Understanding the relationship between signage and mobile map for indoor wayfinding

Young Ju Cho

Iowa State University
Understanding the relationship between signage and mobile map for indoor wayfinding

by

Young Ju Cho

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Program of Study Committee:
Paul Bruski, Major Professor
Lisa Fontaine
Jennifer Margrett

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ABSTRACT

Wayfinding, a fundamental task in daily life, becomes more complicated and difficult with greater development of a society. People can become lost and frustrated by being disoriented in complex built environments.

This study investigates the effect of combining a physical wayfinding system with a digital device on users’ wayfinding performance in a building with architectural complexity. Through exploring the combined use of signage and the Google Indoor Map, the study provides information on their interactivity, effectiveness and reliability for use in a wayfinding system that may increase understanding the design of well-functioning wayfinding systems.

Twenty participants ranging widely in age were divided into four groups, which performed under different combination of four variables: existing signage, newly-designed prototype signage, and combination of the Google Indoor Map with the two signage systems. The task was to find three given destinations: Bookends Café, Tier 5 and CELT.

When video recordings of the participants’ wayfinding behavior during the three tasks were reviewed and the post-survey after the task was analyzed, the limitations of using the Google Indoor Map as an interactive wayfinding aid were revealed and the significant role of physical sign system was reinforced. The study discussed these findings and suggested future directions for the combined use of physical signage systems with digital aids to improve the quality of the wayfinding experience for users.
CHAPTER 1. OVERVIEW

1.1 Introduction

Interdisciplinary research on wayfinding, for the purpose of aiding human navigation, has been performed for several decades. The approach of graphic designers to improve wayfinding has often been carried out in collaboration with professionals in other disciplines, such as architecture, human-computer interaction, environmental psychology and human behavior, with the specific area of interest of solving recurring problems in wayfinding in given environments (Hunter, 2010).

Although wayfinding tasks might be viewed as simple and fundamental activities, they have become more complicated with advances in society and the complex infrastructure that accompanies urbanization. People in developed countries now spend up to 90% (NHAPS 28) of their time indoors, and attempts to incorporate all facilities in multi-story buildings or add new buildings to old ones increases the complexity of buildings’ structures. These facts make it necessary to develop efficient ways for people to reach targeted destinations. For example, in hospitals, train stations, and college buildings, extensions added onto older buildings could make it challenging to find desired destinations, and in multi-level buildings, vertical movement through the building, each floor of which may consist of small, fragmented spaces, could seriously impact wayfinding performance.

From the point of view of graphic communication, signage plays a key role in conveying messages and supporting the process of decision making in wayfinding activities. With signage as the backbone of a system, digital technology systems such as mobile applications, virtual
reality systems, and computational models can be applied to help ensure that user experiences are positive and to make the wayfinding process more effective and efficient.

Development of a well-established wayfinding system for providing navigational assistance that offers high-quality user experience in a building can be approached in numerous ways. The recent advent of a mobile navigation service for a built environment, such as Google Indoor Maps, enables users to see how to get to a destination in a building in advance and provides real-time feedback on the pathways to destinations. However, although the service provides convenience through its portability, it still has problems of user experience, behavioral strategies, and spatial learning processes related to digital indoor maps. Many devices appear to have been designed without considering potential barriers, such as complicated menus with high demand of memory, inappropriate interaction techniques, and metaphoric symbols.

In addition, according to Chris Calori in her book *Signage and Wayfinding Design*, technological obsolescence and resource depletion will make it unlikely that digital information systems will be able to replace physical signs completely (Calori, 2007). Even though GPS technology and tools can provide accurate guidance from a point to a destination, they do not give information on the surrounding passive environment, which may cause people to get lost. In addition, physical signage is preferable over digital systems in terms of permanence of locations. Thus, both passive and active wayfinding will probably still be indispensable for indoor navigating in the future. Combining conventional media such as static signage with the dynamic responses of digital information systems may provide synergistic effects.

In this study, both of these wayfinding systems were compared and combined with regard to effectiveness of human interactions with a given environment. The effect of signage design on wayfinding when signage is used together with a digital information system was also
investigated. The methodology was developed in the Parks Library at Iowa State University. The library contains many features that commonly cause wayfinding problems, such as architectural features, graphic system and sign placement. Also, the library provides the Google Indoor Map as another wayfinding tool. Twenty participants were divided into four groups and tested with wayfinding systems having different variables. Groups A and B were tested with the original signage system, and group B was asked to use the existing signage system along with a mobile Google Indoor Map. The two other groups, C and D, performed wayfinding tasks using the prototype signage system, with the addition of the Google Indoor Map for Group D. Through real-world observations, participants’ wayfinding performances were analyzed to identify the influence of wayfinding cues such as signage and mobile map.

Understanding of relationships among space, users’ spatial behavior, physical information systems, and assistive digital devices are the focus in increasing effectiveness of wayfinding systems. Correa de Jesus pointed out, “Environmental communication for wayfinding can be described as a dynamic relationship involving spaces, users and forms of representation,” indicating that consideration of the environment, users and the devices used for communication will allow for effective design of helpful tools for wayfinding (de Jesus and Sergio, 1994).

Wayfinding research has been conducted in various disciplines such as architecture, interior design, environmental psychology and human-computer interaction; the recent introduction of various digital aids as wayfinding tools potentially makes our daily tasks of navigation easier. However, few research projects have investigated how conventional wayfinding systems effectively work with digital aids such as the Google Indoor Map in the physical world, or which such combinations are beneficial to users.
Through exploring the relationship of signage and a digital map such as the Google Indoor Map, the study sought to investigate their interactivity, effectiveness and reliability of the combination of the two for a wayfinding system, with the goal of furthering our understanding of effective design of a well-functioning wayfinding system.

1.2 Definition of the terms

Wayfinding
The term “Wayfinding” coined by Kevin Lynch in 1960, refers to the process of spatial navigation by use of maps, signs, and one’s own memories and sense of direction. Originally, he defined it as “a consistent use and organization of definite sensory cues from the external environment” (Lynch, 1960).

Navigation
Navigation is the process or activity of identifying one’s location, deciding and following the route, and achieving the desired destination.

Wayshowing
“Wayshowing” is any practice assisting and facilitating wayfinding, such as creating maps and signs for directions, usually by designers.

Universal design
“Universal design” means a variety of ideas for producing buildings, products and environments that are accessible to people regardless of age, disability and many other restrictions.

AIGA
AIGA, the American Institute of Graphic Arts, a professional organization for design that was founded in 1914, focuses on communication design, including graphic design, typography,
interaction design, branding and identity. The aim of the organization is to establish and provide standards of professional ethics and practices for the design profession.

**ADA**

ADA is an acronym for The Americans with Disabilities Act, a wide-ranging civil rights law enacted by the U.S. Congress in 1990 to protect people against discrimination on the basis of disability.

**SEGD**

SEGD, the Society for Experiential Graphic Designs, has members in a variety of design professions, including many areas of graphic design, architecture, industrial design and landscape architecture. The main interests of this field are the visual features of wayfinding, identity and brands, information design, and designing identity and character of places (SEGD). To avoid confusion, the name was changed to "Experiential Graphic Design" from “Environmental Graphic Design,” where the word *environmental* indicates the built environment in the field of graphic design, but was often confused with the natural environment or environmental engineering.

**Mobile user interface**

A mobile user interface (mobile UI) is the graphical and usually touch-based display on a mobile device, such as a smartphone or tablet, that allows the user to interact with the device’s apps, features, contents and functions.
1.3 Research questions

Questions to be considered in this study of an effective wayfinding system are as follows with regard to use of signage and mobile maps used together in a building with architectural complexity:

- Do digital navigation aids, such as Google Indoor Maps, improve a user’s wayfinding?
- How does the use of a digital navigation aid affect wayfinding behaviors in complex architectural environments?
- How do users understand wayfinding information provided in built environments?
CHAPTER 2. REVIEW OF LITERATURE

2.1 Problem solving process

Wayfinding is a spatial problem-solving process (Arthur and Passini, 1984), a conceptualized process for finding a desired destination (Passini, 2000). The process consists of a series of actions, including searching, decision making, and decision executing, in which both external and internal information are involved (Arthur and Passini, 1984). External information refers to all information given by maps, signs, verbal descriptions, modern GPS technologies, apps and other forms of wayshowing supports; internal information consists of one’s environmental perception and cognition. Users make plans for their transition pathways to target places on the basis of this internal and external information and their resulting decisions play a major role in how people solve spatial problems they encounter.

Seeking information and making decisions for action in advance are crucial, especially for unfamiliar or long trips, during which additional information may be acquired. The information on the environment acquired during the trip, along one’s cognition and perception, directly affects the processes of decision making and execution needed to solve spatial problems on the way to the destinations.

To smooth the process of solving spatial problems, a wayfinding system should provide hints that let a user know about decision points that are placed between subsections of a trip. The information at each decision point should lead the user in right decision to aid them to reach the destination. For this mission, the task of designers is to increase the effectiveness of environmental communication in wayfinding (Arthur and Passini, 1984).
2.2 History of Wayfinding

Wayfinding has existed for a great deal of time and has been closely related to human life. Paleolithic cave paintings contain information about the region around the cave. A 100-year-old tree in a town, the street name system in Manhattan, subway routes, and mobile applications can all be used or included in a wayfinding system. Thus, wayfinding has long been rooted in our lives and has a long history. The American architect Kevin Lynch first coined the term “wayfinding” in his book *The Image of the City* (1960), in which he analyzed city elements based on the concept of “spatial orientation.” He described how individuals navigate the city using their surrounding environment’s paths, edges, landmarks, nodes, and districts, which are the legible elements by which people organize their images of their cities (Lynch, 1960).

Paths are the routes or channels that people take in moving to a destination; streets, walkways, corridors, hallways, roads, and transit lines are examples of paths. They are principal constituents in constructing the mental map used to explore sites and can help people to find their way without difficulty if they are established and well organized, even in complex buildings and sites (Levine 2003, 55). Edges, the boundaries of adjacent regions, include shorelines, walls, railroad cuts, corridors, hallways, or even handrails. If they are not well defined, they could be barriers. Districts are “medium-to-large” sections of the area that have common characteristics. The center of each district usually has nodes such as a plaza area that people use for congregating. Landmarks are external reference points and physical objects such as buildings, signs, mountains, or other features that expedite wayfinding. They are used more frequently as cues as the user becomes more familiar with the areas.

More recently, architect and environmental psychologist Romedi Passini and his collaborator Paul Arthur pointed out the crucial role of one’s special behavior and cognitive
ability. In their book, *People, Signs, and Architecture*, they argued that individuals create their mental map to reach their destination by evaluating the information and cues they receive about the environment (Arthur and Passini, 2002).

After Lynch coined the term “wayfinding,” Paul Arthur and Romedi Passin used the word in a similar meaning. For those in the design professions who work in wayfinding, Per Mollerup coined the term ‘Wayshowing’ and suggested used of the term in professional disciplines. The goal of wayshowing is to effectively show users of signs how to find the way to a destination. The relation of wayshowing to wayfinding is analogous to that between teaching and learning, or cooking and eating (Mollerup, 2013).

Today, wayfinding not only helps people find destinations, but serves as a basic component of brand identity for a city, company or individual building.

Furthermore, wayfinding systems have evolved to interrelate with information systems and transportation systems that can guide and describe ways of moving in space by means of consistency of the system, such as in color theme, typography, and icons.
Figure 1. Examples of consistency of wayfinding system, Cologne-Bonn Airport

[Photo Credit: Integral Ruedi Baur]

Such systems now encompass Internet Web sites, mobile applications, and kiosks that provide the latest information on navigating through urban settings and individual buildings by a geographic information system(GIS) (Hunter, 2010).
2.3. Issues and difficulties in wayfinding

2.3.1 Architectural features

Because of increasing the number of large and complex buildings, the life style has been changed. According to the research, people today spend 90 percent of their time indoors (Klepeis, 2011). Buildings provide people with the full of conveniences, but the enlargement of buildings with multiple functions caused the complexity of indoor environment. For instance, healthcare facilities, university buildings, transportations are architecturally complicated in these days. Because many building facilities tend to extend their new facilities to exiting structures which make complicate indoor environment and its navigability. User has a difficulty with indoor navigation leads to stress and frustration which would negatively affect the use of building (Mandel, 2010).

2.3.2 Differences related to individuals, gender and cultures

Individuals differ in their spatial skills and strategies, and each person has a distinctive range of what is known and wanted (Huelat, 2004). Variability across individuals is an inevitable problem related to the effectiveness of wayfinding. For communication to be effective, gender, age, stature, social and cultural background differences should be considered (Arthur and Passini, 1992). For example, women tend to depend on local landmarks more than on the comprehensive configuration, which is a wayfinding strategy favored by men (Lawton et al., 1996, 2001).

In addition, differences in special configuration and perceptions vary among ages and cultures (Downs and Liben, 1985; Suzuki and Wakabayashi, 2005). The aging process often results in decline of physical and mental abilities such as cognition, perception, and vision. Cultural differences in recognition and cognition can lead to various views of single fact.
Research has shown the impact of cultural differences resulting from the influence of cultural and geographical features and leading people to perceive the world in different ways. According to psychologist Richard Nisbett, the people of western societies value individuals themselves, while those of Asian cultures recognize individuals as part of the whole and tend to see the whole picture instead of focusing on details (Nisbett, 2003).

There are also different points of view from which to observe a situation. If the West gives priority to focus more on delivery of information in a situation, Eastern people tend to see the relevance of situations (Nisbett, 2003).

We can also find differences in meanings of colors among cultures and countries. Although we can recognize color scientifically only as corresponding to a wavelength of light, there are also symbolic meanings through cultural references in the place where a person was born and grew up (Geboy, 1996). Colors reflect customs, nationalist sentiments and social norms. For example, when students in high schools in 20 countries rated seven colors in the semantic categories of evaluation, potency, and activity, blue ranked highest, followed by green and white, in the evaluation category. Black and red were chosen as the most potent colors, while the students selected black and grey as the most passive colors and red as the most active.

In a different study, participants from four countries (Japan, People’s Republic of China (PRC), South Korea, and the US) were asked to pick one out of eight colors corresponding to the 13 words most often used when consumer products are characterized. Regardless of cultural differences, all responders chose blue for high quality and red as being related to love, and associated black with the descriptive words “expensive” and “powerful”. While participants from Japan, PRC, and South Korea related purple to “expensive”, those from the United States linked purple with the opposite, “inexpensive” (Bortoli and Maroto, 2001).
Preference for certain color combinations and avoidance of use of specific colors are also associated with cultural traditions and beliefs. Selected colors or pairs of colors are thought to have meanings that make them appropriate for special events. For instance, black and red indicate happiness in China and are therefore often used in wedding invitations. As red signifies blood and death in Korea, people there may be reluctant to write their names in red. These examples illustrate how important it is to know cultural differences associated with colors, which will affect the design decision for audiences from diverse cultures.

Such differences emphasize the significance of universal signage that can be interpreted and understood by speakers of diverse languages. Ronal Wardhaugh (2002) stated that people with different mother tongues would perceive the world with dissimilar viewpoints and perspectives, which agrees with what Edmund Leach wrote about the different perceptions coming out of varying cultural backgrounds (Leach, 1976).

Since one’s cultural perspective is influenced by other cultures through development of technology that connects people more closely and results in intercultural communication, it may be crucial to identify and select colors that can convey shared perceptions and similar meanings in various cultures.

2.3.3 Digital aids to a wayfinding system

To convey information effectively in a wayfinding system, using interactive digital aids is another method of place-showing (Mollerup, 2013). Such aids have become ideal supporting tools in a variety of ways, providing pre-visit information and enhancing efficiency of communication. To this end, it is important to understand the mental processes through which we react to the spatial map data, information of which will vary depending on the extent to which a
visualization system was used (Longley et al., 2001). In general, many devices have been designed without considering various potential barriers. These barriers include the complicated menus, with high demand of memory, inappropriate interaction techniques, and metaphoric symbols designed for the larger screens of desktop computers. Simple application to these gadgets, with their small display, leads to confusion and frustration for computer beginners especially for older adults.

The kiosk has developed over time, with customized computer terminals in a certain place where information is needed, but it has weaknesses in effectiveness. For instance, only one person can use it at a time, and specific only at places. Other barriers, such as the need for updating information, high setup cost, and inability of users to carry and record information from kiosk, must also be solved (Mollerup, 2013).

In contrast, mobile applications provide many functions with given digital maps, such as the Google Indoor Map containing specific location and indoor floor plans for wayfinding, although, their small screens sizes, buttons and typefaces should be improved to make then easier to see and operate, which is a significant challenge for both app designers and users (Brewster, Goodman and Gray, 2005). Even though wayfinding apps provide location information directly with additional useful information, their maps are not still easy to use, and there is room for improvement in their functions and usability. In addition, since indoor applications are still immature in terms of technology and user expectations compared to those for outdoors, users, even with the indoor application, could be lost in unfamiliar buildings.
2.4 Wayfinding strategies

Per Mollerup defined wayfinding strategies in terms of search, decision, and motion (Mollerup 2013). Although reason can change a certain place, specific situation and one’s information sources, logic should lead the strategies process. In a logical process, the effectiveness of the wayfinding strategy varies with the quality of wayshowing aids (Mollerup, 2013). For instance, some strategies require only rule following, whereas some need deeper understanding of the spatial problem, or a GPS system, mobile app, or map can be used.

2.4.1 Environmental cues

Wayfinding becomes more challenging in large complex buildings with no distinctive elements and of similar appearance in different parts. Much research has emphasized the value of environmental affordance, which is related to design of an environment that guide can us through the structure (Carpman, J.R.; Grant, M.A.; Simmons, D.A. 1985). The word “affordance” was coined by psychologist J.J. Gibson (1977, 1979), who perceived affordances as part of arguing about natural that things do not have to be visible, known, or desirable. Norman (1999, 2002) recommended that designing with affordance is a good way to provide user-friendly environments and user-friendly products (Ruabal, 2008). He brought the concept of affordance to the area of design with the word of “perceived affordance” emphasizing the importance of design to evoke user actions and pointing out that the physical properties of a device can give clues to its proper operation and that the role of designers is to design the device so as to indicate relevant actions through perception and interpretation of visible clues, without any words or symbols. Needless to say, the concepts of affordances and of transparency underpin successful
wayfinding. A good wayfinding design should focus on environments and wayfinding systems that are transparent, afford the easiest movement, and promote memorability.

Thus, a wayfinding system should not be added on taken into account later. Despite its effectiveness, a wayfinding system is often considered after the planning process or construction of a building complex. For creation of an effective wayfinding system with environment affordance, the master planning process should be considered along with wayfinding plans (Easter, 2007). Recognition of independent wayfinding by facilitating environments would significantly reduce costs in the end, because later addition of wayfinding aids can be avoided, and fewer interruptions increase employees’ work efficiency.

Baskaya commented that wayfinding encompasses both building structure and environmental cues such as landmarks, and signage (Baskaya, Özcan, Wilson, 2004) that provide visual cues at the decision points regarded as one of the most efficient factors in indicating direction of wayfinding systems (Allen, 1997) (Marquardt, 2011).

According to researchers who developed the theory of wayfinding at the neural level, humans and animals determine their position and destination by using landmarks. Thus, describing a spatial layout itself as a kind of landmark raises the level of spatial recognition and long-term memory in perceiving the relationship between location and space (Epstein and Vass, 2012).

The attempt to divide wayfinding into two factors is found in other studies. Carpman et al. concluded that environmental affordance and manifest cues are used to describe and construct the floor plan. Another study (Vilar; Duarte; Noriega; Mayhorn; Rebelo; 2014) reported that those two components were comparable and illustrated how they function in the daily location tasks as well as in infrequently occurring emergency cases.
According to Huelat (2007), good design and planning of building features, such as clear pathways and ease of localization of entrances, elevators, and landmarks, provide good wayfinding and assist people to construct their cognitive maps. Also, they provide subsequent user satisfaction and increase the usage rate of the building features (Hunter 2010). In other studies (Haq and Zimring 2003, Huelat 2007), the preference of paths people take can be affected by the building layouts and floor plans and by selection of interior materials such as selection of paint colors and lighting.

2.4.2 Cognitive map

A cognitive map consists of an internally-stored spatial representation of the experienced environment (Bell et al., 1996) and plays a crucial role in ensuring correct decision making in wayfinding tasks, by connecting information about environmental cues which have been seen or perceived previously to the routes or directions for the planned journey. The characteristics of the cognitive map include variation from user to user and inexact representations of the real environment. It could include shapeless and unreal features, an occurrence which is called augmentation (Bell et al., 1996). Another characteristic of cognitive maps is the dynamics; they improve as more information is acquired, whereas they can deteriorate as details are forgotten. (Mollerup, 2005).

2.4.3 Signage

Signage is the most widely used way of guiding people in a showing facility. Although the importance of being self-explanatory is emphasized and although signage alone is not enough for effective wayfinding (Calori, 2007), which is more than signage (Arthur and Passini, 1992),
signs are often depended as an important wayfinding design element. This is because signage as visual communication provides direct instructions to help remove confusion in wayfinding problems.

Huelat (2007) asserts that signage can serve as structural backbones and reference points in physical configurations. Signs indicate not only the way to go, but also the location. Well-organized signage systems provide various types of information, such as description, direction, recognition, and regulation of which usage is contingent upon the signage (Mollerup, 2013). Name, function, or nature of allocation can be shown on identification signs and directional signs. Detailed information can be found on the description signs. Regulation signs informed people about prohibition related to safety, security, and effectiveness. Mollerup created categories for signage to explain these different functions, which is vital to creation of better wayshowing design.
• Identification Signage

Signs can let people recognize services, facilities, and buildings. The main purpose of identification signage is to let people know the name of a place and distinguish it from other places. Identification signage includes the most basic description of the place and often reflects the context and characteristics of the place.

According to Miller and Lewis (1999), identification signs should be distinguishable from other signs in the environment so as to provide users with clear information. To achieve this, use of distinctive colors and the placement of signage are important (Miller and Lewis, 1999).

![Identification signs in The Seattle Children’s Hospital](www.seattlechildrens.org/wayfinding)

**Figure 2. Identification signs in The Seattle Children’s Hospital**

[www.seattlechildrens.org/wayfinding]
Directional signage provides information on a route from the position of the sign to a certain place given on the sign. Information provided in directional signage is derived from its location and the text, symbols or pictures that tell what will be found in the indicated direction. Arrows are commonly used to represent direction, and people can understand the meaning of the arrow as a direction to follow the way the arrow points. Where the signage is placed also affects its functionality. According to an observation from Carpman (Carpman et al., 1984), directional signs are more effective when the signs are placed at or ahead of an intersection and at the destination. In addition, use of singular environmental cues or cues in series leads to effective wayfinding by making individuals sense they are moving from one place to another.

*Figure 3. Overhead Directional Sign, Toronto International Airport*

[Photo Credits: Peter Mauss, Esto]
- Description signage

Description signage describes a location, making it easy for a traveler to understand the situation. This deals more with placemaking than a function such as wayshowing. For example, signs with departure and arrival times in train stations or airports, contents of a museum, are often placed together with the need for wayfinding.

Figure 4. Descriptive signage for the Zoo am Meer in Bremerhaven

[Photo Credits: Buro 7 cisuelle Kommunikation GmbH]
• Regulatory Signage

Regulatory signage has the purpose of influencing human behavior, so it is more directly designed with a message to readers, such as what they can do or what they need to avoid doing. Capital letters with easily detected colors should be used for expressing authority by graphic means.

Figure 5. Regulatory/prohibitory sign for the National Mall in Washington, DC

[Photo Credits: Hunt Design]

Well-designed signage creates a positive impression in visitors with regard to their navigation experience (Harkness, 2008) and thus provides more than direction and information. Signage plays a significant role in wayfinding behavior related to understanding of the building
overall outline (Garling et al., 1986). Tang et al. (2009) has shown the great impact of a signage by conducting a wayfinding study with three situations: finding an exit with no sign, then with old version of a sign (the text “exit” placed inside the large arrows next to a symbol of a running person), and lastly, with a newly designed sign (the text “exit” placed outside the thin arrows next to a symbol of a running person). The results showed that with the use of signs, people took less time to escape than in the absence of signs, and the response time to the old signs was shorter, although not statistically significantly shorter, than with the new signs, indicating that larger text and familiarity with old signage produced a faster exit. This study corroborated the importance of text in signage for wayfinding tasks. A supporting study by Scialfa et al. (2008) showed that the addition of text significantly improves the recognition of signage.

Based on the problems found in the signage design, many efforts have been made to improve perception and ease of locating places. Ineffective design of text and inclusion of complex figures for description of actions, as well as delivery of multiple messages, created negative effects in understanding and legibility (Cahill, 1976; Salmi, 2007).

Obstruction by other objects in the environment and use of reflective material for signage may also prevent effective delivery of context of signage. A study of Tang et al. (2009) showed that the setting of multiple signage at regular intervals may be necessary to improve user experience for wayfinding; otherwise people may disregard signage at first sight and may not even bother to spend time trying understanding the signage. Some studies have tested the effectiveness of signs, symbols and indicators, and the extent of recognition and comprehension, in an effort to improve the awareness of signage (Ng and Chan, 2009). Contrasting arrows, large size of the sign, and modifying the ratio of dimensions of the sign could improve the function of signage (Ng and Chan, 2009). Also, utilizing graphic symbols and pictograms properly can help
overcome language barriers in the wayfinding task. According to a study of Lesch, representing messages with human forms greatly increases comprehension of signage (Lesch, 2008, 2004), but many people could not understand the abstract concepts in pictograms (Foster and Afzalnia, 2005; Jones, 1978). Muhlhausen (2006) suggested that using simple language for ease of understanding, as well as using well-established pictogram colors and words, would increase the effectiveness of help effective graphic communication on written signage (Muhlhausen, 2006).

2.4.4 Maps

Because the main function of a map is to help users decide which pathway they will take to a desired place from the current location, maps should be made effective and useful by incorporating all three elements (current position, route, and final destination) to help people understand the places displayed on the map. They also represent a three-dimensional world showing elements such as streets, information on roads, and landmarks on a 2-dimensional flattened surface scaled down to the real world. In addition, digital maps such as Google maps combine 3D overviews, layouts of buildings, and even street views with photos with established 2D maps, boosting the use of maps for wayfinding. To apply a map in creating spatial awareness, users must connect each element of a map to the real world. Liben and Downs (1993) concluded that the real problem in constructing correlations between elements is to build spatial knowledge from the structure consisting of three components of wayfinder, world, and map.

Per Mollerup, described in his book, wayshowing > wayfinding, described a wayfinding strategy associated with portable maps and stationary maps called, “You Are Here” (YAH) map. This portable map, which can be carried by wayfinders, provides a large scale overview of the area, with relevant conditions and information. The aim of YAH maps is to provide information on the current location in an unfamiliar environment to make the user aware of where he or she is
and takes the current location as a geographical reference in the map space ensuing decision on navigation routes to the next target point. Although Per Mollerup pointed out that YAH maps have disadvantage that the user must memorize the information obtained from the map, it is a simple method for conveying a great deal of information in an efficient way. It provides users with more strategy tool by giving them easy and concise information at a glance. To convey such diversity and provide a large amount of information effectively, decisions on what is excluded are as important as what should be included in the design. Thus, the purpose of the map must be carefully considered. Too much information is not always useful. Alignment of components and structure matching the environment of the map should be well arranged, with appropriate visual aspects and hierarchy of all elements.

Figure 6. Map / Wayfinding system for city of Bath by PearsonLloyd
[http://pearsonlloyd.com/2013/01/city-information-system]
2.4.5 Interactive wayfinding aids

With the maturation of mobile technology, wayfinding aids such as automobile car navigation system and personal navigation devices are becoming so popular that they significantly improve quality of life. From the time when a hard copy of a digital map in a website was downloaded and employed for wayfinding, portable maps have culminated in the advent of smartphones in combination with a GPS system.

Advances in computing hardware and faster wireless communication technology are expected to further accelerate the growth of smartphone usage. According to survey data from the Pew Research Center, ownership of smartphones by American adults increased from 58% in early 2014 to 64% in 2015, while another mobile device, the tablet, is owned by 45% of American adults. These devices are being used as an essential tool not only to connect to the cybernetic world for communication to other people, but also to gain access to various types of information needed just by clicking or touching. Today, such electric gadgets have become indispensable tools in our daily lives (Pew Research Center, 2015).

As an assistive technology for wayfinding, the mobile device not only provides visual representations of physical environments but also serves as a communication tool that provides relevant information on the specific place.

For example, many hospitals offer mobile applications for their patients and families to provide them with better services and hospital experiences. The mobile applications feature navigation, easy access to personal information, convenient listings which increase the user’s satisfaction. In particular, mobile apps, including a building navigation system, are one of the ways used to overcome users’ wayfinding issues related to architectural complexities and guiding patients and families. Boston Children's Hospital provides a free mobile app, Boston
Children's MyWay, to help their patients and family members to find places in the hospital. Step-by-step directions guide them to reach many of the locations.

![Image of the Boston Children's Hospital MyWay app](image)

**Figure 7.** Boston Children’s Hospital MyWay By Meridian Apps, Inc.

In 2011, a form of indoor map from Google map became available for public buildings, allowing people to navigate inside the buildings and thus increasing the convenience and enjoyment of the visitor experience. Users can see the entire layout of a mapped building, or of each floor if the building has multiple levels. Mobile navigation support based on global positioning systems (GPS) allows for continuous YAH information with a blue dot showing the user’s current location, which is similar to a “You are Here” mark on stationary maps. It also offers turn-by-turn instructions that are easy to follow. As long as people follow the specified instructions, a complete map is not even required. This indoor map service as a new wayfinding
aid may improve user experience and avoids the need to spend time searching for building directories.

Wayfinding can be more engaging with active exploration of a space. In contrast, a study (Parush, Ahuvia, and Erev, 2007) reported that automated navigation systems decrease user engagement and lower the desire for acquisition of spatial knowledge. In addition, the repetitive and monotonous patterns of the environment may lead to inefficient cognition and perception of the environment. Consideration of prominent and dynamic patterns of the environment are therefore required for the acquisition of environment and spatial knowledge.

Figure 8. Example of Google Indoor Map
[https://www.google.com/maps/about/partners/indoormaps]

The Augmented Reality (AR) application is another promising tool to deal with wayfinding problems. AR is a recent technology integrating computer-generated data, such as text, images, and video, on top of real world scenes. It is distinct from virtual reality, which is completely based on an artificial environment provided by computers. The AR technology has been applied to a wide range of fields, such as education, medical service, entertainment such as movies and computer games, tourism, and others (Mekni and Lemieux, 2014). Development of
various software solutions and platforms such as ARToolkit, Wikitude, Layar, Aurasma, and Junaio have accelerated and facilitated implementation of AR technology (Radhakrishnan, 2015). In particular, combination of AR technology with a mobile device helps people to discern the cues for decision making from the mobile screen that gives related information, which can decrease the user’s cognitive load by overlaying the directional signs in the real world and recognizing the location for wayfinding decision to get to the destination. Like the GPS and the compass used for early wayfinding apps, AR technology employs the camera feature, which provides a more intuitive user experience. For example, after users search or browse the destination, rather than listing walking directions, the directional arrow appears with distance on the real world. The scene is observed in real time through the smartphone camera in the “augmented reality” mode. This AR system provides a more immersive environment and a more natural user experience. Also, it is believed that the mobile AR technology can replace or complete conventional signage systems by eliminating the limitations of space and use of different languages of physical signage. Despite surging interest in and fast advancement of mobile AR technology, challenges and issues such as social views regarding privacy, technology of sensors for tracking and recognition, and usability still exist and must be resolved.

Figure 9. Augmented Reality applications (Left: wikitude, Right: Layar)

2.5 Wayfinding graphic system for improving user experience

2.5.1 Universal design

For wayfinding in complex public buildings such as airports, hospitals, and large shopping malls, wayfinding design should include all possible circumstances, including the extreme case of limitation of people’s abilities. With such diversity in mind, it is crucial to understand how people deal with finding their way in everyday life. Results of a study by Salmi suggest that signage should be designed to be universally comprehensible, using color, font, size, location of signage, etc. (Salmi, 2007) to make graphic communication effective, because these factors facilitate comprehension of signage. Universal design signage directs people through the site, allows people to move through space independently, and provides information and instructions (Osterberg, 2005). Moreover, signage is an important element in creating a safe environment; for example, it can assist people during emergencies to find and use an exit (Osterberg, 2005).

The term “universal design” was coined by Ronald L. Mace, founder of the Center for Universal Design at the NC State University College of Design. He described the goal of universal design as “design all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life.” Under this philosophy, the Center for Universal Design (1997) established a set of basic universal design principles based on general accessibility guidelines that can be an effective solution to the problem of providing the same quality of experience for all people, without discrimination.
Table 1. Principles of Universal Design by The Centre for Universal Design (1997)

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equitable Use</strong></td>
<td>The design is useful and marketable to people with diverse abilities.</td>
</tr>
<tr>
<td><strong>Flexibility in Use</strong></td>
<td>The design accommodates a wide range of individual preferences and abilities.</td>
</tr>
<tr>
<td><strong>Simple and Intuitive Use</strong></td>
<td>The design is easy to understand, regardless of experience, language, or knowledge.</td>
</tr>
<tr>
<td><strong>Perceptible Information</strong></td>
<td>The design communicates information effectively regardless of ambient conditions.</td>
</tr>
<tr>
<td><strong>Tolerance for User Error</strong></td>
<td>The design minimizes hazards of accidental or unintended action</td>
</tr>
<tr>
<td><strong>Low Physical Effort</strong></td>
<td>The design can be used comfortably with minimal fatigue.</td>
</tr>
</tbody>
</table>

To achieve universal design, designers should abide by the guidelines suggested in the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and the Standards for Accessible Design (SAD) recommended by the Society of Experiential Graphic Design. These guidelines suggest considering several important factors that affect readability of signage, including distance from which the sign will be viewed, proportions of characters, color contrast, and font style.

- **Raised Characters**

  SAD classified signage into two categories: identifying a permanent room or space and giving direction or information about permanent rooms or spaces. Signs indicating a permanent room or space should include raised characters and Braille and should be placed in a consistent
location. Raised characters use sans serif with upper case characters only, to increase understanding of signs. It has a 5/8-inch to 2-inch maximum heights based on “I” height and raised 1/32-inch minimum above the sign surface, which must have a non-glare finish and 70% contrast with the background. Character width is required to be 55% minimum to 110% maximum based on the uppercase letter “O”. Thickness of stroke is 15% maximum based on the letter “I” and spacing between individual characters is 1/8 inch minimum to 4 times stroke maximum.

Figure 10. Raised Characters / Stroke Thickness and Character Proportions

[SEGD 2012 ADA White Paper]

Figure 11. Raised Characters and Spacing

[SEGD 2012 ADA White Paper update / Signage requirements in the 2010 Standards for Accessible Design]
Figure 12. Raised Characters / Multiple Line Spacing

[SEGDA 2012 ADA White Paper update
/ Signage requirements in the 2010 Standards for Accessible Design]

- Visual Characters

Visual Characters for giving direction or information about rooms or spaces were not required to be raised above the sign surface. Uppercase and lowercase can be used with Serif and Sans serif.

Use of sans serif typeface increases understanding of signs, it is also stated that “Character width should be 55% minimum and 110% maximum the height of the character with the width based on the uppercase letter O and the height based on the uppercase letter I.” Stroke thickness is 10% to 30% of “I” height and spacing is 10 to 35% of “I” height.
Figure 13. Visual Characters / Stroke Thickness and Character Proportion

[SEGID 2012 ADA White Paper update / Signage requirements in the 2010 Standards for Accessible Design]

Figure 14. Visual Characters / Spacing

[SEGID 2012 ADA White Paper update / Signage requirements in the 2010 Standards for Accessible Design]
• Pictograms and Symbols

The use of symbols can reduce the barrier caused by different human abilities and languages. To meet the goals of the “Equitable Use Principle” of universal design for everyone, use of standard symbols included in the ADA guidelines is one effective way. According to the book *Access for everyone*, by Arvid E. Osterberg, symbols indicating accessibility have been adopted internationally and have a common appearance in various countries or cultures (Osterberg, 2005). Another researcher pointed out that signage should be designed for easy recognition by the elderly and by people with disabilities, leading to improved accessibility by such people (Scialfa et al., 2008).

ADA guidelines would require buildings to be renovated and updated. According to Rousek and Hallbeck (2011), the hospital industry spent over $200 billion to build new facilities and expand existing ones across the United States in the next 10 years. It is important that a new universal wayfinding system be designed in accordance with ADA guidelines so as to create
better user experiences for such public buildings and healthcare facilities. One example can be found in increased identifiability of high contrast signage containing human figures and not containing too much detail or being too abstract. Standardization of signage is also recommended to speed up and assist the cognitive processes involved in detecting signage and interpreting its meaning (Rousek and Hallbeck, 2011).

- **Color**

  Many studies have demonstrated the influence of color in signage design on understanding. Carpman and Grant contended that good wayfinding systems should combine colors that increase visibility, as well as understanding of signs, numbers and symbols (Carpman and Grant, 1993). Color enhance effectiveness and can bring draw attention to important messages (Harrell, 1999). For example, attract warning sign of distinguishable color from that of its surrounding environment can people’s attention (Gill et al., 1987). However, caution must be used in selecting colors, since they may work differently for different people. Not all people see color the same way. Various cultures differ in color perception, and individuals have a wide range of abilities to detect colors, for congenital or acquired reasons. For these reasons, color selection has many constraints for sign graphics; however, color plays significant roles in decision making during navigation.

  **Color Universal Design**

  “Color Universal Design” is based on principles focusing on users with a range of abilities to discern colors and has been established to used color to deliver information accurately to almost all people.
Core Principles

• Select colors that draw people’s attentions through the conditions where the signs are mounted, such as natural or artificial lighting conditions.

• Use various colors with a combination of shapes, locations, and patterns of coloring to deliver the information and messages to the general population as well as color-blind people.

• Clarify the names of colors that users expect to be used for communication.

• Attempt to make the design visually appealing and aesthetic.

Color-blind people, also sometimes known as people with Daltonism, color-weak people, or people with color-vision defects, color-vision deficiencies, or dyschromatopsia, constitute a large population with color vision different from that of ordinary people.

Over 10 million people in the US and around 2 million in the UK, which is corresponding to 8.3-10% of males and 0.5% of females are colorblind. 5% of males and 0.2% of females suffer from color blind. Worldwide, more than 200 million people are color-blind. Although color-blind people have otherwise normal eyesight, they see certain colors differently. (Color Universal Design Handbook, 2006)

In addition, a large number of people can not distinguish any colors; they can detect only differences of brightness and darkness of colors. While people with normal vision differentiate colors by hues such as green, yellow, and so on, people with color blindness set colors them by brightness. Thus a wayfinding design for visually impaired people should use the differences in brightness alternatively named as color reflectance, rather than differences in hue (Passini, 1992).

Age and age-related illnesses can also affect eyesight, which can change the way we see colors. Thus, a significant number of people, called “people with low vision,” suffer not only from weakened eyesight but problems in contrast sensitivity and visional image processing as well.
Figure 16. Different vision from the common-type vision

[Color Universal Design Handbook]

Figure 17. Different vision from the common-type vision

[Color Universal Design Handbook]
Use of color is a widely-used way to deliver information efficiently in our society. However, many designs have used colors without considering the needs of those with low vision that makes reading difficult and inconvenient. Color Universal Design was developed to solve this problem and encourage conveying information accurately and effectively.

Especially in wayfinding design, use of color must be considered thoughtfully to allow all people to understand color the same way, regardless of their color vision. Designing with color blind people in mind can reduce the amount of unnecessary color use, which distracts people from the message and challenges users’ cognitive load.

2.5.2 Color selection

Selection of appropriate colors can effectively transmit the meaning of signs and make them more distinctive and separate from their surroundings. However, people from different culture may have various color perception, responding differently to a color depending on their cultural backgrounds. Thus, choosing colors that are universally understandable can prevent confusion in users.

As Eiseman stated (2006) in her book, people have similar general responses to color regardless of cultural differences because of universal reactions to color in terms of physiology and psychology. Eiseman argued that red attracts the user’s attention because it is related to fire and blood, which are significant elements in human life. For this reason, we use red for stop signs, green for an emergency exit, and yellow for warning messages.

Choice of color in a sign depends on the function of the sign. Color makes the sign stand out or be in harmony with the surrounding environment. In the case of wayfinding, color can be one important factor in assisting uses to make navigation decisions, by being clearly visible
against the rapidly-passing environment. In other cases, in which the purpose is harmony, colors can be selected to mingle with the environment.

In addition, focusing on the user’s perspective, rather than only pursuing the designer’s aesthetic sense, is crucial and beneficial in color selection.

• Color Coding

Another way to deliver the meaning of signs and effectively communicate is color coding, whose goal is to prevent confusion and help users in decision making. In the U.S., color coding has been developed by using stereotyped implications of color. Examples of generally accepted color coding can be found in the use of red for warning and alerting information, yellow or amber for caution information, and various other colors for advisory information (Wickens et al., 2004).

Color coding, is usually suggested as the first way to find solutions to wayfinding problems (Arthur and Passini, 1992), can be useful to indicate different parts or areas (Mollerup, 2013) and curtail the load of information on signs (Miller and Lewis, 1999). However, color coding in itself is not enough to deliver clear messages: thus, it should come together with messages. When the given message is connected to the color coding, it is readily distinguished from other messages. In addition, the meaning of codes should be able to communicate between a “sender” and a “receiver” through previous learning of the codes.

Color and graphics can make it easy to find pathways and underscore service points (Regnel, 2003). Use “a limited number of nameable colors for the purpose of visual orientation or direction” in wayfinding had been advised (Arthur and Passini 1992). Although there are many advantages of using color coding in different parts of a site, it should not be overdone. An attractive design may not represent reality effectively and may not function well. When too many
colors are used to express the messages, they could end up hampering message delivery. It is said that most people can remember the meaning of only four or five colors at a time.

![Image of a map for a large high school campus in Australia where different colors are used to distinguish buildings, functions, and departments](image_url)

**Figure 18.** A map for a large high school campus in Australia where different colors are used to distinguish buildings, functions, and departments

[Photo Credits: Jonathan Wherrett]

2.5.3 Typography

Most of the contents of a sign is conveyed by words, expressed in a manner based on typography, which is considered the most dominant element of the sign graphic system. Selection of typeface is a key element in effective communication in a sign graphic system. For example, as hospitals have a wide range of visitors and patients with varying levels of eye impairments and disabilities, use of readable font types is critical in terms of readability.

In selecting typeface for signage, four factors should be considered:

- Formal suitability
- Stylistic longevity
- Legibility
- ADA/SDA guidelines, as already discussed.
Formal suitability refers to how visually compatible a typeface is with both its environment and stylistic longevity. Serif and Sans Serif are the basic typographic formats with regard to visual compatibility and suitability.

**Typography**

*Figure 19. Serif and Sans serif*

The most representative feature of the serif font is the presence of a short horizontal stroke. It can be sharp or blunt, decorative or plain which makes it usable for a wide range of purpose from printable things to websites. Each serif typeface family has unique features that make them more distinctive. The stroke makes the feeling and mood more connected with concepts such as classic, elegant, formal, confident and established. Time Roman, Rockwell, Georgia and Baskerville are well-known serif typefaces.

“Sans serif” means “without serifs” and has various widths and shapes. Sans serif typefaces represent the simple and clean, which is associated with the feeling of being modern, friendly, direct and minimal. Helvetica, Arial, Futura and Franklin Gothic are popular examples of sans serif typefaces. Serif typefaces are commonly use on signage where a traditional look is desired, whereas sans serif fonts are better on signage designed to have a contemporary feeling. Although there are many stylistic variations for both typefaces, these are not categorized as novelty faces, which are often quirky and therefore excluded for use in signage. Because trendy and novelty typefaces can change quickly, they are not suitable for use in signage that must have a comparatively long life span. Using typefaces with stylistic longevity is important for permanent signage design, so unusual fonts should not be used widely, although using different fonts can emphasize warning sign (Bailey and Milheim, 1991).
For the signage design, legibility, defined as the ability to be read, is also a crucial factor in the typeface selection phase (Morville, 2005). To communicate and convey information, signs must be easy to read and understand in urban and building plans (Morville, 2005). “Legible typography is essential for clear communication” (Calori, 2007).

Information in signage should stand out and be highly legible even from a distance. To increase legibility in signage, basic rules must be followed: Large X-height, medium weight, stroke widths that are neither too thick nor too thin, and letter forms that are not too condensed or too expanded. Miller and Lewis said that the overall size of letters and viewing distance determines the height of a typeface. Variations of font size can also be employed to draw attention (Silver and Braun, 1993): in general, larger fonts can elicit much attention, but densely packed letters require less cognitive and visionary effort by readers (Harrell, 1999).

In addition, typographic treatment such as case and letter spacing can also affect legibility. Typefaces consist of uppercase and lowercase versions. Legibility can be changed significantly depending on use of uppercase and lowercase.

Miller and Lewis (1999) stated that people read by identifying the shapes in entire words rather than reading letter by letter. Therefore, combining lowercase and uppercase letters is more effective than using all uppercase, especially when there are two or three word lists in a single sign. Proper and appropriate use of letter case can improve the legibility and authority of a sign. For example, while the use of capitals or uppercase letters in the initials in words, with lowercase letters otherwise, increases legibility, words in all uppercase, such as ‘STOP’ and ‘EXIT’ are perceived as authoritative and commanding.

Also, using bold weight for the main information, with a single font, would increase efficiency. The use of upper and lower case letters with sans serif promotes legibility (Strickland
and Poe, 1989; Poncelet and Proctor, 1993). SEGD, the Society for Experiential Graphic Design, claims that characters should be used in combinations of upper and lower case, sans serif or simple serif (SEGD, 2006).

2.5.4 Symbols and Pictograms

Signs with symbols can the need for rapid communication across age and language barriers (Foster, 2001). For this reason, symbols and arrows are often used as graphic tools to communicate. Humans have a long history of using simple pictures to communicate before written language was developed. The Lascaux cave paintings, circa 15,000-10,000 BC, in Southern France, are early examples of pictorial communication. With the development of society, written languages evolved from various arrangements of pictures. The hieroglyphic writing of ancient Egypt and the writing of the Chinese language are pictorially based.

In the US, although English is the majority language, the number of people who use English as a second language has dramatically increased. In addition, according to a National Assessment of Adult Literacy (NAAL) conducted by the U.S Department of Education and the National Institute of Literacy, 32 million adults in the U.S, 14 percent of the total population are illiterate. The United States Census Bureau also has reported that about 56.7 million people, in the U.S., 19 percent of the population, has a disability.

Symbols are powerful graphic tools to assist people in understanding the work done by the words. Symbols used in signage should be regarded as vocabulary that contains manifest meanings and should be interchangeable with words (Calori, 2007) so as to eliminate the necessity of using multiple languages. For example, the symbol for an airplane, the man and woman icons for public restrooms, and the wheelchair are universally understandable and depict the concept of objects directly. Arrows are also a representative symbol that is generally
understood to indicate direction. Their use is an effective way to reduce long descriptions and allow people to easily find their destination by following the direction of the arrows.

![Image: Signs with symbols](image)

**Figure 20. Signs with symbols**

*Photo Credits: Allianz Arena/B. Ducke, Quirin Leppert, Philipp Meuser*

However, symbols that were developed to describe certain situations require a learning process for understanding them, which designers should be aware cultural differences, language barriers, and individual variations in ability can affect recognition and understanding of symbols.

The AIGA/DOT symbol system, developed by the American Institute of Graphic Arts, commonly used across the United States. AIGA / DOT symbols have been used widely in various transportation authorities and facilities, and their usage has been extended to general public. Symbols for accessibility have been developed for the signage and graphics, in line with the Americans with Disability Act (ADA). Use of symbols and icons that are universally understandable can avoid message confusion.
Figure 21. Selected symbols from the AIGA/DOT symbol vocabulary

[http://www.aiga.org/symbol-signs]
2.6 Wayfinding mobile interface for improving user experience

2.6.1 Effective design of mobile interface

Donald Norman (2013) contended in his book *The Design of Everyday Things* that the mistakes and misunderstanding of the user is not from the user’s faults, but from defective design. If the design of interfaces or products confuses users, it may not be considered a user-centered design. In addition, designers should not assume that application of a design will be practiced under optimal and ideal conditions but rather should consider any conditions under which the design may be employed by the users, such as be while working or just before going home from work, or under frustration from getting lost. User-centered design allows users to experience high usability, which is defined as “the extent to which a product can be used by particular users to achieve specified goals with effectiveness, efficiency, and satisfaction in a particular context of use” (Stone et al., 2005, p.6).

For application of a user-centered design to mobile system, visual elements to be used include type and color, and the concept of usability should be considered. Most interactions with mobile device are made by usage of typography, the importance of which is emphasized in the IOS Human Interface Guideline stating that “If users can not read the words in your app, it does not matter how beautiful the typography is (Apple, 2015 https://developer.apple.com/library/ios/documentation/UserExperience/Conceptual/MobileHIG/).” Guidelines for typography in mobile applications have been suggested. Hoekman proposed that consistent sizes and fonts, with only 2 or 3 kinds, make users focus on the task; otherwise, too many different fonts can confuse or distract users (Hoekman, 2011). When the small font is needed, sans serif typefaces should be used to increase readability (Nielsen, 2000). As for colors, high-contrast colors, e.g., black text on a white background or white text on a black background,
can produce high legibility. Either a solid color or a very fine pattern is recommended for the background, and use of graphics for the background should be avoided, because the interference can make it hard to perceive the word shapes and lines of characters.

Effective design of a mobile interface should consider the necessary functions and age group of the people interacting with the mobile devices. Quick identification of the current position, fast acquisition of location-related information by searching, and ease of interface usage are the main considerations in the design process. Older adults may have difficulty in mastering new technology, such as smartphones, and this fact should be taken into account to make the technology more accessible, usable, and comprehensible to those of different (Coleman, Lebon, Clarkson, Keates, 2003)

2.6.2 Guidelines for Digital Wayfinding

Usability and user satisfaction are the two main factors, to consider in design of mobile wayfinding applications with enhanced efficiency for wayfinding tasks. Increased usability can be achieved through consistency, simplicity, legibility and readability, as well as use of alternatives and environmental cues.

Consistency in the presentation of navigational information, such as the naming system, typeface, color, graphics, sounds and animation, are important to effective delivery of accurate information, providing users with easily recognizable patterns that can lead to successful accomplishment the tasks.

Simple interface design will help users find the least minimum necessary information when users need it, rather than being overwhelmed by too much and excessively complicated information.
Legibility and readability, are other important elements to think about in the design process for mobile media, in terms of a limited display size and selection of typeface of appropriate size, color and contrast. Comprehensive guidelines on legibility and readability are still needed for digital wayfinding, although those for physical wayfinding are well established, having been introduced by the Americans with Disabilities Act (ADA Standards for Accessible Design, 2010).

Traditional wayfinding tools such as maps and signs should be incorporated into the digital wayfinding system, to work as alternatives when the technology is not applicable; landmarks used as environmental cues should also be integrated into the system to facilitate arrival of people at their destinations (Wang, Hedgecock, Fernandez, 2011).

User satisfaction can be achieved through improvements in dynamic interaction, customization, use of the non-visual senses, and interpersonal communication. Dynamic interaction between users and information is the distinctive characteristic a digital wayfinding system that provides tangible and immediate feedback based on a user’s action, in contrast to the static counterpart. The strategy of traditional wayfinding is to make contents and presentation of information for people in general; however, digital wayfinding provides the freedom to choose only the information the users want or need from various alternatives.

Customized presentation of information can let users focus on the task without the distraction of unnecessary information. In addition, when the customization of the display of digital information is designed rationally users have more sense of control, which can lead to user satisfaction.
Also, although traditional wayfinding systems rely heavily on visual information, a digital wayfinding system can let people rely on information gained via various senses, such as sounds and touch, as from the vibration of a mobile phone.

Interpersonal communication may be used in circumstances in which people get lost in an unfamiliar environment and can ask personnel over the phone for the information they need to find their way (Wang, Hedgecock, Fernandez, 2011).

CHAPTER 3. ANALYSIS OF THE EXISTING WAYFINDING SYSTEMS AT THE PARKS LIBRARY

3.1 Introduction

Complex built environments may have a confusing layout, which is a common feature of structures designed for education, health and transportation, such as universities, hospitals and airports. Part of the reason of the complexity of such the buildings is that they were often extended with additional structures added repeatedly over decades. Considering the influence of the physical environment on people’s ability to find their way to their destinations, effective design of wayfinding systems cannot be overemphasized.

As discussed in the literature review, a fundamental aspect of dealing with wayfinding problems is the need to design building structures so that users are led to their targeted places naturally and without difficulty; thus wayfinding plans should be considered during the early phases of the master planning process. Accommodation of ways for easy updating, extensive investigation before restructuring of buildings, and consideration of user complaints allow for construction of effective wayfinding systems (Klipp, 2006). Well-designed wayfinding systems
produce an organized environment where users can fathom feasible options, by providing a sequential flow of information from a starting point to the final destination (Lynch, 1960).

Especially for visitors who are new to a building, directional signs placed before decision points will give them enough time to prepare for taking action at decision points. While directional signs at decision points are usually placed for confirmation, identification signs are employed to verify the identity of the destination. Therefore, wayfinding systems should contain information such as architectural cues, linearly arranged signage, and floor plans adequate for allowing users to make and execute decisions along a route. Also, effective use of additional wayfinding aids could improve users’ wayfinding experience.

### 3.2 History and architectural features of the Parks Library building

In developing the methodology for this study, the Parks Library at Iowa State University was chosen because it contains many features that commonly cause wayfinding problems in complex built environments.

The Parks Library, established in 1925, has underwent expansion of the buildings several times before attaining its current appearance. In 1961, the first expansion, on the west side of the library, was completed; a second expansion, which added to the first extension, was finished in 1969. Multi-tier stacks were added at this time. The last addition was completed in 1983. The old buildings were remodeled to cope with matters of building regulations, energy management and climate control, and to build architectural consistency throughout the facility. As a result, the library was enlarged to four times its original size and consists of both the new and the old parts of the building. While the five floors of Parks Library belong to the newer parts of the building,
the seven tiers were built into part of the original 1925 building. (http://www.lib.iastate.edu/about-library/art/parks-library-architecture)

Through this long period of expansions, a complex spatial layout and limited visual access were created. The way each of the seven tiers is connected to the newer part of the building is awkward. For example, tier 3 and tier 5 are located between the 1\textsuperscript{st} and the 2\textsuperscript{nd}, and between 2\textsuperscript{nd} and 3\textsuperscript{rd} floor of the newer part of the building. Such an unusual layout makes it difficult for users to find their way in the library building.

In addition, different architectural styles, such as traditional and modern, are seen in the old and new buildings, and different materials, such as glass and limestone, were used in various interior spaces in the Parks Library. Such discordance of mixed architectural styles and layouts may negatively affect the cognitive process during navigating tasks.

\textbf{Figure 22.} Different architectural styles
3.3 Analysis of graphic system

Graphic systems on the exiting signage system in the Parks Library were analyzed and their placement was examined along the task routes to the Bookends Café, Tier 5 and Center for Excellence in Learning and Teaching (CELT).

A cohesive style can make a place memorable and recognizable, enabling people to connect with it. To increase the cohesiveness of sign graphics and the effectiveness of communication, the same visual language should be used on signage in a wayfinding system; signs can share common visual features such as typeface, color, materials and shape to enhance visual similarity so as to provide consistent and hierarchical organization of information, and cues at key decision points (Klipp, 2006).

The Parks Library contains various kinds of signage that show lack of continuity of the overall wayfinding system in the building (Figure 23). Directional signs and identification signs do not have similar design elements, and temporary signage does not provide a user-friendly wayfinding experience. If a consistent signage approach were used for the wayfinding system in the library, it could improve the overall impression of the system and facilitate better use of the library and its services.
Figure 23. Various kinds of Signage at Parks Library
3.3.1 Typography

**Orientation sign** The Parks Library provides a main directory list showing each floor’s map in the middle of the lobby. However, the readability is questionable because the list of facilities was just piled up with small fonts and insufficient space. This does not allow use by users in a wide range of age groups (Figure 24). Older adults may have difficulties with reading these small texts because the aging process often results in blurred or reduced vision on reading small print.

![Figure 24. Main directory / Orientation sign](image)

**Directional signs** As mentioned in the literature review, typeface and color are crucial factors in the legibility of signage. Most of the directional signage in the Parks Library is designed with a sans serif typeface. Such clear and simple typefaces are easy to read so that information is readily communicated. However, using different styles of signs and typefaces for the Bookends Café decreases readability and disturbs the unity of the whole system (Figure 25). Generally, sans serif is a clear and straightforward typeface that enables people to read and understand the message easily.
Letter spacing should be slightly open or normal to enhance the visual appearance and to increase legibility, but some of the signage in the library has tight letter spacing and uneven spacing between letters. The space between the letters and the arrow is relatively great, which can increase a user’s confusion. Inappropriate use of font size causes information on some temporary directional signage to be easily overlooked (Figure 26).

**Figure 25.** Uneven letter spacing and arrow / disunity of typeface

**Figure 26.** Inappropriate use of font size on directional sign
Identification sign  Various forms were used for identification sign in the Parks Library (Figure 27). Since identification signage was added according to changes in needs, there is no consistency. Different fonts, weights, sizes and materials are disconnected from each other, decreasing credibility and reliability to users.

![Identification signs](image)

Figure 27. Various kinds of identification signs

3.3.2 Color

Color contrast between the foreground and the background is one of the most important factors in ease of reading. All signs with visual elements such as letters must have contrast with their background: letters of dark color against a light-colored background, or vice versa. Primary signage in the library has a grey background and white letters, which presents a weak contrast that goes against the ADA recommendation of a 70% contrast between the background and lettering (Figure 28). The grey background of the directional signage blends with the grey and beige interior wall colors. These color selections cause the signage to stand out less and decrease its legibility.

With regard to the map, a white background surface can be used universally and goes along with many combinations of graphics and letters, but it should be used cautiously because white blends into its environment so that people pay less attention to it. Squeezing black letters
into the background of the map should be avoided, as it makes the letters hard to read. Although different colors distinguish the locations of books, use of too many colors, along with much information in the floor plan map, does not result in well-functioning color usage.

*Figure 28. Example of color usage*
3.4 Placement of existing signage

Although some effort has obviously been made to construct an integrated wayfinding system in the Parks Library, the complexity of the building layout makes it difficult for many users to navigate between the old building and the new one. Not all changes in the building were followed by alteration or adjustment of wayfinding plans. In addition, insufficient signage and ineffective sign placement of the Parks Library result in a lack of wayfinding cues to help users make decisions on the routes to their destination.

**Figure 29.** Placement of existing signage on the task routes in the Parks Library
3.4.1 Orientation sign

A building directory with library floor maps is located in the center of the library, but it is not easily distinguished from many temporary signs and posters. The size of the directory listing, 11 by 17 inches, is too small for all the room information to fit on it, which may decrease legibility for users (Figure 30). Each floor provides its own a floor map indicating a user’s current location, which helps uses set their particular orientation.

Figure 30. Orientation signs in the lobby
3.4.2 Directional signs

There is a lack of directional signs in the lobby to lead users to places that they may want to find. Only one directional sign is hanging from the ceiling in the fireplace reading room and seminar room. For user navigate to other places, such as tiers, Bookends Café and CELT, orientation signage is the only way of obtaining wayfinding information in the lobby. Although additional directional signage is provided consistently in the learning center on the first floor, users couldn’t directly see these signs from the lobby (Figure 31). On the second floor, there are two directional signs, for the periodical room and the upper rotunda, whereas directional signage was not posted for tiers or for the CELT room (Figure 32).

![Figure 31. Directional Signs on the routes on the first floor](image-url)
3.4.3 Identification signs

Although various kinds of identification signs are in the library, signage in the Upper Rotunda lounge located on the second floor is not present, which may cause visitors to lose their spatial orientation (Figure 33). For example, a clear and legible identification sign for the CELT, as well as directional signs for exits in the Rotunda lounge all need to be placed on this area to help users in making decisions.

Figure 33. Rotunda lounge view with no sign
3.5 Summary of the wayfinding problems

Architectural features

- Complex spatial layout
- Limited visual access

Sign placement

- Signs not distinguishable
- Insufficient number of signs
- Inconsistency of sign placement

Graphic system

- Incohesive graphic style of the wayfinding system
- Low legibility of signage
- Ineffective color usage so that sign blends in with surroundings
4.1 Design in brief

The purpose of designing the prototype signage was to increase visual communication between a complex built environment and a wide range of users. Based on the information obtained from a literature review, primary design principles such as contrast, unity, and consistency were applied to create a prototype wayfinding system that could increase legibility and efficiency. The prototype sign system was printed out on matte paper to reduce glare of the surface and was posted on the routes to the three destinations (Bookends Café, Tier 5 and CELT) that users were asked to reach.
4.2 Design process of prototype signage system

4.2.1 Orientation signage

The map was redesigned based on the layout of the existing map. The main purpose of the version one map is to show the primary routes on each floor (Figure 34). Main passages were described with thick straight lines to help users read the layout quickly and easily. Symbols provide information on the features in the building and a “YOU ARE HERE” dot assisted users to orient themselves. Each tier was distinguished by a distinctive color and contained specific information for the arrangement of books. Room names were separately listed to avoid having the sign crowded with too much information on a small space.

Figure 34. Version one of the prototype map
Version two of the prototype map was created to show overall layout of the floor at a glance by using only lines on a dark navy background (Figure 35). To improve readability and legibility, color contrast and different font (Futura) were used for version two of the prototype.

![Figure 35. Version two of the prototype map](image)

At the top of the map, illustration was added to describe how Tier 2 and 3 and Tier 4 and 5 fit with the first and second floor (Figure 36). Thus, the unusual connection of structures could be interpreted and users can form a cognitive map.

![Figure 36. Illustration of Tiers](image)
Through several experiments involving the design process, the final version of the prototype map was designed with a navy background and light blue layout, which increases legibility and makes the layout of the indoor floor plan stand out. Each tier of the map can be quickly identified by its color coding (Figure 37).

Figure 37. Final version of the map
This map describes where each tier is located and to which floor each one belongs (Figure 38). Color coding of each floor is identified easily, and a red dot gives users a sense of orientation in the narrow passageway between floors.

*Figure 38. Explanation of Tiers*
The first version of the orientation sign displayed the layout of the building and listed room information together, which can help users to connect rooms to their locations (Figure 39).

Gotham medium was the primary typeface used for the directory.

**Figure 39. Partial View of a First Version of the Directory**
The 27 by 40 size of the final version of the directory was designed focusing on the typography along with color contrast (Figure 40). Information was aligned in the order of the floors, with each floor displayed with tiers that belong to it.
4.2.2 Directional Signage

Through exploring several variations of typography, such as *Avenir, Helvetica* and *Gotham medium*, and through changing background colors, the final directional signage was designed to use Gotham medium with a navy background and white typeface. This is because it creates great contrast which comply the ADA requirement for 70 percent contrast. Light blue was added for the background color of arrows.

*Figure 41. Typeface Avenir / 40 inch by 13 inch*

*Figure 42. Typeface Helvetica / 40 inch by 13 inch*

*Figure 43. Typeface Gotham Medium/ Add Color on Background of Arrows / 40 inch by 13 inch*
**Figure 44.** Typeface Gotham Medium / 40 inch by 13 inch

**Figure 45.** Typeface Gotham Medium and Blue Background 40 inch by 13 inch

**Figure 46.** Final Design / Typeface Gotham Medium and Navy Background 60 inch by 14 inch
4.2.3 Identification Signage

Because all signage should work as a unified system, several versions of identification signage were designed and modified with use of graphic elements, such as typography, color and layout, that were similar to those of the directional and orientation signage.

Figure 47. Variation of typefaces, background colors
4.3 Final prototype graphic signage system

4.3.1 Typography

Typography is the foundation of visual communication and one of the essential elements in signage. To ensure that the wayfinding system with the prototype signage would work, selecting appropriate typeface was the most important step in the design process.

The prototype signage system was designed with Gotham medium as the primary letterform and Futura used as the secondary letterform. Since ADA requirements do not allow for use of condensed or extended typefaces, Gotham medium, which is neither too bold too light, was chosen as the primary font style for the prototype signage.

The Gotham letter form, was designed by the American type designer Tobias Frere-Jones in 2000, was inspired by the geometric lines of Futura. It is a geometric sans serif style font, which has a high X-height and wide apertures, which increase the legibility of the signage. Also, words on the signs consist of a combination of upper and lower case letters to improve readability. Positive letter spacing and distance between lines, enhance the visual appearance and ensures that a series of messages can be easily read and understood without wasting or compromising space.
Figure 49. Primary Typeface - Gotham Medium

Figure 50. Prototype Signage with Gotham Medium

Futura, the secondary letterform used on the floor map, is a clear and straightforward typeface that can make information more distinctive. While Gotham is used to show the names of places, Futura indicates how books are organized, providing users with the location of books. It clearly distinguishes the different functions on one page of the map.
4.3.2 Color

The primary colors for the signage system were chosen on the basis of psychological effect, symbolic and social relations, and universal acceptance. The main color for the signage system was a dark shade of blue on a white background. Very close to navy, dark blue carries the
symbolism of importance, confidence, power, and authority (Long, 2011 and Eiseman, 2006).

Being very dark, midnight blue can sometimes be a neutral like black, which is also often seen as a conservative and authoritarian color.

Use of navy as a background color in this study is thought to convey the trustworthiness of the information to users and to allow for contrast of the white used for letters against the dark blue background, which draws more attention to the signage and makes the signs stand out from their surroundings. The light blue behind the arrow on the directional sign makes distinction to the letters.

**Figure 53. Colors for Signage**

- Background: Pantone P 174-16 U / CMYK C-65, M-48, Y-37, K-60
- Text: Pantone White / CMYK: C-0, M-0, Y-0, K-0
- Background for arrows: Pantone P 129-9 U/ CMYK: C-12, M-0, Y-6, K-7
- Stripes: Pantone P 4-8 U / CMYK: C-0, M-8 Y-100, K-0

**Figure 54. Example of Using Color Palette**
Figure 55. Additional colors for the map

- Yellow CMYK C-0, M-19, Y-90, K-0
- Green CMYK C-18, M-0, Y- 91, K-0
- Pink CMYK C- 6, M- 61, Y- 42, K- 0
- Beige CMYK C- 23, M- 24, Y- 39, K-0
- Orange CMYK C- 2, M- 41, Y- 86, K- 0
- Blue CMYK C- 60, M- 0, Y- 32, K- 0

Figure 56. Colors of the prototype map
4.4 Placement of prototype signage

The prototype signage consists of three kinds of signs: orientation, directional and identification. This information system allows people to orient themselves and navigate in the Parks Library.
Second floor

Figure 57. Placement of the prototype signage
4.4.1 Orientation Signs

Orientation signage consists of the map and directory in the lobby of the library, which provide users cognitive representations of the library (Figure 58). Showing the connection between tiers on the map would help users understand the overall layout of the building (Figure 59).

**Figure 58. Free standing / Orientation prototype sign**

**Figure 59. Orientation prototype signage**
4.4.2 Directional Signs

Directional signs were installed at decision points on the task routes. Some were placed on the existing signage locations, and the contents of directional signage were changed to provide participants with information to help them find given places (Figure 60). Because of a lack of signage in the rotunda lounge on the second floor, additional directional signs would give participants a sense of orientation.

Figure 60. Directional prototype signage
4.4.3 Identification Sign

Identification signs were put at each destination (Bookends Café, Tier 5 and CELT room) that the participants were assigned to find (Figure 61). In particular, identification signage for the CELT room allowed the participants to recognize easily that they have arrived where they wanted to be.

*Figure 61. Identification prototype signage*
CHAPTER 5. METHODOLOGY OF THE STUDY

Research protocols and related materials were reviewed and approved by the institutional review board (IRB) of Iowa State University (Appendix A).

5.1 Participants

The participants for the study consisted of 20 individuals age 18-75, divided into 4 groups with 4 different combinations of independent variables. Participants were recruited across a range of ages and of both genders on the basis of demographic information collected in the pre-survey. Most participants were unfamiliar with the library layout and a few had not visited the library before.

5.2 Design of study

The study focused on users’ wayfinding behavior, as affected by the factors of the mobile map and physical wayfinding information. Through performing the task, how users perceive and apply wayfinding information and how they utilize a digital device as a wayfinding aid in a complex indoor building were revealed.

To answer these questions, the wayfinding usability test was conducted with four variables in the Parks Library at Iowa State University. While two groups undertook the wayfinding tasks using the newly designed prototype of signage system, the other two groups used the existing signage system. Two groups out of four groups used the Google Indoor Map in addition to the signage system. To test the new signage, it was installed at the decision points and replaced the existing signage on possible routes that the users were expected to take to the
destinations. For collecting accurate data, current library signage was covered on the routes so that it would not influence users’ wayfinding behavior.

5.3 Google Indoor Map

The ISU Parks Library provides a Google indoor map that contains floor plans of each floor, user’s current location, and detailed information on the inside of the building.

The Google Indoor Map collects and updates indoor information through uploading geographic data carried out by property owners or their authorized representatives, and provides floor plans and building layouts.

A user can simply zoom in and out of a building and go floor to floor with the indoor map by clicking between levels and floors with the buttons in the bottom right corner of the screen. Using indoor Google Maps, visitors can access the desired floor plan to identify places easily in the building, see the respective layouts by switching between floors, and obtain indoor walking directions. In addition, visitors can choose the ‘My Location’ function that turns on the ‘blue dot icon’ on the digital map showing real-time information of the current location within a few meters range. The Google map offers a particular means of hiding the functions automatically at the side of the screen in order to present more navigation content and location information in the limited screen size. All these features can provide positive experiences for guests in terms of navigation.
Figure 62. Google Indoor Map interface showing the Parks Library

5.4 Procedure

Prior to testing, the researcher explained the study procedures to participants and obtained written informed consent assuring confidentiality and voluntary participation. This test was conducted one-on-one, with each of the 20 individuals, being observed and questioned individually.

Participants were asked to implement a “thinking aloud” technique intended to capture what the participants were thinking, such as confusion or frustration, which assisted the author to “read their minds.”

Each participant started at the main entrance of Parks Library and returned to the starting point after reaching three target places in order: Bookends Café, Tier 5, and the CELT room. The first group used the existing signage system and the second group used the Google Indoor Map in addition to the existing signage; the third group used the new signage system, and the fourth group used the newly-designed signage and the Google Indoor Map (Figure 62).

With the agreement of participants and IRB (Appendix A), participants were video recorded to allow for data analysis. After the task, each participant was asked to respond to a post-questionnaire about the experience with the signage systems (Appendix E). The surveys
were formatted so that for each question, participants either chose one applicable response or checked all responses they agreed with, depending on the question. (Appendix E).

Figure 63. Captured images from videos showing the testing procedures
5.5 Data analysis plan

For qualitative data analysis, all video and audio data for each task were synchronized into a single file which was analyzed to examine signage use, hesitation, and errors in wayfinding. In addition, participants’ overall experience of the wayfinding task and effectiveness of the graphic systems were analyzed from the post-survey. The task completion time was not analyzed because individuals differed in physical ability and speed of walking.

CHAPTER 6. RESULTS AND DISCUSSION

6.1 Limitations

This research was limited in scale and scope, since it was based on wayfinding tasks performed by a small number of participants responding to a specific environment, and the existing the Google Indoor Map. The 20 participants, consisting of males and females of a wide range of ages, were not evenly distributed in groups because of the constraints of recruiting time and participants’ schedules. Spaces available for posting additional prototype signage and the time frame for testing were limited. In addition, the study used the form of the Google Indoor Map current at the time and did not attempt to redesign it for improvement of usability of the digital map, which is beyond the scope of this study. However, the results showed clear trends of people’s wayfinding behavior when receiving spatial information from a physical wayfinding system and a digital wayfinding aid.
6.2 Results

Through the real-world observation in the Parks Library at Iowa State University, the following analyses were performed to examine how people understand and apply wayfinding cues such as a signage and a mobile map, and how these tools and graphics affect the users’ wayfinding process.

Twenty participants were divided into four groups, A, B, C, and D, as shown in Table 2. The groups were tested with the wayfinding systems under different variables. To collect baseline data, groups A and B were tested with the existing signage system, and group B was asked to use the existing signage system with a mobile Google Indoor map. The other groups, C and D, performed wayfinding tasks using the prototype signage system, with a Google Indoor Map included in the test for Group D.

Table 2. Wayfinding systems used in different groups

<table>
<thead>
<tr>
<th></th>
<th>Existing Signage</th>
<th>Prototype Signage</th>
<th>Google Indoor Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Group C</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group D</td>
<td></td>
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<td>X</td>
</tr>
</tbody>
</table>
Table 3. Participants’ age in different groups

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>31-40</td>
<td>19-30</td>
<td>19-30</td>
<td>41-50</td>
<td>51-20</td>
</tr>
<tr>
<td>Group B</td>
<td>19-30</td>
<td>19-30</td>
<td>19-30</td>
<td>51-60</td>
<td>51-60</td>
</tr>
<tr>
<td>Group C</td>
<td>61-70</td>
<td>61-70</td>
<td>31-40</td>
<td>51-60</td>
<td>31-40</td>
</tr>
<tr>
<td>Group D</td>
<td>31-40</td>
<td>51-60</td>
<td>31-40</td>
<td>41-50</td>
<td>51-60</td>
</tr>
</tbody>
</table>

Table 4. Participants’ gender in different groups

M-Male, F- Female

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
</tr>
</thead>
<tbody>
<tr>
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<td>M</td>
<td>M</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>Group B</td>
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<td>F</td>
<td>M</td>
<td>M</td>
<td>F</td>
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<tr>
<td>Group C</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Group D</td>
<td>M</td>
<td>F</td>
<td>F</td>
<td>F</td>
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</tr>
</tbody>
</table>
Table 5. Participants’ familiarity with the Parks Library

1-Never been before, 2, 3, 4-Very familiar

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
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<td>Group B</td>
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<td>Group C</td>
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<td>1</td>
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<tr>
<td>Group D</td>
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<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

In the following sections, use of spatial reference information and ways of getting a sense of orientation and direction were discussed based on the video and survey analysis, by comparing the groups with regard to different variables.

Figure 64. Average time taken for each group to finish each task for each route and average of total time for all tasks
Figure 65. Comparison of time taken for all tasks by different gender and in total

It takes more time for female to finish the wayfinding tasks compared to male.

Figure 66. Average time taken for different age groups to finish each task for each route and average of total time for all tasks
New signage system showed better than the current signage system in many aspects including placement, typeface and color usage.

**Figure 67.** The number of participants answering the questions in post-survey
6.2.1 Group A (utilizing existing signage only)

Group A consisted of 4 males and 1 female, of ages ranging from 19 to 60 years. One of the participants was familiar with the Parks Library, but most of them had barely visited it. They were asked to use the existing signage system only to find given places in the Parks Library.

6.2.1.1 - Wayfinding task

• Task 1 – Go to Bookends Cafe

Most of the participants utilized the orientation sign (maps) placed in the middle of the lobby to receive spatial information. The participants tried to understand the spatial orientation of the building through reading a map, rather than looking at the directional signage, presumably because the number of directional signs in the lobby is insufficient and of low legibility.

• Task 2 – Go to Tier 5

Based on their memory of the map, participants searched and walked around the building to find Tier 5. Most of the participants struggled to find their way to Tier 5 and spent a relatively longer time finding it. This may be because of relying on a memory of a map, which often creates uncertainty, the unusual connection between the new and old building, and lack of directional signage, all of which could cause difficulties for participants to navigate through the spaces. Lack of directional signage made it necessary for participants to memorize the layout of the building from the map, which was a burden on their cognition until they were assured that they found the destination.

The female participant, who struggled reading a map and orienting herself in the building, also wanted to ask directions to the tier 5 of someone who knew the library well.
• Task 3 – Go to Center for Excellence in Learning and Teaching (CELT)

Participants learned the spatial information on the second floor during task 2 and found CELT relatively quickly. However, since identification signage for the CELT room is not provided, the participants kept walking around and were not sure about finding the place even after they had arrived.

6.2.1.2 Problems - The problems for the group A were insufficiency and inconsistency of wayfinding cues. Especially on the second floor, because there was no directional signage for tier 5 and no identification for CELT, the map was the only wayfinding tool for Group A. Inconsistency of signage did not allow it to function as a unified system. For example, the temporary directional signage, with much information not legible, made it hard for participants to read it or pay attention to it.

6.2.1.3 Results – Although Tier 5 was difficult to find, tiers were arranged numerically which can make it somewhat easier to find a specific tier after the tier building is entered.

In the post survey for group A (Appendix E), most participants thought that the current maps are helpful to find the destinations, whereas legibility of signage and efficiency in use of color should be increased to make signage really noticeable. Therefore, participants agreed that maps provided useful information for their tasking rather than signage.
**Table 6.** Group A (utilizing existing signage only)

M-Male, F- Female / 1-Never been before, 2, 3, 4-Very familiar

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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<td>31-40</td>
<td>19-30</td>
<td>41-50</td>
<td>51-60</td>
</tr>
<tr>
<td>Gender</td>
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<td>M</td>
<td>M</td>
<td>F</td>
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<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Figure 68.** Wayfinding behavioral mapping for group A
6.2.2 Group B (utilizing existing signage and Google Indoor Map)

Group B consisted of 3 males and 2 females, with an age range of 19 to 60 years. Three participants had visited the Parks Library, but only a long time ago. Group B was asked to use a Google Indoor Map as a digital wayfinding tool, along with the existing signage system. All participants had been using smartphones for several years, and most of them felt moderately comfortable using the Google map.

6.2.2.1 Wayfinding task

• Task 1 – Go to Bookends Café

All participants started using the Google Indoor Map and followed the routes that it suggested. At the beginning of the task, most of the participants relied solely on the mobile map, tried to follow the routes and did not look around the building or utilize any physical signs. As a result, one participant missed a directional sign to the Bookends Café, misunderstood the routes and took the elevator to the 4th floor, which was totally away from the routes to the Bookends Café. After realizing an incorrect self-positioning on the mobile map, he became confused and frustrated. Two people who had an experience of visiting the building applied their memories to the task and ignored the routes that Google Indoor Map suggested because the mobile map routes were different from what they knew about the building. Since their current location shown on the Google Indoor Map was not accurate, participants had doubts on its reliability. The others, who were unfamiliar the Parks Library building, spent more time trying to understand routes on the mobile map, because it showed the routes from outside the building to the Bookends Café, which inside was the building.
• Task 2 – Go to Tier 5

For finding Tier 5, the participants started by looking at the stationary map with physical signage because they doubted the reliability of the Google Indoor Map. First, they checked the stationary “You Are Here” map, and looked at the mobile map on the way to tier 5. At this time, the user’s location on the mobile map did not respond concurrently with the user’s walking speed, and tier 5 had no labeling to identify the place, so that participants often became lost and walked around. Although one directional sign for tier 5 was provided on the 1st floor, the placement was inadequate to provide visibility, so that it did not provide the information on an alternative route that users could choose to go to tier 5. Any directional signs to Tier 5 were not provided on the second floor. Those two factors may explain why the participants relied on the map rather than signs.

• Task 3 – Go to CELT

The last place, CELT, did not have an identification sign and directional sign in the building, and the Google Indoor map provided an incorrect name, “Map room.” Only a physical map and temporary directional sign on the second floor helped participants to find their destination. All these experiences with digital wayfinding aids did not give a positive impression of the wayfinding experience to the participants.

6.2.2.2 Problems - The Google Indoor map did not work properly because of failures in showing the user’s location, confusing route directions service, and mislabeling of the place name. During the 1st task, it showed a path from outside the building to the Bookends Café instead of from the user’s current location. When the participants selected the second floor button on the Google Indoor Map for the next task, it did not provide the route to Tier 5, and the
Bookends Café which is located on the first floor still remained on the screen. This caused confusion in navigating inside the building and required spending more time to read and understand the interface of the map. The CELT room was labeled incorrectly on the Google Indoor Map and no route was suggested to CELT. Identification signage for CELT was not provided in the building, which negatively impacted the user experience.

6.2.2.3 Results - Participants’ emotional reactions to the wayfinding task were revealed on the post-survey. The participants suffered frustration, and stress, blamed themselves, and felt unintelligent. They answered that physical signs are located in useful places, but the color needs to be changed to be more noticeable. Moreover, most participants considered the effectiveness of combining the signage system with the Google Indoor Map to be low.

Figure 69. Group 2 confusion of routing and user location feature
Table 7. Group B (utilizing existing signage and Google Indoor Map)

M-Male, F- Female / 1-Never been before, 2, 3, 4-Very familiar

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
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</thead>
<tbody>
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<td>2</td>
<td>3</td>
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</tr>
</tbody>
</table>

Figure 70. Wayfinding behavioral mapping for group B
6.2.3 Group C (utilizing prototype signage only)

Group C, consisting of females only, had an age range between 31 and 70 years. Two participants had visited the Parks Library only once, and the rest of the participants had never visited the Parks Library before. This group used the prototype signage system to find their given destinations.

6.2.3.1 Wayfinding task

• Task 1 – Go to Bookends Café

Group C participants employed physical signage (prototype) more than Group A for doing their wayfinding tasks. At the beginning of the test, most of the participants walked to the directory and checked the room numbers, which is a slightly different strategy from that used by previous groups. Then they went to the map and made plans for the route they needed to take, although one participant just looked at the directional signage and walked the way the sign pointed to the Bookends Café. This first task was easily done by all the Group C participants.

• Task 2 – Go to the Tier 5

Finding Tier 5 was the most challenging task for Group C. Except for two participants who was familiar with the library building, the participants struggled to find the way to the tier area. Because most participants who were completely unfamiliar with the library took unexpected routes to find Tier 5, and directional signage was missing at the decision point to Tier 5 on the second floor, they had to rely on the layout map and spent more time finding Tier 5, which is located at a higher level than the second floor but lower than the third floor of the main building. From the video analysis, it could be seen that the participants pointed out the illustrations showing the different levels of Tier 4 and 5 on the prototype map and understood how the tiers were actually located between the second and third floor.
• Task 3 – Go to CELT

For the last destination, CELT, there were several directional signs at regular intervals on the routes to guide participants in their task, and an identification sign for CELT confirmed the place. After arriving at Tier 5, the participants seemed confident on the way to the last destination, because the directional signs guided them and they could build a cognitive map during task 2, which made the third task easier to do. Also, in the Rotunda on the second floor, additional directional signage for finding an exit and the lobby helped users to navigate their route.

6.2.3.2 Problems - Locations at which to install prototype signage and the expected routes were decided on the basis of results of a preliminary test. In task 2, to find Tier 5 from the Bookends Café, some participants unexpectedly returned to the lobby to see the physical map again, rather than taking the direct route from the Bookends Café to Tier 5. Another unexpected route was through an elevator where no prototype signage was installed, which made participants struggle and become confused by the lack of wayfinding cues.

6.2.3.3 Results - Orientation signage including a directory and map helped participants obtain broadly spatial information in the library, and directional signage assisted them to get to the destinations. Through the observation during the task and the interview with the participants after the tasks, following a series of sign types helped people to navigate throughout the building and eventually led users to their desired destinations. Increased legibility by means of color contrast and appropriate information on the directional signage were noticeable, enabling participants to utilize and rely on the directional signs more than they would have otherwise.
In the post-survey, all the participants agreed that the color and typeface were easy to read and stood out in the spaces, but a few participants complained of insufficient numbers of directional signs for the tier section of the building.
Table 8. Group C (utilizing prototype signage only)

M-Male, F- Female / 1-Never been before, 2, 3, 4-Very familiar

<table>
<thead>
<tr>
<th>Participant</th>
<th>Participant</th>
<th>Participant</th>
<th>Participant</th>
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<td>1</td>
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<td>4</td>
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<tr>
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<td>2</td>
<td>2</td>
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<td>1</td>
</tr>
</tbody>
</table>

Figure 71. Wayfinding behavioral mapping for group C
6.2.4 Group D (utilizing prototype signage and Google Indoor Map)

Group D consisted of 1 male and 4 females and had an age range of 31 to 60 years. One participant had visited the Parks Library but most of them were unfamiliar with it. They had used smartphones more than 3 years and felt very comfortable using them as well as the google map.

6.2.4.1 Wayfinding task

Group D participants were asked to use the Google Indoor Map along with the prototype signage for their wayfinding task. Despite the general idea that the mobile map is a useful wayfinding aid, the Google Indoor Map was not a reliable wayfinding tool for group D.

- Task 1 – Go to Bookends Café
  
  Group D started by using the Google Indoor map to search for the Bookends Café. They then could see the directional signage of the Bookends Café, which indicated a different route than the Google Indoor Map suggested. Most participants followed the physical signage instead of following the route that the Google Indoor Map indicated.

- Task 2 – Go to Tier 5

  Similar to Group 3, which used only the prototype signage, the participants in Group 4 had difficulty perceiving the spatial connection of Tier 5 to other floors on the mobile map, which made them abandon the mobile map and depend entirely on the physical signage system to complete the task.
• Task 3 – Go to CELT

Although using the digital map could not help participants to find CELT, they could easily find it with the directional signage and identification signage. As seen in the results from group B, participants did not depend on the Google Indoor Map, because it gave inaccurate information on place names and routes to the destinations. However, they did not complain and get frustrated as much as people in group B, because physical signs were provided on the paths to CELT, and the newly-posted identification sign was helpful in confirming that they had reached their destination.

6.2.4.2 Problems - With regard to the use of the Google Indoor map, the GPS detected only the Bookends Café in the library; no routes were provided from the Bookend Café to Tier 5 and from Tier 5 to CELT; and the Google Indoor Map showed only the floor plans for each floor separately. Thus the digital map did not play a key role in supporting the wayfinding
performance. With regard to the Google Indoor Map, older participants in group D needed to wear reading glasses to use it, which indicates some problems of readability and legibility of the mobile map interface. Some people couldn’t immediately understand why the buttons for the floor changed because of a mere change of color indication.

6.2.4.3 Results - Despite the expectation that the mobile map would be a useful wayfinding aid, most participants did not rely greatly on the Google Indoor Map, probably because sufficiency of signage, along with inaccurate information on the digital map, discouraged the use of the Google Indoor map as an additional wayfinding tool.

In the post-survey, most participants in group D agreed that effective use of colors and fonts made signs easy to read and detect, and placement of signs was also useful. Overall satisfaction of the wayfinding experience was greater than Group A and B.
Table 9. Group D (utilizing prototype signage and Google Indoor Map)

M-Male, F- Female / 1-Never been before, 2, 3, 4-Very familiar

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
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<tr>
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<td>41-50</td>
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</tr>
</tbody>
</table>

Figure 73. Wayfinding behavioral mapping for group D
Figure 74. Comparison of behavioral mapping for the groups (A, B, C, D)

/ Task 1 – Go to Bookends café
Figure 75. Comparison of behavioral mapping for the groups (A, B, C, D)

(Task 2 – Go to Tier 5 and Task 3 – Go to CELT)
6.3 Summary of findings

Through analyzing the result, the following facts were noticed:

**Signage**

- Improving noticeability of directional signage through the color contrast seemed to increase reliance upon it.
- Repeating of signage is desired by all the groups.
- Map plays an important role in overall wayfinding process.

**Google Indoor Map**

- User positioning is irregular and inaccurate.
- The routing service does not provide directions to most of the places in the building.
- The routing service for the walking direction does not consider of user’s position, which leads confusion.
- Incorrect naming of a places produces frustration.
- Readability should be improved with regard to font size and floor buttons.

**Wayfinding behavior**

- Participants may prefer to ask for help instead of depending on signs or maps.
6.4 Discussion

The study started the questions with the lists of below:

• **Do digital navigation aids, such as Google Indoor Maps, improve a users wayfinding?**

The merit of using interactive map such as the Google Indoor Map is questionable in the built environment, because group B and D who used the Google Indoor Map during the task did not show much improvement in terms of completing the task.

• **How does the use of a digital navigation aid affect wayfinding behaviors in complex architectural environments?**

The digital map as an additional wayfinding tool did not positively affect user’s wayfinding task. Connecting the physical environment with the digital map created cognitive overload and mismatch of physical information with digital information caused frustration for the users.

• **How do users understand wayfinding information provided in built environments?**

Naturally, providing sufficient signage and proper information at decision points to meet the needs of users is important, as is effective design of signage which enhanced wayfinding performance.

This experiment obtained information on how people perceive and understand the environment, and how they utilize wayfinding information and cues to perform their wayfinding task. It compared the use of a traditional wayfinding systems with the Google Indoor Map, found ways to improve wayfinding efficiency through redesigning signage which was able to overcome inconsistent architectural cues and improved participants’ wayfinding behavior.
6.4.1 Signage

Effectively designed signage can play an essential role in guiding wayfinders. In this study, whereas group A participants did not pay attention to the directional signage and relied on the map during their task, group C utilized the directional signage on the routes and reached their destination through use of the identification sign for each destination, which increased the quality of the overall wayfinding experience to the participants. With increased legibility, readability and noticeability through emphasizing color contrast and typestyle selection, and by conveying its intended message in the prototype sign, signage was utilized and relied on more by people.

Repeating signage at regular intervals, particularly at decision points, can significantly reduce the user’s cognitive working load and improve the wayfinding experience. Because of insufficient directional signage, group A participants needed to memorize the map in order to find the destination, which made it difficult for them to carry out the wayfinding task.

In the test for groups C and D, even though a larger number of prototype signs had been added based on the author’s predicted route to guide participants, the participants often deviated from the predicted route and struggled to find tier 5. Because it is difficult to predict the public's navigational patterns or to know what directional cues visitors will need, addition of more signs may be advisable to improve usability of the wayfinding cues.

Placing signage at the appropriate height, sight lines and orientation to paths of travel maximizes visibility and increases wayfinding efficiency, which makes it easy for people to see and read the signs. Inconsistent and inappropriate placement of signs in the Parks library makes it difficult for people to find given places, especially Tier5 and CELT. Proper location and placement of signs are critical to their effectiveness.

Participants in group A and B relied heavily on static maps with a “You-Are-Here” mark
to orient themselves, and matched the spatial information with the environment. This is because the lack of wayfinding cues and signage that was not highly noticeable failed to guide them to their destinations. In contrast, the participants in group C and D, who were provided with the legible and a sufficient number of redesigned signs, they utilized the map but not tried to memorize the static map and signage on their routes greatly help to accomplish the tasks 1 and 3. However, in the task 2, when directional sign was missing on their routes which is similar situation with group A and B who tested with existing signage, they relied on the static map because the static map helps users understand the overall layout of the building when they cannot make decisions.

6.4.2 Google Indoor Map

The Google Indoor Map as a digital wayfinding tool showed several shortcomings of usability during the wayfinding tasks in the Parks library.

Irregularity and inaccuracy of the user’s current location and indoor walking directions occurred frequently. The discrepancy of the computing power of the mobile device and the speed of wireless connections may prevent users from accurately knowing their locations. Walking directions with the wrong assignment of locations often did not start from the user’s current place, which made the user find the environmental cues to correct the wrong information given by the mobile tool.

Because of the small screen size and font size the detailed information was not legible without using the function of zooming in and out. Also, buttons for selecting floors need to clearly indicate the correct usage. Donald Norman stated in his book *The Design of Everyday Things*, “Two of the most important characteristics of good design are discoverability and
understanding” (Norman, 2013). The user should be able to figure out easily what actions are possible and what is meant by all the buttons.

Language used in the mobile map must match with physical environment and signage. For example, CELT was named as a “map room” on the Google Indoor Map, which caused confusion and decreased the reliability of the mobile map with regard to the service aspect of the building. The latest information on the digital map should be updated in accordance with space usage.

6.4.3 Wayfinding behavior

During the task, some participants wanted to ask people for directions. This situation is similar to that in hospitals where has an architectural complexity with ineffective wayfinding system. Patients who get lost tend to ask the nearest hospital employee for help, which could decrease personnel productivity and often result in receiving inconsistent information from different people. An accurate representation of the physical environment on the digital map and a well-planned wayfinding system may decrease the need to ask for help in finding a destination in a building by allowing people to use the independent wayfinding process.

Last, as discussed in the literature review, differences of wayfinding efficiency depended on the familiarity of individuals with the environment. The wayfinding process requires a cognitive or mental map of space. People who are familiar with the building performed better and reached their destinations more quickly, whereas participants unfamiliar with the place needed to search for more clues to orient themselves.
CHAPTER 7. CONCLUSIONS

Digital devices are indispensable today in improving efficiency of many aspects of daily life. One exemplary application is use of the digital device in wayfinding. Many researchers have pointed out that integration of mobile application is one of the effective ways in solving wayfinding problems. (Mollerup, 2013; de Jesus and Sergio, 1994).

In this study, the Google indoor map was used in an effort to find the focal point of wayfinding efficiency in a built environment by comparing two physical signage systems: an existing signage and a redesigned signage system. Through the observations described in the methodology section and by analyzing the results, the findings on users’ ways of utilizing physical information system in this study, which provided designer with valuable information about users’ behavior, can be used to improve the design of wayfinding system. Also, ways of improving the wayfinding information system, with regard to both the physical environment and digital aid, were found.

The Google Indoor Map is currently used comprehensively as an interactive wayfinding tool. However, the results of this study show that the Google Indoor map does seem not yet effective in the built environment. Technical issues related to the GPS system, such as inaccuracy of user’s current location, unreliable routing suggestions, and inconsistency of real-time feedback inside the building, create frustration as users encounter additional problems on the mobile screen during the wayfinding problem-solving process. Beside these technological issues, several other ideas that can improve wayfinding efficiency can be suggested.

As Peponis and Weiseman (2002) pointed out, designers should not assume that wayfinding principles can be applied at all different scales and should include comprehensive considerations on potential users, regardless of the degree of familiarity with the places, and the
differences in age and gender. Understanding of spaces and users’ needs are critical factors for creating an effective wayfinding system. The current system used to produce the Google Indoor Map is uploading floor plans of buildings that fit into the Google Indoor Map interface. This creates a similar appearance of numerous built environments, ignoring variables with diverse groups of uses, number of characteristic features of individual buildings, and so on. This operates according to the provider’s system more than to consideration of users’ needs within that specific context.

To improve service and usability of the Google Indoor Map, collaborating with a local designer who has close access to the building and can provide detailed information, including the configuration of the environmental layout, detailed architectural elements, the circulation content such as building signs, and major user groups, would be one possible solution. Google can integrate the information on their system to create more accurate interface of the map so as to provide useful information to users.

In addition, if features are provided that designers can use to customize the interface of the maps for their buildings, such as matching the color palette with their physical signage, adding pictures of landmarks, and additional information, users can go through perception and cognitive processes concurrently in an organized physical environment shown on the Google Indoor Map.

Through this study, the key role of physical signage was also reinforced. Some researchers have argued that nothing is more basic to good wayfinding than a map (Huelat, 2007). Users’ wayfinding experiences are greatly influenced by physical information system such as ease of use, location and interface as well as users’ familiarity with the places. Various interpretations of the space were evident, depending on individuals’ ability with regard to
configuration of the space, gender and familiarity with the building, which are hard to predict. To fill these gaps, wayfinding systems should be planned and created so as to include the view of users. The designer can then display information relevant to the exact needs of the user in a particular context.

In the future, effective integration of conventional wayfinding systems based on design principles and more advanced digital wayfinding technology will allow people to understand their environment in complex buildings without losing their cognitive mapping skills. For future research, a study with a larger sample size, incorporating the use of a prototype wayfinding mobile application for each specific place and improved posting of signage, should be helpful in providing additional evidence for or against the results this study has provided.
APPENDIX A. IRB APPROVAL FORM

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2027
515-294-7358
FAX 515-294-4287

Date: 1/5/2016

To: Young Ju Cho
156 College of Design

CC: Dr. Paul R Bruski
156 College of Design

From: Office for Responsible Research

Title: Understanding the relationship between signage and mobile map for indoor wayfinding

IRB ID: 15-681

Approval Date: 1/5/2016

Date for Continuing Review: 1/4/2018

Submission Type: New

Review Type: Expedited

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.

- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.

- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.

- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.

- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.

- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 1138 Pearson Hall, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
APPENDIX B. INFORMED CONSENT DOCUMENT

INFORMED CONSENT DOCUMENT

Title of Study: Understanding the relationship of signage and a mobile map for indoor wayfinding

Investigators: Principal Investigator: Young Ju Cho / Faculty supervisor: Paul Bruski

This is a wayfinding research study for testing signage system and the mobile Google Indoor Map to understand their interactivity and effectiveness for a wayfinding system. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time. No items will be purchased during the session. No personal or financial information will be collected during the session. Participants will be provided with the appropriate testing apparatus, whether it is signage or smartphone.

Introduction

The objective of this thesis study is an understanding the relationship between signage and the Google Indoor Map to improve user’s wayfinding experience in a complex indoor building. You will test prototype signage and the Google Indoor Map to find given places in the Parks Library at ISU.

You are being invited to participate in this study because your testing of results will contribute to improve an effectiveness of a wayfinding system. There is no direct benefit to the participant. However, the knowledge gained can be expected to provide significant opportunities to improve user experience on a wayfinding system for the general public.

You must be 18 years or older to take part in this study.

Description of Procedures

If you agree to participate, the task will last for approximately 45 minutes. During the study you may expect the following study procedures to be followed:

1) The researchers will contact prospective participants to schedule for a wayfinding study and will send an informed consent document with a pre survey questionnaire regarding demographic information and the familiarity with the site and the technologies. Based on this information, participants will be divided into groups for testing.

2) On the selected date of the wayfinding study, you will be given a copy of the Informed Consent Document for review and to sign prior to the start of the session. If you agree, and sign the Informed Consent Document the session will begin.
3) Information regarding the project will be read before the session.

4) The wayfinding testing will be conducted in the Parks Library at Iowa State University. You will be recorded in a video and audio format. During the task, your entire body and hand gesture will be recorded to help me later analyze the tasks. Because of the character of the study, it is important to know what directions participants look and how they find the way to get to their destination. However, your face will be obscured and will not be identified in any future video use.

5) The participants will perform a series of tasks on the prototype signage and the Google Indoor Map. You will be asked to “think aloud” (explaining your actions as you preform them). You may skip any tasks that you do not wish to perform or that makes you feel uncomfortable.

6) The participants will complete a brief exit survey after the wayfinding testing and answer brief interview questions given by the researcher (Principal Investigator: Young Ju Cho).

**Risks or Discomforts**

There are no foreseeable risks in this study. However, you may leave the study at any time without penalty.

**Benefits**

There is no direct benefit to the participant. However, the knowledge gained can be expected to provide significant opportunities to improve user experience of a wayfinding system for the general public.

**Costs and Compensation**

You will not have any costs from participating in this study. There will not be any compensation to participate in this study.

**Participant Rights**

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or to leave the study early, it will not result in any penalty. During the testing, if you feel uncomfortable at any time you can quit.

**Confidentiality**

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken.
The participant’s identity will be anonymous to outside sources throughout the study. Only the researcher will have access to the data. The data will be entered and kept in a password-protected computer located on the researcher’s computer. Any field notes taken during this study will not contain the names of the participants. Questionnaires and field notes will be shredded after all the information is entered into the computer.

Any video/audio files may be retained for future use pertaining to this research, however videos will not contain any identifying information, such as the participants name, nor will the video include the participants face.

Once the study has been concluded, all data files may be retained for future use pertaining to this research (process).

Questions
You are encouraged to ask questions at any time during this study. For further information about the study contact Paul Bruski, Faculty Supervisor, email bruski@iastate.edu, and Young Ju Cho, Principal Investigator, yjcho@iastate.edu / phone 515-292-3644

Consent and Authorization Provisions
Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant’s Name (printed)


Participant’s Signature                                      Date
APPENDIX C. TASK LIST

Task list

**Group 1** – Find given places in current condition
- Point A (Starting location) > Go to Book End café > Go to the Tier # > Go to the Map room > Go to the Point A (Starting location)

**Group 2** – Find given places in current condition with using mobile indoor map (google)
- Point A (Starting location) > Go to Book End café > Go to the Tier # > Go to the Map room > Go to the Point A (Starting location)

**Group 3** – Find given places in prototype signage setting.
- Point A (Starting location) > Go to Book End café > Go to the Tier # > Go to the Map room > Go to the Point A (Starting location)

**Group 4** – Find given places in prototype signage setting and using mobile indoor map (google)
- Point A (Starting location) > Go to Book End café > Go to the Tier # > Go to the Map room > Go to the Point A (Starting location)
APPENDIX D. PRESURVEY

PRESURVEY

Please answer all of the questions below.

1. What is your age?

   □ 19-30   □ 31-40   □ 41-50   □ 51-60   □ 61-70

   □ 71-89   □ 81-

2. Gender

   □ Male
   □ Female
   □ Other, please specify______________________

3. Native Language

   □ English
   □ Other, please specify______________________

4. Do you use a smartphone?

   □ Yes
   □ No

5. If yes, how long have you used a smartphone?

<table>
<thead>
<tr>
<th>Less than 1 year</th>
<th>1 year-2 years</th>
<th>3-4 years</th>
<th>5+ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
6. How comfortable are you with using a smartphone and Google Maps? Rate the following.
(1- being the least comfortable, 4- being the most comfortable)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Google Maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Are you familiar with Park Library at Iowa State University?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Very familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never been before</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

APPENDIX E. POSTSURVEY

POSTSURVEY

- Signage

Q1. User experience: I find the signage easy to navigate.

<table>
<thead>
<tr>
<th></th>
<th>1 Very difficult</th>
<th>2</th>
<th>3</th>
<th>4 Very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Q2. Information Quality:
Signage provides easy to understand information.

<table>
<thead>
<tr>
<th></th>
<th>1 Very difficult</th>
<th>2</th>
<th>3</th>
<th>4 Very easy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Q3. Please check all the items you agree with the signage.

- The color scheme is effective
- The color scheme is distracting
- Signs were of an appropriate/useful size
- The fonts used on the signs is easily legible
- Most signs are located in useful places
• Interactive Google Indoor Map

Q1. Do you think the smart phone indoor map was helpful to find your destination?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not helpful</td>
<td></td>
<td></td>
<td>Really helpful</td>
</tr>
</tbody>
</table>

Q2. How much did you rely on the interactive map (Google indoor map)?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barely relied on</td>
<td></td>
<td></td>
<td>Relied on a lot</td>
</tr>
</tbody>
</table>

Q3. Interaction Quality:

Do you think the interactive map was easy to use in combination with the signage?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very difficult</td>
<td></td>
<td></td>
<td>Very easy</td>
</tr>
</tbody>
</table>

Q4. What task did you find to be the easiest?

Q5. What task did you find the most frustrating?

Q6. Additional comments:
# APPENDIX F. PRESURVEY RESULT

### Native Language

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td>1.Korean</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td>2.English</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>3.Hindi</td>
</tr>
<tr>
<td>4</td>
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<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>4.telugu</td>
</tr>
<tr>
<td>5</td>
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<td>1</td>
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</table>

### Do you use a smart phone?

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<td>1</td>
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<td>1</td>
<td>1</td>
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<td></td>
<td>1.yes</td>
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<td>2</td>
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<td>2.no</td>
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</table>

### If yes, how long have you used a smart phone?

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<td>1</td>
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<td>3</td>
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<td></td>
<td></td>
<td>1.less than 1yr</td>
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<tr>
<td>2</td>
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<td>2.1yr-2yr</td>
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1. the least comfortable
4. the most comfortable

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<th></th>
<th>M31</th>
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1. the least comfortable
4. the most comfortable
# APPENDIX G. POSTSURVEY RESULT

**Q1** user experience: I find the signage easy to navigate

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</tr>
</tbody>
</table>

- 1. Very difficult
- 4. Very easy

**Q1**. The Google indoor map was helpful to find your destination?

<table>
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<tr>
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<th>A</th>
<th>B</th>
<th>C</th>
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<th>K</th>
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- 1. Not helpful
- 4. Very helpful

**Q2**. How much did you rely on the interactive map?

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- 1. Barely relied on
- 4. Relied on a lot
Q3 Do you think the interactive map was easy to use in combination with the signage

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BIBLIOGRAPHY


Rengel, R. *Shaping Interior Space* New York: Fairchild


