UI Design

Through the implementation of our experiment, we studied two different sets of visuals for the purpose of comparing two various conation (persuasion) modes. Our findings revealed that the conation mode had less effect on the passersby engagement or touching behaviour. Through the online survey it was reported that the participants were mainly and initially fascinated by means of the technology itself. Although around 95% of the participants had the experience of using a LID in a public setting, still this novel technology may prevent the user to go through deeper layers of the interpretation process. Survey participants reported the main recognized visual elements to be the bookshelf, books and the bike (Appendix E). This can be interpreted as the most important pieces of information to the participants were the things that could be recognized in a sudden glance. The passersby who were walking inside the deployment environment had successfully read the big picture. However, when it came to reading the detailed content which was provided inside the information visualization, the interpretation process appeared to fail. These findings guided us with several lessons:

We learned that LID as a channel of transferring information is quite different from other static medias such as poster. Due to the novelty effect, the LID technology may prevent the passersby to go through deeper layers of interpretation process or read referential visual elements. Therefore, less detailed animated information visualization which can communicate the wanted messages in a shorter time span may be more effective if we intend to use proxemics-based animation.

Although our study research showed no main effect difference between direct and indirect persuasion techniques, still various animation effect served as a persuasive element which enticed the passersby attention. This can be argued that the passersby initially recognized the moving objects (cognition). In the next state, they approached the display which suggest that the participants were positively affected. The prior mental states (cognition and positive affection) led them to react to the display. Hence, we can argue that animated visual effects were successfully addressing the conative function in order to persuade and convince the users to start exploration. Here the lesson is that, in order to address the conative function of the communication for a novel interactive media, more visible interactive or even playful messages are required. We learned that detailed information might be useful in case the user is very close to the display (personal zone) and is not afraid to spend enough amount of time to read the content. However, if we are supposed to persuade a user to move towards the display, randomized animated feedback can address the conative function better than detailed visuals.

7.2 Randomized Animated Visual Elements

In this research we provided three levels of animation for revealing information which including the tilt effect, book opening, and pop-up bubbles. Our findings through statistical analysis and from reported results in the online survey emphasizes that proxemics-based animation led to significantly less touch interaction than randomized animations. However, randomized step by step animation was found to help catch the attention of passersby. One interpretation could be that proxemics-based animation may call for certain action which should be taken by the user. However, randomized animation effect is following a self-revealing strategy and assist the uncertain users to feel more confident in terms of confronting with the system. Another possible interpretation is that static elements of the interface which do not change through different distances or through time span cannot be sufficiently salient to win other environmental stimulus. If we want to compare the LID design with a poster design, in the former one the experienced user expects to see some visible and instant feedback. In a poster, the user does not expect any feedback. The users' expectation is to take some information in a specific amount of time by standing in front of the poster in distance. However, in an interactive LID, we need to meet the following requirements:

1) Provide instant signifiers to imply the idea of interactivity. Although they can be static, still they need to be salient and visible even in the distanced zones.
2) Define a specific animated behaviour for the system. This helps us to address the phatic function of the communication. To provide an example, if someone says "Hi" to another person, it is very probable that the receiver of the message responds to it. This means that the word "Hi" behaved as a bridge to connect the first person to the next one and have activated the channel of communication to address the phatic function. In our research, the randomized animated effects behaved as the word "hi" and has activated the channel by enticing users' attention.

7.3 Comparing with the Findings of the Motivational Study

As this study was inspired by the research conducted by Cheung and Scott (2013) and Cheung (2016), here we tended to compare our findings with their motivational study. In their research, they investigating the impact of adaptive shadow, adaptive speed, and adaptive trajectory while each item was changing according the user's movement from one zone to another zone (perpendicular to the LID). The researchers argue that based on the analysis of the collected data, it was revealed that proxemics-based adaptive speed and adoptive shadow had significant effect on enticing users' attention and intriguing sense of curiosity (Cheung and Scott, 2013; Cheung, 2016). However, in our research, self-revealing systems design was more effective in term of persuading the users to become engaged with the display and the proxemics-based conditions were less effective. One explanation might be the detailed information visualization which was designed for this current study. In our study, the UWaterloo Community Application looked like a high-fidelity product which may imply this idea that the user needed to learn about its different functions to be able to use it. Our application was able to invoke some playful behaviour and it seemed during the observation that many were interested to show different body gestures. However, for an application which looks like a final product, it seems that randomized animation effect had more success in terms of teaching the users about different layers of information inside the UI. Our understanding is that, if the UI design details increases, we need to put more effort on designing self-revealing system in order to assist both cognition and generating positive-affection. However, simplified interface design UI design may look less intimidating and work better for proxemics-based systems design.

7.4 Chapter Summary

In this chapter, we discussed some of the learned lessons through conducting this field experiment. We argued how the animated UI design may help to obviate the conative function of communication. We also explained the impact of randomized animated visual effects. Finally, we compared our findings with our main motivational study.

Chapter Eight

Conclusion and Future Work

Being inspired by the studies conducted by Cheung and Scott (2013) and Cheung (2016), as well as the Symbolic Interactionists notions, and several communication functions from the field of Communication Studies, this thesis focused on the following research objectives:

- Investigating potentially relevant concepts on persuasion and engagement from the field of Communications Studies
- Utilizing the identified concepts from the related literature to design potential LID interfaces to attract and engage passersby in a public setting
- Validating our design by running a field study in a public setting.

To do so, we investigated two independent variables in the context of a field experiment which are included:

1) Proxemics-based versus randomized information revealing techniques: we provided various animated elements which could reveal information in three different layers. In the proxemics-based conditions, the information was revealed based-on the distance of passersby and their location on the three identified zones in front of the display. In the randomized conditions, the animated effect was functioning automatically and were not linked to the distance of user from the display.
2) Indirect versus direct conation modes: Since one of the main goals of this study was to investigate persuasive messages, we adopted design concepts from the study conducted by McQuarrie & Phillips (2005) that investigated two different sets of indirect and direct visual stimuli. For the indirect visual stimuli, various ideographic icons which were inspired by DOT pictograms were designed for the three levels of revealing information. For the direct visual stimuli, the ideographic icons were replaced with realistic photographic picture.

Our findings revealed that, for our specific study, the randomized information revealing technique was significantly more effective than the proxemics-based information revealing approach on enticing the passersby attention. This result suggests that for novel technologies such as LID, self-revealing systems design can assist the users to feel more confident. We also learned from the online survey that the users can visibility recognize the big picture but may not go through interpretative process of more detailed visual elements especially when the distance from the LID increases. Other investigated variables had no significant effect on persuading the passersby to become engaged with the LID.

8.1 Contribution

This thesis contributes a number of concepts and empirical results to the field of human-computer interaction, and more specifically, to the sub-area of designing large interactive displays for public contexts. First, to our knowledge it provides the first direct investigation of LID interfaces that explicitly incorporate an “indirect conation” or “indirect persuasion” approach to the design of public interfaces to attempt to persuade a passerby to stop and engage with the display. Moreover, our investigation studied the “indirect conation” design approach with the “proxemic interaction” design approach that has been used in prior public LID studies. Corroborating prior work, our study contributes additional evidence of the “holding power” of LIDs that employ the proxemic interaction approach. Similarly, our study also corroborates Cheung’s (2016) prior observation that while proxemics-based LID interfaces can engage passersby for longer periods of time, this additional time does not necessarily translate into effective interaction (i.e. touching the display in our case).

Although the study did not find a strong main effect of the Indirect Conation condition, the triangulation of the different study data (Conversation analysis based on the “zonal” data derived from the body tracking logs, and the Holding Power analysis based on length of stay data derived from the body tracking logs), provides some evidence that the indirect conation design approach combined with the proxemic interaction design approach may provide some level of persuasion on passersby’s behaviour to help them effectively interact with the display. The study results showed that, when proxemic interaction was enabled, more passersby who experienced the indirection conation interface touched the display than those who experienced the direct conation interface. Yet, the same difference in touch engagement did not occur in the non-proxemic condition. This suggests an interesting potential for interaction between these design approaches that warrants further study.

8.2 Future Work

This research suggests a number of opportunities for further investigation:

1) Our findings demonstrate that passersby may fail to notice the details of the UI. Hence, we suggest the investigation of more minimalistic visualizations. As the system is quite dynamic and is not a static poster, we still need to learn about the amount of visual details which can be read and accepted by the public.
2) Another main finding of this thesis is that self-revealing systems design may encourage the user to become engaged with the LID. Our interpretation is that the system may intuitively teach the users about certain tasks. Hence, there is a possibility that the user feels more confident to take intended actions. Our suggestion is that self-revealing systems design become embedded with the idea of teaching about needed actions in subtle ways. Future work, can be focused on the way that we can indirectly teach the user to follow step by step action through the message delivering process.
3) We also suggest investigation on the appropriate timing of various layer of self-revealing information for various deployment environments. More traffic does not mean that we should be in rush in terms of delivering information. Various deployment settings should be considered for the purpose of timing the layer of dynamic information. The amount of layers and the appropriate timing for a LID which is deployed in a waiting room of a hospital may not work for a LID that is deployed in an airport.
4) Finally, we argued some of the main functions of message communication and focused on only one of them. For the future work more attention should be payed to the other functions. This may assist us to learn more about human interactions and open doorways through designing more intuitive interactive UIs.

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Appendix A

Sunlight Direction and Its Effect on LID in E5 Building

Since the building has an all-glass facade, it has floor-to-ceiling glass windows in the area of the building selected for the study. Thus it can easily reflect the sunlight and interfere the vision.

Figure A-1. Left: A non-interactive display in E5. Right: Sunlight effect on the visibility of the non-interactive display: floor to ceiling windows in the building can reflect the sunlight on the display and makes an interfering silhouette of the user on the screen.

Figure A-1 shows a display that is permanently installed in E5 building to showcase non-interactive information and as can be seen the sunlight direction in interfering the passersby vision. As it is shown in the picture (Figure A-1), the content of the display is not visible due to the sunlight direction.

The sunlight also creates a solid shadow of the user which can visibly block the process of transferring messages via the display. The provided pictures were taken during summer around 6:00 p.m. and as it is shown, the sunlight effect causes that the currently installed screen in E5, reflect the building and the outer space just like a big mirror.

Appendix B

Generating Frame by Frame Visualization for Three Identified Zones

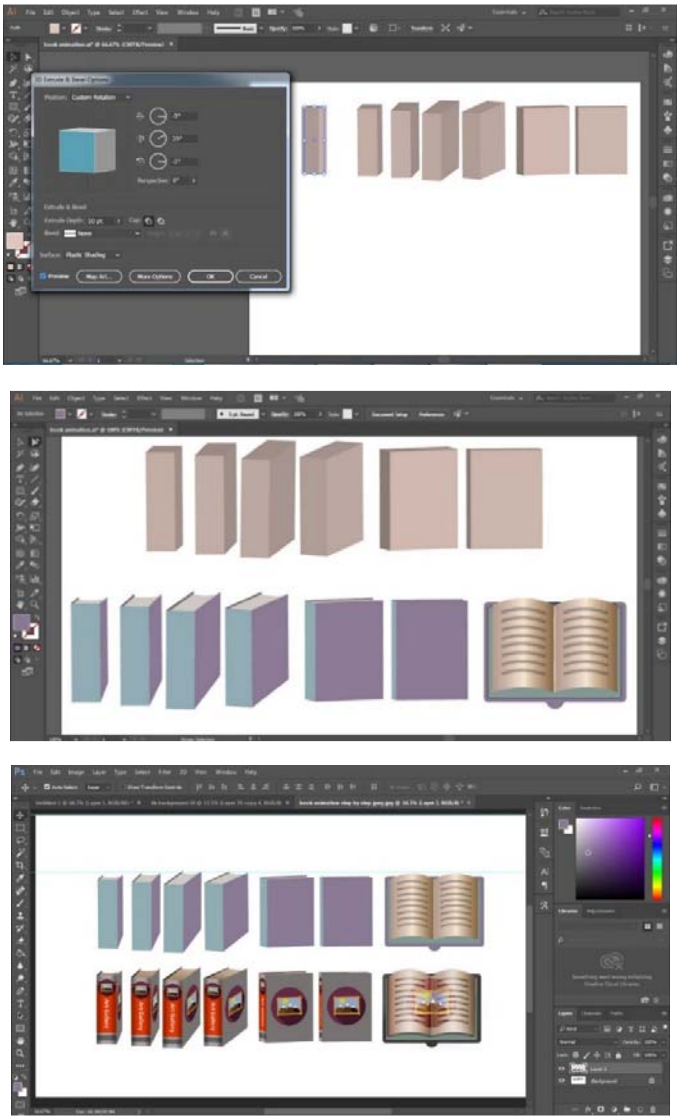

Figure B-1. Frame by frame visualization for three identified zones

Appendix C

Digital Information Letter and Consent

UNIVERSITY OF WATERLOO

Research Study Participation Invitation

For fulfillment of the
thesis requirement for the degree of
Master of Applied Science
in
Systems Design Engineering

Title of Project: Investigating Attraction of Animation on Large Displays in a Public Setting

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Summary of the Project:

Large interactive displays capable of delivering dynamic content to broad audiences are becoming increasingly common in public areas for information dissemination, advertising, and entertainment purposes. A major design challenge for these systems is to entice and engage people passing by the display to interact with the system. This project aims to investigate the effectiveness of different graphical animations and visual interface designs to attract people's attention and engage them in interactions with public large displays. To better understand the different visual designs being tested during our field study, we will gather feedback in the form of a short survey completed by people who have passed by and/or engaged with the display and ask about their experiences viewing or using the display.

Procedure:

Your participation in this study will involve completing an electronic survey on the provided digital tablet regarding your perceptions of the various visual and animated design elements you may have noticed or interacted with on the display.

Completing the survey will take approximately 10-15 minutes.

You may decline to answer questions if you wish. You may withdraw your participation at any time without penalty by advising one of the student investigators.

You must be 18 years old or older to participate in this study.

Risks, Benefits, and Renumeration:

There are no known or anticipated risks from participation in this study. Also, there are no direct benefits to you for participating in this research. However, the results of this research may contribute to the knowledge base of Human Computer Interaction research and to lead to the development of improved usability and effectiveness of future interactive large displays deployed in public settings.

In the appreciation of the time you have given to this study, you will receive a $5 on-campus retail vendor gift card. The amount received is taxable. It is your responsibility to report this amount for income tax purposes.

Confidentiality and Data Security:

All information you provide is considered completely confidential. Your name will not appear in any publication resulting from this study; however, with your permission anonymous quotations from any free-form textual answers you provided may be used. In these cases, participants will be referred to as Participant 1, Participant 2, … (or P1, P2, …). Data collected during this study will be retained for a minimum of five years in locked drawers or on password protected computers in a secure location accessible only to researchers associated with this project. Electronic data will be de-identified before being stored. Survey data collection will be conducted using the SurveyMonkey® online survey tool (www.SurveyMonkey.com)

You will be explicitly asked for consent for the use of your survey responses for the purpose of reporting the study's findings. If consent is granted, these data will be used only for the purposes associated with teaching, scientific presentations, publications, and/or sharing with other researchers and you will not be identified by name.

Contact Information and Research Ethics Clearance

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 20740). However, the final decision to participate is yours. Should you have any questions for the Committee please contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions or if you would like additional information to assist you in reaching a decision about participation, please ask one of the student investigators now. Also you may contact one of my supervisors, Prof. Stacey Scott, (Computer Science Dept. University of Guelph) email: stacey.scott@uoguelph.ca, or Prof. James Wallace, (Public Health and Health Systems, University of Waterloo) email: james.wallace@uwaterloo.ca.

Thank you for your assistance in this project.

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

Project: Investigating Attraction of Animation on Large Displays in a Public Setting

I have read the information presented in the information letter about a study being conducted by Mojgan Ghare of the Systems Design Engineering at the University of Waterloo conducted under the supervision of Professors Stacey Scott (Computer Science Dept. University of Guelph) and Dr. James Wallace (Public Health and Health Systems, University of Waterloo). I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I may allow data from my completed survey to be included in presentations and publications related to this project, with the understanding that any quotations will be anonymous.

I am aware that I may withdraw my consent for any of the above statements or withdraw my study participation at any time without penalty by advising the researcher.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# ORE# 20740). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact Mojgan Ghare (mojgan.ghare@uwaterloo), Dr. Stacey Scott (stacey.scott@uoguelph.ca), or Dr. James Wallace (james.wallace@uwaterloo.ca).

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.	**YES**	**NO**
I agree to let my survey responses during the study be directly quoted, anonymously, in presentation of the research results.	**YES**	**NO**

Appendix D

Log Data and Statistical Results

Table A-1. Body log data collected during the four days of field study

BODY LOG	C1: Direct/Off	C2: Indirect/Off	C3: Direct/ON	C4: Indirect/ON	Total
Day 1	570	561	261	489	1881
Day 2	426	961	733	224	2344
Day 3	200	305	373	618	1496
Day 4	429	429	429	275	1562

Table A-2. Touch log data collected during the four days of field study. (TA: Touch Area, NTA: Not Touch Area).

TOUCH LOG	C1: Direct/Off		C2: Indirect/Off		C3: Direct/ON		C4: Indirect/ON	
	TA	**NTA**	**TA**	**NTA**	**TA**	**NTA**	**TA**	**NTA**
Day 1	52	55	49	3	6	3	16	5
Day 2	14	2	105	154	27	4	10	0
Day 3	2	7	27	54	0	0	31	31
Day 4	140	201	19	15	2	0	0	0

- **Chi-Square Tests of Experimental Conditions**

  Test of touch logs: χ^2=(3, N=56)=13.28, p=0.004.

  Test of body logs: χ^2=(3, N=56)=13.28, p=0.015.

- **Conditions Tested Against Condition 1 (control group)**

  C2: χ^2=(1, N=56)=0.014, p=0.09.

  C3: χ^2=(1, N=56)=6.745, p=0.009.

  C4: χ^2=(1, N=56)=2.814, p=0.09.

- **Tests on Independent Variables**
  - **Proximity On/Off:** χ^2=(1, N=56)=9.89, p=0.001.
  - **Direct conation Vs Indirect Conation:** χ^2=(1, N=56)=0.65, p= 0.41.

- **Chi-squared Test on Symbol Touch Distribution**

  χ^2=(1, N=517)=27.57, p=.0005.

- **Icon Touch Analysis (5 Symbols in Middle Vs 4 Symbols Close to the Edges)**

  More touches on the symbols in the middle: χ^2=(1, N=517)=13.02, p=.0003.

- **Attraction Power Analysis**

C1 (direct conation/ proxemics OFF) Vs C2 (indirect conation/ proxemics OFF): χ^2=(1, N=196)=0.55, p=0.45.

C1 (direct conation/ proxemics OFF) Vs C3 (direct conation/ proxemics ON): χ^2=(1, N=196)=0.54, p=0.46.

C1 (direct conation/ proxemics OFF) Vs C4 (indirect conation/ proxemics ON): χ^2=(1, N=196)=.404, p=0.52.

- **Engagement Analysis**

C2 (indirect conation/ proxemics OFF): χ^2=(1, N=196)=0.038, p=.084.

C3 (direct conation/ proxemics ON): χ^2=(1, N=196)=4.74, p=.02.

C4 (indirect conation/ proxemics ON): χ^2=(1, N=196)= 3.21, p=.07.

- **Holding Power**

Table A-3. Length of stay data for display visitors across conditions.

Condition	Mean length of stay	Standard error	75^{th} percentile
C1 (direct conation/ proxemics OFF)	15.56s	1.29s	21s
C2 (indirect conation/ proxemics OFF)	14.61s	1.05s	18s

C3 (direct conation/ proxemics ON)	18.45s	1.60s	27s
C4 (indirect/ proxemics ON)	18.28s	1.65s	22s

Table A-4. The 2-way ANOVA Test Result

	Df	**Sum Sq**	**Mean Sq**	**F value**	**Pr (>F)**
Proxemics	1	1153	1153.2	5.894	0.0156*****
Conation	1	36	36.3	0.186	0.66
Interaction	1	16	15.5	0.07	0.778
Residuals	411	80412	195.6		

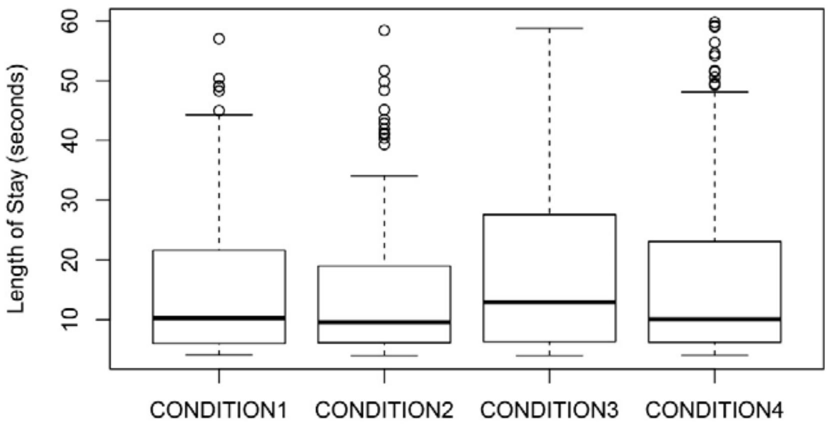


Figure A-2. Length of stay data for display visitors across conditions.

- **Regression Analysis of Touches on the Coffee Symbol**

Table A-5. Number of touches on coffee symbol

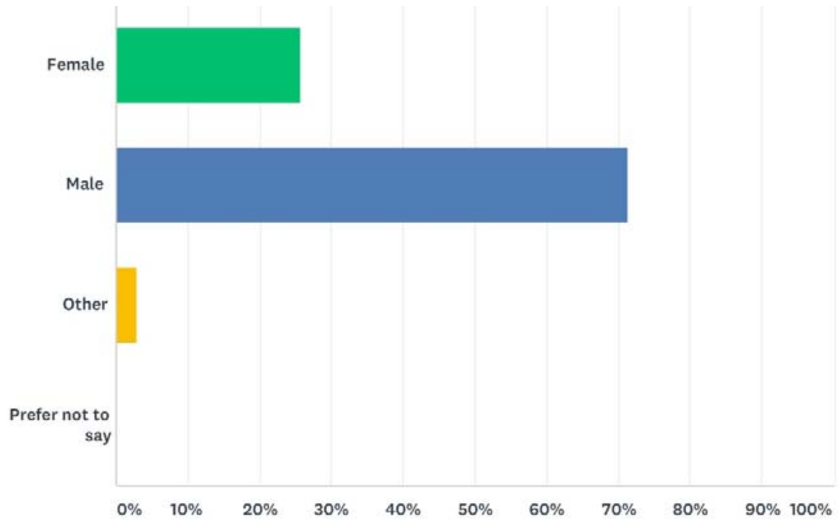
First Hour	**Second Hour**	**Third Hour**	**Fourth Hour**
45	1	13	2

$F_{1,2} = 2.34$, $p > .05$.

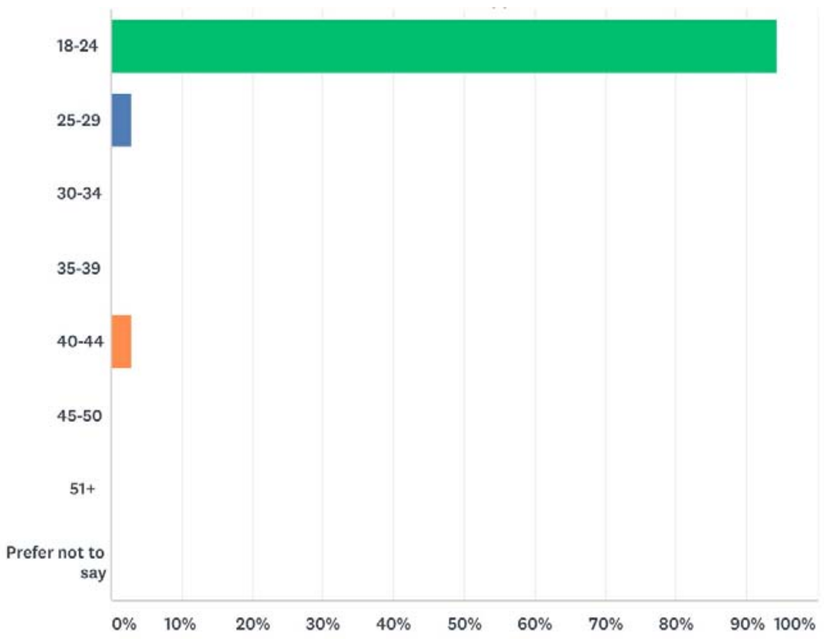
Appendix E

Online Survey Results

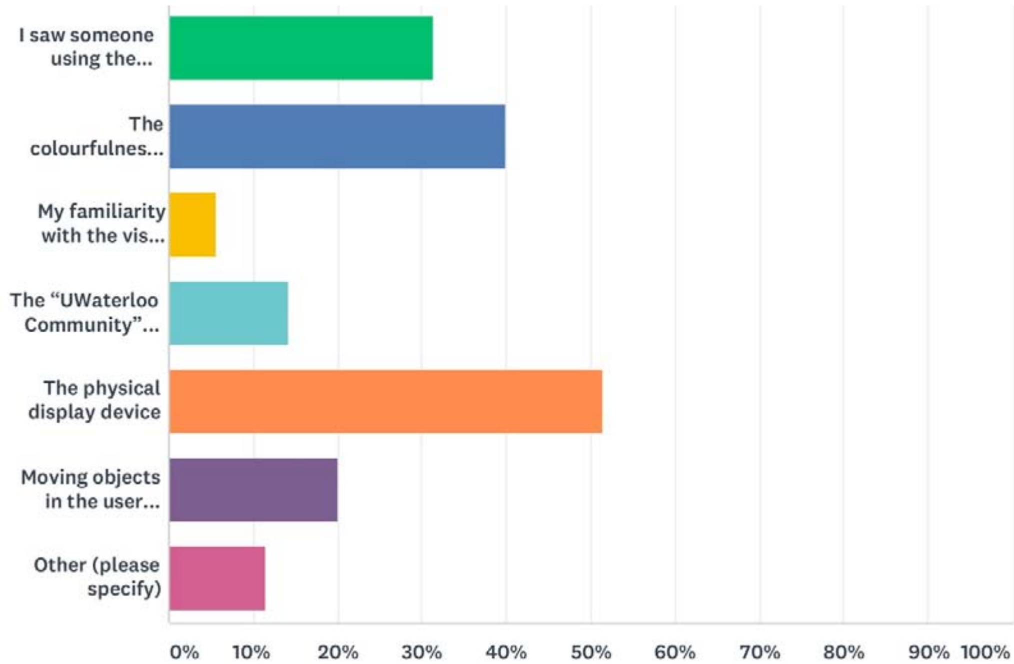
Q3. What is your gender?



Q4. What is your age?



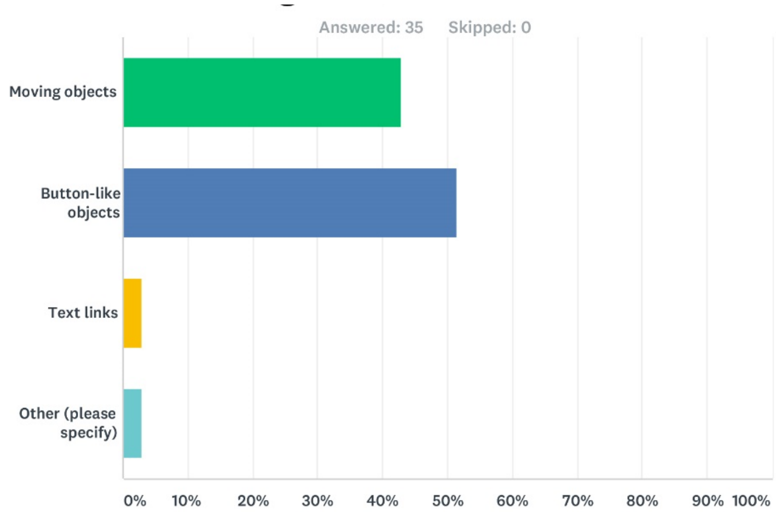
Q6 What initially drew your attention to the display? (Select all that apply)



Answer Choices	Responses	
I saw someone using the display	31.43%	11
The colourfulness of visual content	40.00%	14
My familiarity with the visual content	5.71%	2
The "UWaterloo Community" title	14.29%	5
The physical display device	51.43%	18
Moving objects in the user interface	20.00%	7
Other (please specify)	11.43%	4
Total Respondents: 35		

#	Other (please specify)	Date
1	Not normally placed here	2/16/2017 2:50 PM
2	i designed a few of the pcbs in this model	2/15/2017 3:34 PM
3	it wasnt there yesterday	2/14/2017 3:15 PM
4	looked cool	2/14/2017 2:47 PM

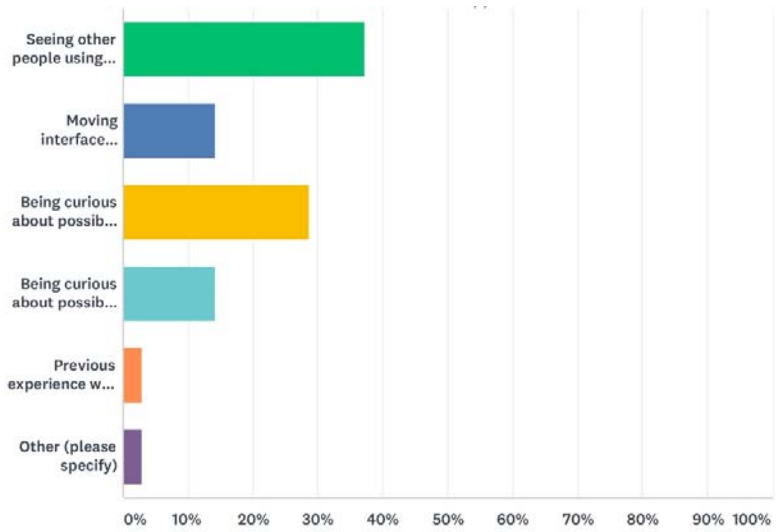
Q8. What interface element(s) made you think the display was, or might be, interactive?



Answer Choices	Responses	
Moving objects	42.86%	15
Button-like objects	51.43%	18
Text links	2.86%	1
Other (please specify)	2.86%	1
Total		35

#	Other (please specify)	Date
1	books opened when i walked by	2/15/2017 12:59 PM

Q10. What encouraged you to approach the display?



Answer Choices	Responses	
Seeing other people using the display	37.14%	13
Moving interface objects	14.29%	5
Being curious about possible information I could get	28.57%	10
Being curious about possible changes in the interface	14.29%	5
Previous experience with knowledge about large interactive displays in public settings	2.86%	1
Other (please specify)	2.86%	1
Total		35

#	Other (please specify)	Date
1	i was describing what i worked on to my friend	2/15/2017 3:34 PM

Q12. To what movements do you think the display responded, and how did it respond?

#	Responses	Date
1	when in front of it the books moved	2/17/2017 1:23 PM
2	walking up	2/17/2017 12:29 PM
3	to tapping on the books, the marker feature did not work	2/17/2017 12:17 PM
4	touching buttons	2/17/2017 12:15 PM
5	when I tapped the book icon on the screen, some words showed up besides the book.	2/16/2017 1:51 PM
6	My touch..the objects started moving	2/16/2017 12:14 PM
7	hand movements, button clicks. It was fairly responsive.	2/15/2017 3:35 PM
8	to touching the screen. it responded pretty well.	2/15/2017 3:12 PM
9	the books tilted in my direction	2/15/2017 3:12 PM
10	With a pop-up box	2/15/2017 3:09 PM
11	pressing the button. it opened a pop-up when i pressed the button.	2/15/2017 3:02 PM
12	touch, responded by opening a link	2/15/2017 3:01 PM
13	books opened when i walked by	2/15/2017 1:01 PM
14	button pressed	2/15/2017 12:25 PM
15	It responded to me touching the screen.	2/15/2017 12:25 PM
16	The display responded to touch	2/14/2017 3:12 PM
17	not sure	2/14/2017 2:49 PM
18	buttoms	2/14/2017 2:48 PM
19	touch	2/14/2017 2:46 PM
20	touch	2/14/2017 2:45 PM
21	pops out information when touching	2/14/2017 1:49 PM

Q16. How did you expect the display to respond to your touch?

#	Responses	Date
1	books open	2/17/2017 1:23 PM
2	i expexcted the objects to move	2/17/2017 12:29 PM
3	like it did	2/17/2017 12:17 PM
4	new window would open	2/17/2017 12:15 PM
5	with pop up options	2/17/2017 12:14 PM
6	there was a simple icon of book, i thought it would shown more information about the book icon if i tap it, and it did show something as expected.	2/16/2017 1:52 PM
7	The look of the screen	2/16/2017 12:15 PM
8	It was clearly an interactive display, so I expected some visual response to happen in response to my touch.	2/15/2017 3:36 PM
9	by opening new windows.	2/15/2017 3:12 PM
10	more info shown when tapped	2/15/2017 3:12 PM
11	With some sort of visual feedback	2/15/2017 3:09 PM
12	i expected the display to pop-up a window	2/15/2017 3:02 PM
13	did not expect response	2/15/2017 3:01 PM
14	button pressed	2/15/2017 12:25 PM
15	I thought it would open rhe book to show information	2/15/2017 12:25 PM
16	New information would be displayed	2/14/2017 3:12 PM
17	button open new menus	2/14/2017 2:49 PM
18	good	2/14/2017 2:48 PM
19	pop ups	2/14/2017 2:47 PM
20	by just opening up a new window	2/14/2017 2:45 PM
21	some information pops up	2/14/2017 1:49 PM