

EXPLORING HOW LIBRARY USERS NAVIGATE INDOOR SPACES WITH
INDISTINCT LANDMARKS

by

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Submitted in partial fulfilment of the requirements
for the degree of Master of Computer Science

at

Dalhousie University
Halifax, Nova Scotia
July 2013

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DEDICATION

This thesis is dedicated to my parents and grandma, who have always encouraged me to study and commit myself to this research. Their support has made this possible.

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ABSTRACT

Libraries are filled with indistinct landmarks, such as rows of identical bookshelves, which make it difficult for patrons to navigate and locate books. Call numbers are the primary resource that can be utilized while locating books, and these consist of letters and digits that are incomprehensible to many library users. With libraries increasingly offering both physical and digital resources and mobile devices being more common, we aimed to investigate the potential for mobile devices to assist in locating books within the complex physical spaces of libraries.

We recruited three groups of participants (inexperienced students, experienced students, and library staff) for an exploratory field study to understand current navigation behaviours. Participants frequently experienced disorientation during this study as a result of the lack of distinct landmarks and their struggle to use call numbers. Based on these findings, four guidelines were proposed for the design of indoor navigation systems for library users. A low-fidelity prototype was then designed and evaluated to assess the validity and usefulness of these guidelines. The results of this prototype evaluation were positive, suggesting that mobile indoor navigation systems that implement the authors' guidelines have the potential to reduce disorientation and frustration while locating books in a library setting.

ACKNOWLEDGEMENTS

I would like to first thank my supervisor Dr. Kirstie Hawkey and co-supervisor Dr. Bonnie MacKay for all the constructive suggestions and guidelines they have provided throughout this process. I have learned a lot and received a wonderful mentorship from them. Thank you to Mike Wheaton for everything; whenever I felt frustrated he always offered support and helped me to find a solution. I would also like to thank my dear Uncle Yu for his frequent phone calls to provide suggestions for research and life in general. My family in distant China also provided a great deal of love and support along the way. Last, thank you to all of my friends and labmates at the GV lab for all of the great times we have had together over the past two years.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

As technology has advanced, environments that have traditionally been physical in nature, such as factory floors and libraries, have incorporated digital artifacts and processes that have changed them into hybrid environments of the physical and digital. Increased adoption of mobile devices in the general public has changed the ways in which people search for information. These devices are used to search not only for digital information, but also to navigate the physical world as can be seen with the inclusion of global positioning system (GPS) devices in cars.

Our research originates with the difficulties that mechanics encounter while constructing and maintaining large pieces of equipment, such as airplanes, on factory floors. These mechanics are assigned to fix specific components that are surrounded by hundreds or possibly thousands of other components that look similar, all of which are located within the complex environment of a large machine. To assist in locating these components, each is given a “grid number” to describe its position within the larger machine that has been segmented into distinct regions. This is similar to how paper maps are divided into grids, allowing users to find a destination in an alphabetical index and then quickly reference this back to a specific area of the map. As Mackay et al. (2011) described, mechanics use different types of document ranging from pure text to 2D/3D model to perform various tasks. Mechanics’ attention is divided as they deal with these numerous documents, which may reduce their ability to locate components by grid number efficiently and without error (Henderson & Feiner, 2011). Locating the wrong components may result in mechanics working on the completely incorrect parts of the equipment.

We intended to carry out a field study on the factory floor to better understand this problem and observe mechanics’ behaviours, with the goal of finding ways to improve this process. However, with limited access to a suitable factory, we instead turned our attention to an approximate substitute with a related set of issues — locating books in a library by call number.

Perhaps to a greater extent than factories, the environment of the modern library has changed to incorporate digital resources and technologies. The traditional card catalogue has been replaced with a digital equivalent, and many resources are available only in digital form. Nevertheless, call numbers (Library of Congress classification used for collections in the library) (Library of Congress, 2013), the complex grouping of letters and digits assigned to books, remain as the primary resource that library users can utilize when it comes to physically locate books. Not only are call numbers difficult to understand and remember, they also require expertise and experience to use efficiently, which leads to problems for less experienced library users (Hahn & Zitron, 2011; Carr, 2006). The current library system fails to take advantage of library users' prior knowledge, forcing them to rely solely on call numbers when their knowledge could assist with searching and encourage browsing and exploration behaviours. Library users are forced to adapt their understanding of how books are related to the strict rules of call numbers, resulting in much confusion (Buchanan, 2010). As we experienced ourselves, we believe that these problems are made worse by the environment of a typical library's book stack room, a maze of near-identical bookshelves with few distinct landmarks that results in a poor experience with frequent disorientation.

Taking all the factors into consideration, we believe that library setting is an acceptable proxy for the factory floor: 1) they both have gradually become a hybrid environment (i.e., provide both digital and physical information); 2) people in both environments need to follow the rules provided by grid number/call number system during their locating tasks; and 3) both environments contains a great number of indistinct landmarks.

As discussed above, although mobile devices allow users to conveniently search for information in a variety of environments and contexts. However, their limitations should not be overlooked. As previous research (Dearman, Inkpen, & Truong, 2008; Reilly, Mackay, Watters, & Inkpen, 2008) has found these limitations are often the result of the small screen sizes of mobile devices, which can result in visual clutter if they are not designed accordingly. In order to avoid creating visual clutter, constraints are typically applied so that only a limited amount of information is displayed. Dearman (2006) suggested that the key to overcoming this constraint is to remove details that are irrelevant

to the current situation and present the remainder in a simple presentation. This has also been supported by Jong-yi Hong et al. (2009), who encourage the creation of content adaptation systems (i.e. context-aware systems), which can change the information displayed based on the environmental context. We must also take into consideration the unique behaviours of users interacting with mobile devices. Users have reduced attentional and cognitive capacities while interacting with mobile devices while travelling or completing other tasks. Therefore, complex interactions should be avoided where possible to ensure that the system supports existing behaviour rather than distracting from it.

The details that define an environment form its *context*, as defined by Buchanan, who stated that the current context can help refine the set of results in a useful way, providing the users with a more suitable and exploitable information (Buchanan, 2010). Generally speaking, context can be described as any features that convey ambient environment (Dey, 2001). They described context-aware systems as being those that detect changes in context and support users in their tasks without increasing the user's cognitive load. Allowing users to interact with the system based on the context can improve their efficiency of completing tasks to accomplish their goals. However, the rapid changes in context that are made possible by using mobile devices could result in unexpected and confusing changes to the user interface if these systems are not designed carefully. Therefore, when designing systems that adapt to users' environments, we must take care to present only the information that is most relevant at any given time while keeping some parts of the experience consistent to prevent confusion and disorientation.

In recent years, many studies have focused on designing mobile systems that can adapt to changing environments (Lorenz, Hans & Stoffel 2006; Radoczky 2007; Chun 2000). These has resulted in the creation of many beneficial applications, including those used for mapping and as tourism guides (Adomavicius & Tuzhilin, 2005). These navigation systems are designed to assist people in arriving at their destinations by providing step-by-step directions from their starting location. During each step, landmarks play an important role in helping users to confirm that they are on the correct path and to form a clear mental representation of their current environment.

Many navigation systems solely utilize the physical context (e.g., landmarks) and overlook the benefits of incorporating users' unique knowledge and experiences into the system. Overlooking the role of users in context-aware navigation systems increases the "possibility of creating trivial or meaningless activities that could distract or confuse the users rather than help" (Bardram & Christensen, 2007, p. 48). Therefore, we consider that it is important to consider the role of users while designing indoor navigation systems. These roles include information, such as the user's navigational goals, their interaction with the environment, and how they interact with mobile devices. The functionality of such a system can be determined in large part by the user's goals. For example, when a student wants to locate an available carrel for studying, the system does not have to provide an exact location; general information indicating which floors have empty study spaces is likely enough. However, when that same student is looking for a specific book within the library it is essential to have more accurate information (e.g., which shelf the book is on) to locate the desired book. Additionally, the system should direct users with information that they can physically view at that moment or is easy to recognize even in an environment filled with indistinct landmarks (e.g., bookshelves). Shenton et al. (2013) found that library users perform different types of behaviours when they acquire different knowledge in different areas. For example, when locating books, library users who are familiar with the library would go directly to the part of the library where it has the collections they need without looking for additional information, as opposed to inexperienced library users who need to carefully refer to call numbers on the bookshelves or may seek help from library staff.

Landmarks can generally be categorized as either indoor or outdoor landmarks. The characteristics that identify these are primarily their distinctiveness in comparison to the nearby environment. However, there is a prominent difference between indoor and outdoor environments. In outdoor environments, the landmarks normally are identified by people by their size and uniqueness (e.g., skyscrapers). In indoor environments, the size of the landmarks are not comparable to that of outdoor landmarks due to limited space. Interior objects and decorations are normally designed to fit into a single theme, which may limit the uniqueness of the objects in comparison to the surrounding environment. Therefore, as

Lorenz et al. (2006) has found, indoor landmarks are more likely to vary between individuals based on those objects that they have a certain connection with.

Radoczky (2007) indicated that people are more likely to feel disoriented in indoor environments than outdoors. This is due to the fact wayfinders are not able to rely on existing cognitive maps or their route knowledge when searching for specific location in unfamiliar domain (Frankenstein, Brussow, Ruzzoli & Holscher, 2012). Both Radoczky (2007) and Abu-Ghazze (1996) discussed that an environment filled with indistinct visual features (e.g., libraries) is difficult to navigate and frustrating to learn the landmarks. This highlights the importance of designing context-aware indoor navigation systems that incorporate indoor landmarks. We suspected that, simply adapting the features of outdoor navigation systems to indoor spaces would not address the problems of navigation as indoor landmarks are highly individual. Therefore, it is important that indoor navigation systems take this into account and adapt their directions based on each user's unique preferences and past experience.

We initially wanted to design a context-aware indoor navigation system to help mechanics perform their tasks (e.g., locating a specific component within a large piece of equipment) more efficiently. As noted above, due to the limited access to the factory floor, we placed our attention on a similar environment setting – the Library. We believe our research will ultimately allow us to design a system that naturally supports library users as they navigate in book finding tasks by incorporating landmarks they can easily identify and presenting directions in a way that is consistent with their current navigational process. In our field study, we observed library users' current behaviours while locating books including how they form a mental representation of current environment with/without the landmarks they use to assist this navigation. We hope our findings might be generalizable to a similar system designed for use in a factory floor setting. The library environment shares similarities with the factory floor environment in terms of the use of digital and physical information, the need to follow a coding system to finish finding tasks, and the presence of indistinct landmarks. Therefore, we believe that learning how context in a library assists library users in navigating through the library may help us to understand how mechanics

may be able to use context to locate a specific component among a great amount of similar-looking components.

1.2 OVERVIEW OF RESEARCH

Pazzaglia and Beni (2001) indicated that there are mainly two kinds of spatial representation to help people maintain an awareness of orientation while navigation: survey and landmark-centered. People who have a good mental representation of the whole environment during navigation are considered to be High-survey individual. In contrast, landmark-centered individuals tended to identify and recognize landmarks along the route to help them navigate. In our study, we hoped to observe whether library users' experience would affect their abilities and strategies of forming spatial representation of the environment.

Landmarks are widely accepted as objects with prominent characteristics to the background (Richter, 2007). Research into how people use landmarks has primarily focused on one of two questions: what objects are identified as landmarks, and how efficiently people are able to employ these landmarks (M. Chun, 2000). We had our focus on the first question. Also inspired by prior research (D. Dearman 2006; J. Hahn, 2011; Butz et al. 2001), we believed that by exploiting both physical (e.g., floor plans) and personal (e.g., remembered connections with objects) landmarks, we could positively support navigation tasks in an indoor environment. However, little research has been conducted on people's preferences for identifying indoor landmarks in a specific environment, such as the library. For example, Sadalla (1980) pointed out that landmarks contains features, such as visual dominating nearby locations, visible from a distance, and greater familiarities. In addition, Sorrow and Hirtle (1999) illustrated that during the process of navigating and orientating, landmarks provide key information about the relationships locations and paths. Also, in the end of the study, researchers also proposed the future work as discovering the connections between the theoretical landmarks can be applied to the design of environments or navigation systems. As indoor landmarks stand out by their own meanings, we believed both the characteristic of the environment and people's role in the environment may affect their navigation behaviours.

Libraries have changed in recent years by increasingly offering information in digital formats (Buchanan, 2010). For example, instead of using card catalogue, libraries started storing book information digitally. In addition, with the assistance of mobile devices, library users can access not only the catalogue but also entire books online at their convenience. While some prior research has explored how library users locate books in traditional ways (Buchanan, 2010; Hahn & Zitron 2011; Mandel, 201; Shenton & Dixon, 2004), we wanted to understand specifically how navigation is completed within new hybrid environments. Furthermore, because our end goal was to develop a context-aware system it was important to study a specific library to which we had access. The choice was made to study indoor landmarks in a more realistic scenario by introducing mobile devices to our participants. More specifically, this allows us to obtain a good understanding of how library users navigate and maintain a sense of orientation (e.g., what landmarks they identify in that environment) in a library can shed light on the landmarks mechanics are able to use.

Shenton and Dixon (2013) highlighted in their study the importance of conducting a user study in a library rather than jumping into developing a system directly is great. In this way, the system can respond to users' requests on their terms, not ours. Therefore, we conducted a field study to observe library users' behaviours while locating books so that we could learn what landmarks they identified and how they used these landmarks to assist in navigating through the library environment.

We conducted our exploratory field study in the Killam Library of Dalhousie University. Considering that library users' behaviours may vary widely, we recruited three groups of participants: inexperienced students, experienced students, and library staff work in the book stack room. We expected these three groups of participants to represent library users at all levels. During the tasks, participants had access to all library resources as usual. Additionally, a mobile device (iPhone 5 smartphone) was provided. In our study, instead of observing library users' natural behaviors, we were interested in understanding how mobile devices play a role in a library setting. We introduced a mobile device to our participants as a resource so that we can observe their adoption and usage of the mobile device.

In order to maintain some control over the search tasks of our participants, we opted to give them assigned tasks rather than have them conduct random book searches in a library. Two sets of book finding tasks were assigned to each participant. One set of tasks contained four books in the participant's familiar domain, while the other set included four books in the participant's unfamiliar domain. After completing the first four tasks in each set, participants were asked to return to the first book in that set relying only on their memories. After all tasks were completed, a semi-structured interview was conducted to discuss their experiences while completing the tasks and what resources they used to do so.

The field study gave us a solid understanding of the problems encountered while locating books in the library for several key groups of users. First, we acquired a deep understanding of participants' navigating behaviors, which includes the difficulties they encountered while locating books and the resource they relied on while navigating with a mobile device. Second, we learned what landmarks are used in a book stack room and how these are used to navigate and maintain orientation in a complex environment that is filled with indistinct landmarks. Our results informed the design of a prototype, which takes great advantage of context in a library setting to facilitate a better book finding experience for library users. In addition, it confirmed the results of Lorenz et al. (2006) who found that, unlike outdoor landmarks, indoor landmarks stand out by their meanings due to people's limited visual range. Therefore, when exploring indoor landmarks, it is of great importance to take the user's individual attributes (i.e., their navigation goals, their knowledge of the environment) into account.

After designing the prototype based on our findings in the field study, we conducted a formative evaluation to get feedback from on our proposed functionality and the validity of the guidelines. Similar to the field study, three groups of participants including inexperienced students, experienced students, and library staff who had not participated in the field study were recruited. A video was presented to demonstrate how our prototype would be used by a student to locate a book within the Killam Library. The purpose of the video was to explain the prototype by means of a realistic scenario that would allow participants to reflect on their past experiences and how this device might have changed those experiences. This was followed by a group discussion focused around two primary

topics: what they felt were the most helpful features for finding books, and how these could be improved for future prototypes and systems.

1.3 SUMMARY OF RESEARCH GOALS

In conclusion, we planned to conduct a field study in the Killam Library to understand library users' navigating behaviors in this hybrid environment. We were particularly interested in how library users navigate through the book stack room, when immersed in an environment filled with indistinct landmarks. Specifically, we wanted to see what landmarks they identify and how they use these to assist in navigation. Through understanding library users' behaviours, we hoped to generalize the results we collected from the field study to a higher level. Our aim was to propose guidelines that could be used in the design of systems for other hybrid environments as well.

1.4 ORGANIZATIONAL OVERVIEW

This thesis contains seven chapters, with this introduction being the first. Chapter 2 introduces the background literature in the area of landmarks, context, and related studies in library environments. Chapter 3 discusses our methodologies for both the exploratory field study and prototype evaluation. Chapter 4 contains our analysis of data collected from the field exploratory study, including participants' behaviours while locating books and the resources they utilized to maintain a sense of orientation in the library. Chapter 5 gives an overview of the design requirements based on our findings and the prototype we created. Chapter 6 presents the results of the prototype evaluation focus groups and discusses how this feedback further influences our guidelines. We conclude with chapter 7, which summarizes our findings and discusses the limitations of this study, as well as suggested directions for further study and exploration.

CHAPTER 2 LITERATURE REVIEW

2.1 WAYFINDING

Wayfinding studies mainly try to explain how people navigate in a physical world, their navigating behaviors and what would influence people's wayfinding behaviors (Raubal & Winter, 2002). Reviewing the wayfinding studies allows us to acquire a general understanding of people's basic navigating behaviors.

Wayfinding is a fundamental process that involves exploration, route planning, and other forms of navigation enabling us to use spatial information to navigate and explore a physical space. Several studies (Allen, 1999 & Smith, Glenberg, & Bjork, 1978) described how people find their way in the physical world, including what spatial information they need, how they communicate directions, and how an individual's verbal and visual abilities influence wayfinding experiences. Allen (1999) described wayfinding behaviours as purposeful movements to a specific distant destination, which can be classified into three categories that are travel to a familiar destination, travel to novel destination, and exploratory travel returning to a familiar destination point.

Smith et al. (1978) showed that people intended to maintain the awareness of their surroundings during navigation, especially in a unfamiliar environment. During wayfinding, people use various spatial, cognitive, and behavioural abilities to identify useful environmental cues. Landmarks assist in maintaining an ongoing mental representation of the environment, helping people to find their way. Constructing spatial knowledge by encoding landmarks in the current environment lays the foundation for generating successful navigation routes (Lovelace, Hegarty, & Montello, 1999). Generating routes requires forming a mental representation of the space. Mental representations of a route typically include physical elements along the way (landmarks) and motor activities (e.g., current movements). Lovelace et al. (1999) proposed the definition of "view-action pair" as a pairing of physical elements and motions, claiming these to be the most basic building blocks of a mental representation of the environment. This pair constructs the core of the visualized route and allows patrons to recall all of the

details necessary to complete the route. Similarly, Allen (1997) classified the elements of mental representation of the environment into descriptive (environmental features) and directives (movement or state-of-being verbs). This shows that not only are physical landmarks remembered during navigation, but the person's movements along the way as well. These two factors (physical elements and motion) work in conjunction, with each factor being able to trigger a memory of the other. For example, by seeing a landmark we may recall our movements at the last time we viewed it. Rather than focusing on the elements affecting production of good mental routes, other studies (Richter, 2007; Lovelace et al. 1999) focused their attention on important aspects of constituting good route directions. The studies tested priming the participants for upcoming choice points, suggesting landmarks at the choice points, giving "you've gone too far" alerts in cases where choice points were missed, and providing landmarks instead of street names, etc. Especially when dealing with unfamiliar areas, participants showed a higher preference for getting to know the upcoming choice points (i.e., intersections where they need to make decision on which way to turn). Additionally, participants' familiarity with the environment also played an important role in route direction production. In general when recalling the features of the areas that they had been, participants tended to present a mental representation of the area with simplified, incorrect or even non-existent spatial representation (Lovelace et al., 1999). However, when comparing between areas that participants familiar and unfamiliar with, they explained that the participants' familiarity is positively correlated with the completeness of the mental representation of the environment. In our study, we take this point into consideration by examining data between participants doing book finding tasks in their familiar domains and unfamiliar domains.

2.2 LANDMARKS

As we discussed above, people tend to maintain a clear mental representation of the surrounding environment via encoding landmarks (Sorrows & Hirtle, 1999; Frankenstein, Brussow, Ruzzoli & Holscher, 2012). Landmarks are widely defined. Sorrows and Hirtle (1999) first proposed that landmarks are objects in the environment that can serve to define the locations and the location of other objects. Lynch (1960) defined landmarks as objects with prominent and contrasting characteristics to the background, which can be

summarized by their distinctiveness in comparison with the surroundings. In the study (Butz, Kruger, & Lohse, 2001), landmarks are memorable cues identified by patrons along a path, which enable the encoding of spatial relations between objects and paths. Frankstein et al. considered landmarks help wayfinders “identify their current location and orientation relative to route or survey representation of the environment, either internally on a cognitive map or externally on a cartographic map” (2012, p. 165). Definition of landmarks may vary, but generally they help develop a mental representation of the surrounding environment. Landmarks not only are used to generate mental presentations of space, but also to facilitate in communication of route directions. The significance of landmarks has been demonstrated in many studies. Raubal and Winter (2002) have demonstrated that landmark-enriched maps provide better guidance as well as result in fewer wayfinding errors when compared to maps without landmarks. More specifically, they act as a way to convey route information, orientation cues and suggestions about regional differentiating features. The importance of understanding the way people utilize landmarks during spatial reasoning and communication of routes cannot be overlooked. In addition, Raulbal and Winter also pointed out, the question not only contains theoretical value but is highly practical.

The characteristics of landmarks may vary. Although the features of landmarks are various, they (Raubal & Winte) are generally described as "an object or structure that marks a locality and is used as a point of reference" (2002. p. 245). The breakthrough of landmarks is that researchers Lovelace et al. (1999) proposed that landmarks can be identified not only from its physical attributes (e.g., outstanding characteristics) but also its connection with wayfinders that is based on the current context of the environment. Later on, Sorrow and Hirtle (1999) examined landmarks from more diverse perspectives. They classified landmarks into three categories as: visual landmarks (landmarks with visual contrast), cognitive landmarks (landmarks identified due to their connection with people), and structure landmarks (landmarks with special/prominent locations). Their classification not only expanded the definition of landmarks from only being visual contrasting to the meaning they contain, but also expanded the definition of its form from only including physical objects to including abstract concepts as well. For instance, when revisiting a city, a tourist may have the memory of a nice restaurant he went to before. This restaurant serves

as a cognitive landmark because of the personal connection he built. However, it can easily be missed out by other tourists who have not had the same experience. Other researchers, such as Lovelace et al. (1999) categorize landmarks as on-route landmarks and choice point landmarks. They have found that both the landmarks at the choice point and the landmarks along the way (i.e., on-route landmarks) are of great importance. In their study, participants reported more than 50% landmarks on-route landmarks when navigating through an unfamiliar environment versus 40% on-route landmarks were reported in a familiar environment. This number showed that when in an unfamiliar environment, patron have a higher tendency memorizing landmarks along the way than just memorizing landmarks at choice points. Caduff and Timpf did a thorough literature review on landmark saliency assessment, and analyzed “which components add to the relative importance of spatial objects for navigation” (2008, p. 262). It highlighted the fact that when examining the salience of landmarks, researchers should be determined when taking into consideration the current environment along with perceptual and cognitive abilities of traveler.

Several studies (e.g., Giudice, Walton, & Worboys, 2010;Huang & Gartner, 2010;Radoczky, 2007) have classified landmarks into indoor landmarks and outdoor landmarks. Hang et al. (2010) indicated that although outdoor landmarks and indoor landmarks share some characteristics in common, the way of identifying indoor landmarks and the way people utilise indoor landmarks are quite different from that of outdoor landmarks. First of all, given the indoor environment, it is expected that the number of options for indoor landmarks is limited. Radoczky (2007) generalized the potential candidates for indoor landmarks as elevators, escalators, stairs, doors, plants, information boards, signs, fire extinguishers, etc. Even with the limited number of options, indoor landmarks are still considered as essential for route description. Second, identifying indoor landmarks is a more subjective process than identifying outdoor landmarks. When comparing indoor landmarks with outdoor landmarks, their physical features might not be as remarkable as outdoor landmarks (e.g., tall buildings). However, despite the visual aspect, indoor landmarks can stand out due to their meaning and content. This aspect is similar to cognitive landmarks, which are identified due to their connection with people.

By adding layer of meaning and context to the definition of indoor landmarks, the diversity of indoor landmarks expands and becomes immense, which makes it difficult to effectively include them in guiding instructions. People tend to identify indoor landmarks not only by their physical features (e.g., size or appearance) but also their personal connections. For example, Starbucks in a hospital is frequently cited as indoor landmarks due to their outstanding logo and prominent placement. However, the waiting room might be considered as landmarks when experienced long waiting period under the circumstance that it easily blend in with other rooms in the hospital. The standards of identifying indoor landmarks are various based on individual background and the personal connection they make towards the indoor landmarks.

From the previous discussion, we can see that landmarks are examined and categorized from diverse perspectives. Hailpern et al. (2011) broaden the definition of landmarks further by proposing the definition of "activity landmarks", which are described as incidental items that registered in the mind along with the task that people are doing. Leveraging activity landmarks can associate the incidentals with the views that people were seeing at that moment so that strengthen the ability of recalling and can help navigate. We found that the activity landmarks are similar to abstract landmarks, which fall into category of cognitive landmarks.

Landmarks are of great importance in representing and understanding physical spaces. Sorrows and Hirtle (1999) proposed that "space acquisition often begins with place knowledge, particularly identifying landmarks" (1999, p. 38). Similarly, Sorrow and Hirtle suggested that landmarks are aids for the users in navigating and understanding space. It showed that landmarks can help organize the space for users. The key for facilitating a smooth navigation experience is to representing the spatial characteristics of the environment through identifying landmarks. Radoczky et al. (2005) also indicated that with being able to verify landmarks along the way, users would feel more confident when navigating in an indoor environment. Miller et al. (2010) carried out a study to understand what makes a given landmark salient. They conducted a study using a virtual museum and asked participants to memorize the identities and the location of the objects on the task route. They found that the process of landmark selection is strongly affected by spatial

features. In addition, another study discovered this point by studying why people felt a sense of disorientation in a labyrinth. Passini (1996) summarized the primary reason that people feel a sense of disorientation in a labyrinth is due to the lack of distinctive units in the environment. When envisioning the layout of a maze, the uniform appearance of the walls or tunnels present an almost identical view of every intersection. Furthermore, they indicated that being in a place, such as maze, brings certain level of discomfort, which results in an attempt to navigate out. They also suggested the importance of differentiation in composing a cognitive understanding of environment.

Similarly, Abu-Ghazze (1996) illustrated the difficulty of navigating through an environment without distinguishable landmarks by conducting a study in a university, which contains a set of buildings with nearly identical external architecture and internal floor plans. In this study, researchers observed frustration and confusion from participants during the process of learning and navigating the environment, which was confirmed with participants in a follow up interview to be the result of the visually repetitive spaces. Moreover, the dependency of ambient environment can decrease due to tasks that require people to highly focus. In this case, environmental contextual processing is suppressed to allow better conceptual processing for the tasks. Under this circumstance, it can lead to little or even no encoding of the environmental context. Also, research (Radoczky, 2007) found that landmarks are identified also based on peoples' goal of navigating through the environment. Therefore, the purpose of the navigation should not be overlooked. Not only the tasks but also the characteristics of environment can have great influence on the landmarks identified in the environment (Sorrows & Hirtle, 1999). Various categories of landmarks with different characteristics influence people's abilities to navigate differently. This result highlighted that the participants' dependencies on landmarks, and suggested imposing organization in a complex environment can solve this problem at some degree.

2.3 NAVIGATION SYSTEMS

Extensive studies have been conducted on how to convey spatial information efficiently with the help of landmarks. Studies shows that maps are considered as significant a presentation form that allow spatial information to be communicated efficiently (Radoczky

& Gartner, 2005). Maps outperformed other formats such as pure textual or oral guiding instructions due to their ability to provide direct visual information that users can interact with other than receiving information from one resource. The essence of maps is in providing users with overall views of an area. When it comes to using maps during navigation processes, users value the essential topological information that can be extracted from the map over than its process, under the circumstance that the distortion is not disproportionally high. The topological information can be presented differently from the perceived structure of the real environment based on the use of the map. One study (Reilly et al., 2008) found that textual display of route information was the most effective presentation compared to imaged-based route information (e.g., floor plan).

With technology advancing, automatic navigation systems were developed incorporating the merits of maps. To further detail the use of navigation systems, outdoor navigation systems and indoor navigation system have been studied individually to support patrons' different needs for wayfinding. Although wayfinding in an indoor environment and outdoor environment share some similarities, there are significant differences in systems that support these tasks. Radoczky (2007) highlighted the differences in the designs of indoor and outdoor navigation systems from user's walking speed and attention perspectives. They compared users' walking speed and their available attention in indoor and outdoor environments separately. As to the user's speed, walking speed in an indoor environment is much slower than driving speed. As to users' available attention, users can spare more attention on an indoor navigation system as opposed to drivers who have to closely pay attention to traffic. Taking these two aspects into consideration, Rodoczky (2007) proposed adding multimedia presentation forms to an indoor navigation system can help users access more details and background information about the environment. Similar point was mentioned by Baus et al. (2002). In their study, they pointed out that cognitive resources, such as user's traveling speed and the time pressures should be taken into account when it comes to designing navigation systems. Whereas, another study expressed the concern of bringing multimedia presentation into an indoor navigation system. Michon and Deinis (2001) indicated in his study that multimedia presentation does not provide valuable aid because it requires users to take time comparing reality with the photographs, increasing mental loads. However, there is an exceptional circumstance. He claimed that

when users are not familiar with the environment and are not in a hurry, the multimedia presentation can provide users with additional information of the nearby environment to support their wayfinding.

2.3.1 Current State of Indoor Navigation Systems

Radoczky claimed that “people are more likely lose their orientation within buildings than outdoors due to the density of conventional landmarks is rather low” (2007, p. 302). However, when they compared indoor to outdoor navigation systems for wayfinding they found that "indoor location sensing technology are still in their infancy" (Buchanan, 2010, p. 274). Nurmi et al. (2011) studied how landmarks help people navigate in an indoor environment. They discovered that navigation instructions, which demand more attention from participants do not necessarily improve recall of the surrounding environment. However, this study simply focused on observing how participants navigate by giving them audio instructions in a superstore. It failed to take into account that participants' behaviors may be different when doing grocery shopping than following audio instructions. Abascal et al. (2005) did a thorough literature review about the characteristics of indoor landmarks to exploit the properties of the indoor environment in order to perform intelligent indoor navigation. They took technology limitation into consideration, and only analyzed landmarks that can be identified by robot sensors. Therefore, corridor, emergency exit panel and wooden doors were chosen to be landmarks to analyze how they can help provide navigational aids. However, their theoretical guidelines need to be examined more in a realistic scenario.

There are several difficulties of incorporating landmarks in an indoor navigation system. First, indoor navigation systems can be used under various circumstances. In an indoor environment, patrons' goals differ from one to another. There are many factors that need to be considered, such as a user's background, their familiarities with the environment, etc. Moreover, technology limitations have also limited exploration of indoor navigation systems. Second, the immense diversity of landmarks makes it is difficult to include them in an indoor navigation system (Radoczky, 2007). Indoor landmarks were studied in a general setting. More specifically, the exploration of landmarks is limited to visual landmarks. Little research has studied with respect to how other cognitive landmarks (i.e.,

landmarks stand out by its own meaning or the connection users build) may be able to help library users develop a clear presentation of the current indoor environment as well as help them to obtain an awareness of their current locations throughout the entire wayfinding experience. Furthermore, identifying landmarks is considered as a subjective process (Buchanan, 2010), especially when expanding landmarks to a cognitive level. It is hard to predict the landmarks that people will identify with as individuals' criteria varies.

Currently, most existing indoor navigation systems extract their information directly from physical environment. Extracting the information from natural environment is helpful in an outdoor navigation system, when prominent landmarks, such as outstanding skyscrapers, can be identified by users easily. However, most users feel little connection with the landmarks identified in the indoor navigation system and struggle to make use of these (Nurmi et al., 2011). Buchanan (2010) proposed that in order to make up for the limitations of indoor GPS technology, indoor navigation systems should incorporate contextual cues from the environment . Therefore, incorporating indoor landmarks in an indoor navigation system needs to be given more consideration with respect to the connection between people and landmarks. In conclusion, as Buchanan asserts "the interface design and methods for capturing useful context data are fertile ground for future research" (2010, p.274).

2.4 CONTEXT

Although landmarks are mostly discussed as relating to wayfinding in physical environments, researchers have discovered similarities between the wayfinding process in physical environments and electronic environments. First, consider the methods employed in wayfinding in both areas. Methods including oriented search (orienting themselves with correct directions), following a marked trail (remembering paths), referring to a cognitive map (forming mental maps), and piloting between landmarks based on route knowledge (judging distance between two landmarks), path integration (completing mental map of the current environment) are introduced to accomplish wayfinding tasks in a real environment (Sorrows and Hirtle, 1999). On the other hand, navigation strategies including "searching for information in either a known or unknown location, browsing for new information, and

exploring a space to determine the quantity and coverage of information without regard to the details" are commonly used in wayfinding process in electronic environments. In addition, the study (Raubal & Winter, 2002) revealed that users' navigating behaviours are surprisingly similar in both wayfinding areas. For example, a user might come across interesting paths or location, in order to be able to return to those locations he or she may have to memorize certain landmarks along the way. As to navigating through a digital environment, a complex network consists of different links connecting by nodes. Thus if a user wants to revisit a webpage containing useful information, she has to be able to recall some activity landmarks that were seen during the original search. We believe that gaining a general understanding of the use of landmarks in the digital space may expand our knowledge of landmarks (e.g., activity landmarks, which was discovered in the following study).

We came across prior research on Youpivot, a navigation system, which illustrates how the landmarks assist users with navigation in a digital space. Youpivot (Hailpern et al., 2011) is a contextual history based search tool, which is designed to help users navigate through digital space. It allows users to filter their search results (of online activities and files) by providing contextual cues to the system. Leveraging contextual cues can speed up the recall process without increasing a user's cognitive load (Nurmi et al., 2011). After a user types in the contextual cues they remember (e.g., the name of the song that the user was listening to while using these files), the system can automatically display all the files and web pages opened during that period of time when the contextual cues were active. Context search is a term, first proposed by Hailpern et al. (2011), to describe searching tasks based on context cues. The following is an example given in this study to explain the concept of context search. "Where did I save the PDF file? I can't remember it, but it seems like I got a text message from my co-worker at that moment." In this case, the context search is searching the location of the PDF. Getting a text message from the co-worker is the context cue, which can be interpreted as the activity landmark to help the user trace back the location of the PDF file. In their study (Hailpern et al. 2011), context search is supported by a module called "TimeMark". Generally speaking, TimeMark is an annotation method, which allows users to "mark a moment in time as being important" by typing in the activities that they were doing at that moment or any outstanding events into the system.

Time marks record the contextual cues, more specifically the activity landmarks for users' future recalling.

Youpivot helps shed light on the importance of utilizing contextual cues, which can be considered as activity landmarks for navigating through a digital space. Throughout their study (Hailpern et al, 2011), we also noted that the concepts of environmental contexts and landmarks overlap to some extent. We illustrate this point by introducing Dey's definition of context. Dey (2001) defined context as any features that are relevant and can be used to characterize a particular situation and convey ambient environment, which can either be physical or conceptual. This definition is similar to the definition of landmarks, which serve to define the locations and the location of other objects. Hailpern et al. (2011) defined the context as all related activities that happened during the duration of the context search. This definition of the context reminds us of cognitive landmarks that we discussed above. Furthermore, in another study, Ringel et al. (2002) directly considered that personal landmarks and public landmarks are the contexts in the environment. As to the features of context, Chun and Jiang (2003) indicated that the importance of environmental contextual cues mostly lays in their ability to incorporate visual properties of the environment. Landmarks are often highlighted by their visual attributes and described as "prominent and contrasting to the background" (Chun & Jiang, 2003, p. 235). On one hand, the landmarks were examined by a variety of perspectives, such as their physical attributes perspective and the personal connections that observer built with them. On the other hand, Chun indicated that the process of examining environmental contextual cues is also active as the context must be sensitive to observers' behavioural goals and intentions. In other words, for any given situation, observers tend to prioritize different contextual cues when they are in different environments.

Furthermore, both contextual cues and landmarks can help speed up the recall process without increasing a person's cognitive load. Recalling is a significant aspect that is studied greatly in wayfinding research as well. The initial studies (Chun & Jiang, 2003; Bjork, 1989; Haipern et al., 2011) regarding recalling during the wayfinding process investigated the relationship between human memory and context. Chun and Jiang (2003) illustrated that not only the vision of contextual cues can trigger the memory of the environment

where the contextual cues were identified, but also the environment can activate the memory of the contextual cues, which were identified in that environment. The vision of the contextual cues and the memory of the environment fill up details of the views and help people build a clear mental representation of the environment that they are navigating through. In addition, not only memory but also their personal experiences regarding the current environment may affect visual processes and eventually influence the process of identifying the contextual cues. The advantage of linking environmental context and human memory can greatly improve speed and accuracy in recalling tasks (Murnane & Phelps, 1994). More specifically, when there is a match between the cues that people stored in the memory and the real contextual cues, it facilitates retrieval of other information that registered along with the contextual cues, such as the activity that people were doing or their actions at that moment. However, a mismatched context information (i.e., identifying the wrong cues) is one of the important causes of frustration and confusion during the navigating process. Therefore, in order to build an indoor navigation system, it is important to understand the contextual cues in an indoor environment people identify and adapt the representation of the indoor environment based on the environment's characteristics (Radoczky, 2007).

After reviewing all the similarities between context and landmarks, we can conclude that context is a generalized term that can incorporate the definitions of all different types of landmarks. As Hahn and Zitron said "the notion of context emerged as an important theme in the present wayfinding study" (2011, p.29). Although with research has become more directed toward studying one specific kind of landmarks, we should also not overlook the situation from a holistic perspective.

2.5 REFINDING INFORMATION

Refinding is another important aspect that highly connects with recalling process as during the refinding process, people need to recall information they encountered previously. Finding and refinding information are different activities. Finding information for the first time is an exploratory activity, yet refinding is a more directed process (Buchanan, 2010). As we can see, by definition, a refinding task implies doing a previously accomplished

finding task. For the past few years, the challenges involving how people re-find information have received much attention. Re-finding tasks can be categorized in many ways (Huang & Gartner, 2010), such as the primary reasons behind searching activities or the content of searching activities. Elswailer et al. (2011) categorized re-finding tasks into three types--lookup tasks, item searching tasks and multi-item searching tasks. The main differences between lookup tasks and item searching tasks are the required quantity of information and the certainty of resource searching. In a library setting, tasks are normally item-searching tasks and multi-item searching tasks (e.g., searching a specific book or finding several books).

Many studies have also focused on understanding what factors make re-finding tasks difficult (Huang & Gartner, 2010; Elswailer, Baillie, & Ruthven, 2011; Capra & Perez-Quinones, 2003). For instance, Ratwani et al. (2008) suggested factors such as frequency and recency of information finding, have a huge impact on the efficiency of re-finding tasks. A few studies have showed that elapsed time impacts the effectiveness of re-finding information (Elswailer, Baillie, & Ruthven, 2011; Capra & Perez-Quinones, 2003). The duration of elapsed time can impact how people deal with re-finding tasks. Capra and Perez-Quinones (2003) performed a field study, he illustrated that, if the elapsed time is long enough that participants would forget information initially acquired, they would consider the re-finding task to be a finding task. Frequency is another factor that influences re-finding tasks. Elswailer et al. (2011) proposed the concept of "temperature" to describe the frequency of re-accessing information. A "hot" task was defined as information that needs to be re-accessed with a frequency of at least once a week; a "warm" task is information needs to be re-accessed once a month; and a "cold" tasks has an elapsed frequency longer than a month. We summarized those factors (i.e., frequency and recency of information retrieval, elapsed time, "temperature" of tasks) as information familiarity. Libraries are vast, and most library users will only have experience in certain domains. To fit our study need, we adopt "information familiarity" in our study with a slightly change of focus. Instead of focusing on the frequency of people using library, we interpreted "information familiarity" as the familiarity of the domains of the books that our participants need.

Although, most research studied "information familiarity" in a digital domain and only required participants to navigate through their personal information management (i.e., the resources are in the participants personal information spaces), we value the importance of understanding how they utilize their acquired knowledge from previous experience in conjunction with other context in a physical environment to finish refinding tasks. Thus, we considered library is a good environment setting, where users are familiar with small area but may have not encountered most of the context in the library.

2.6 CURRENT LIBRARY STUDIES

Library users may find it hard to maintain a sense of orientation while navigation in the libraries, which have confusing layouts (Mandel, 2011). Their difficulties of navigating in a library may result from using the call number system (Hahn & Zitron, 2011; Carr, 2006), which requires library users to pay attention on knowing the patterns of call numbers. Eaton (1991) conducted a field study to observe library users' reactions (participants ranging from 5th grade and high school students) after they got lost between the catalog and the stack. This study found that his participants normally did not follow the direct route due to the need of searching orienting information. In addition, he also found that participants' choices of routes are depended on many factors (e.g., availability information at that point, and the searcher's ability of using that information). Two library studies (Hahn & Zitron, 2011; Sorrow and Hirtle 1999) have had the goal to provide better instructions by modifying and hanging signage in the library and making sure library users have easy access to get help from library staff. However, as we learned from the field study (see Chapter 4.) locating books in a library is still considered as difficult tasks by most of our participants. For example, Sorrow and Hirtle (1999) showed that signage is easily missed, especially when wayfinders are not familiar with this environment. Because their unfamiliarity with the environment, they have few clue about where those signs are and what the signs look like. With the adoption of mobile devices, some researchers developed systems trying to help users identify physical landmarks in a library so that they can retain the sense of orientation (Buchanan, 2010; Satpathy & Mathew, 2006). Whereas, identifying physical landmarks are helpful to some degree, it also creates user's cognitive load by asking them to adapt their wayfinding strategies from the system's perspective. Buchanan

pointed out that "our understanding of how people interact with library is poor, and the study of library from a human-computer interaction perspective is minimal" (2011, p. 274).

In addition, the library environment has changed. Researcher Veronikis et al. claimed that "During last decades, many information providers, such as libraries, have been collecting, organizing, and delivering information in both print and digital formation, which forms a hybrid information environment" (2011 p.77). Both studies (Buchanan, 2010; Veronikis, Tsakonas, & Papatheodorou, 2011) have noticed and started valuing the notion of "hybrid environment" in a library. However, they chose to study the "hybrid environment" from different perspectives. On one hand, Buchanan (2010) interpreted "hybrid environment" as a library contains both digital holding of printed books and digital library (i.e., only online documents provided in the library, no printed copies). With this concept, they put efforts into understanding how context cues of user's surrounding area can support user's digital searching results on catalog. On the other hand, Veronikis et al. (2011) emphasized the fact that library has been improved so that it is able to organize and deliver information in both digital and physical format (i.e., printed format), and then placed their attention on studying the influences brought by mobile devices in a library setting. With the high adoption rate of mobile devices (e.g., mobile phone, tablets), the essential change is that library users are able to access to more resources to find books of their interest. Although the hybrid environment has become a characteristic of libraries, many studies still made use of the conclusions from user studies conducted several years ago, which lead to obtaining results derailed from the real situation (Elsweiler, Baillie, & Ruthven, 2011). We adopted latter concept of "hybrid environment" as there are more resources for library users to access to the information of their own interest in a library. This study is motivated by this concept and hope to study the changes in the library through focusing on the change of the library users' behaviours with respect to finding books under the assistance of the mobile device. Even though there are limited landmarks in the library that can be utilized, Buchanan (2010) proposed that we can make advantage of context in the library by acquire understanding of library users' behaviours, especially regarding their navigation strategies, what their goals of finding the book are, etc.

As discussed above, library users are immersed in endless of bookshelves, their confusion and disorientation arising during the wayfinding process are mostly due to the lack of distinctive units in that space. Lack of distinctive units leads wayfinders to fail to mentally visualize the spatial layout of this surrounding environment (Passini, 1996). Libraries have system using signs, arranging stacks and providing service to facilitate a library user's wayfinding experience to some extent. However, this system can also hinder the wayfinding experience by creating conflicts between library user's understanding of this system and how the system actually works at some point. Therefore, it is understandable why library users easily get lost in a library. For instance, when library users are trying to envision the path they navigated, purely recalling the identical features of a library (e.g., endless walls or identical book stacks) make it difficult to differentiate the path they took before. Furthermore, the concept of information overloaded was examined by study (Chun & Jiang, 2003). Information overload is a situation occurs when there are an overwhelming number of objects and events competing for visual awareness and control of actions. Although their behaviours can be guided by these objects in an environment, people's attention is easily distracted by those objects, which may result in a feeling of being lost in the overloaded information.

After reviewing the library environment, we will be presenting two library studies (Buchanan, 2010;Hahn, 2012) that were motivated by the common understanding that library environments contribute to library users' feeling of being lost. Buchanan (2010) adopted the concept of "context search" that was first proposed in study (Hailpern et al., 2011). They introduced a system Emli, which extracts the topics or contents from the stacks of books near library users and recommend books that are tightly relevant to the topics/content that library users need. A user study was first conducted to obtain a better understanding of library user's behaviours, followed by a semi-structured interviews to get further information on library practices. From the user study, researchers identified the causes of unpleasant book finding experiences to be mostly the result of unclear classifications of books and identical landmarks in the environment. Moreover, two patterns of behaviours were observed regarding using books in a library – hoarding and dipping. Hoarding is a behaviour that library users take a pile of books from bookshelves that are relatively far from where they are sitting, and dipping describe a behaviour that

library users sit nearby by bookshelves where she/he can constantly go back to get the books on the shelves. In order to be able to extract book topics/contents, books are placed with simple sensors (i.e., electronic tags and Bluetooth beacons). By analyzing information extracted from sensors placed on those books, the system can suggest highly relevant books to library users. Although this system that was developed mainly focused on the interaction between users and library catalogue and failed to directly support user's interaction with the physical library, it did shed some light on the importance of utilizing context in the surround environment to assist library users with book finding tasks.

Instead of digital library, another study (Satpathy & Mathew, 2006) focused on improving the wayfinding experience for library users from a more technical perspective. Researcher Satpathy and Mathew (2006) developed a system by using RFID and Bluetooth technology to support library users throughout the entire process from finding book information on the catalogue till checking out. A large database was designed to store book information including call numbers, ISBN, title, author's name, abstract, keywords, location, etc. RFID tags were placed on the books that act like barcodes to transmit information. RFID and Bluetooth technology support the system to keep track of the books that library users are looking up. With the information acquired from RFID and Bluetooth, the system can extract information, such as book location from pre-designed database. In their system, the floor plan was displayed in a grid without showing any landmarks or user's location. After get the book information, the system highlights the corresponding grid to inform users the location of the wanted book. However, the model is built based on many assumptions they made during the study. Researchers were not certain whether their assumptions still holds when it comes to a realistic scenarios. In contrast, the prototype we designed mainly takes advantage of the book information stored in current database. Moreover, their system was developed without acquiring a solid understanding of library user's behaviours, which might overlook the real situations in the library.

Similar to our study, Hahn (2012) conducted a use study to gain an understanding of how students conceptualize the search for books in the library after they have a call number in hand. They emphasise the importance of gaining a basic understanding from students when looking up books in a library so that they can deliver the most preferred information to

students successfully. This study was mainly to reveal the environmental context that students who are new to this environment would utilize for wayfinding in a library setting. Participants in this study were asked to find two random books and one DVD on the lower level of the University Library. Hahn et al.(2010) noted that students were easily confused with call numbers. This is due to the students' lack of context and reference to associate the call number with corresponding location of the book on the shelf, and the wrong interpretations of call numbers often led them to an incorrect place, which arose confusion. Furthermore, this study classified the "fail points" (i.e., objects that could create confusions to the inexperienced library users) and the wayfinding tools that they used during the finding tasks. However, researchers failed to report that how they decided the fail point, the accurate description of the tools they used (e.g., they only mentioned participants used signs in the library without articulating what signs) and how participants used in the study. This study successfully revealed the difficulties that inexperienced library users encountered in a library, it later switched their attention on drawing recommendations for library layouts in the end. In the future work, they highlighted the preferred information in the book finding tasks, such as signage or assistance that are currently available in the library. Whereas, it mentioned little regarding how taking advantage of user's knowledge of the environment can improve the wayfinding experience in a library.

Another user study conducted in a library setting (Shenton & Dixon, 2013) revealed a valuable point regarding library users' behaviours. They indicated that library users performed different types of behaviours when they have different goals or acquire different knowledge in certain areas. For example, when locating books, library users who are familiar with the library went directly to the part of the library where it has the collections they need without looking for additional information as opposed to inexperienced library users who need to consult letters' ascending/descending orders carefully on the bookshelves or sought help from library staff. This point expanded our view from understanding the user's behaviour of looking up a book into understanding how users react to finding a book in their familiar area and finding a book in their unfamiliar area.

CHAPTER 3 METHODOLOGY

3.1 EXPLORATORY FIELD STUDY

3.1.1 Introduction

Once the call numbers are found by library users, locating the books in a library consists of two general steps: 1) navigating the book stack room in search of the correct section, followed by 2) a localized search of that section to locate the target book on the shelf. Throughout this process, library patrons reference the target books' unique call number and make use of signage in the library to systematically reduce the searching area. Given the large and complex environment that these tasks take place in, we felt that conducting the study in a real library would provide more accurate information on these wayfinding tasks than would be possible in the lab. We need a technique, which would allow us to examine the behaviors of library patrons as they locate specific books within a real-world library. Therefore, we chose to conduct an exploratory field study. Our research questions in the study were:

- A. How do library patrons locate specific books within an environment filled with indistinct landmarks?
- B. What difficulties do library patrons face while locating books in a library?
- C. Do library patrons use mobile devices while locating books? If so, how are they used?

The first question helped us understand what information participants require while navigating the library. Our goal was to answer this taking into account participants' familiarities with the environment (e.g., using signage in the library) and their knowledge of the topics/domains. The second question can be answered by observing participants as they complete a number of tasks that simulated real-world usage of a library. The third question helped us acquire a general sense of participants' willingness of using mobile

phone (i.e., mobile adoption) in a library setting and if, when difficulties were encountered, patrons used these mobile devices as resources in problem solving or if they use more traditional methods. We consider, by answering above-mentioned research questions, we can acquire a better understanding of library users' behaviors when navigating in a library and propose guidelines for the indoor navigation system, which help library users with finding books by providing them a clear representation of current environment with landmarks they are sensitive to (see Section 4.6).

We considered conducting a field study vital to understanding the current challenges of locating books with the assistance of a mobile device within the environmental context of a library. However, we were aware of the challenges inherent in conducting exploratory field studies. For example, field studies are time-consuming and the added value is often unknown (Kjeldskov et al. 2004). Furthermore, during the field study, participants' behaviours might change due to the fact that they were followed and observed by researchers (Henderson & Feiner, 2011). Dearman et al. (2005) conducted a study which showed the importance of providing details of the methodology to assist in interpreting the results properly.

3.1.2 Participants and Setting

Because the experience of library users may result in different behaviors in terms of finding books, we recruited three groups of participants who represent library users at all levels. We defined inexperienced students as students who borrowed books from the Killam Library less than twice a month; experienced students as students who borrowed books from the Killam Library twice a month or more. We only recruited library staff who are responsible for organizing the books in book stack room. Initially, ten students and five library staff took part in our study. All participants were recruited through emails and received pre-session questionnaires (see Appendix F and Appendix G) before taking part in the study. After receiving the pre-session questionnaires, we chose books in each participant's familiar and unfamiliar domains and scheduled a time with our participants. Participants met with researchers in the Killam Library then began the tasks, after having provided their informed consent, were compensated \$20 for their participation. However, during the study, we discovered that three students who claimed to be experienced library

users did not meet our criteria. We decided to place these participants into an inexperienced students group and then recruited another five experienced students to participate in this study. By the end of the study, we had fifteen students (eight inexperienced students and seven experienced students) and five library staff in this study. Participants were from various departments including Art and Social Science, Engineering, Computer Science, and Management. All participants had experience using a smartphone, so we expected few significant barriers due to unfamiliarity with the technology. We understand that providing a mobile phone to participants could potentially impact the normal behaviour. However, we consider it as a tradeoff since we were hoping to learn more about how a mobile device could help with their locating tasks.

The exploratory field study took place in the Killam Memorial Library at Dalhousie University, one of the largest and most active academic libraries in Canada (Dalhousie University, 2013). The library is five-floor high with a computer lab, reading room, reference collection, reserve desks and information commons on the first floor and a stairwell near the entrance leading to the second floor. However, the stairwells between the second and fifth floors are at the sides of the library and seem to be intended primarily as fire exits; elevators are located centrally, and according to our observations, they appear to be used more frequently to move between floors. A set of library maps is placed across from the elevator on each floor. Each floor's layout is unique (see Appendix A for the floor maps of the library). Most books are stored on the second to fourth floors. With the exception of the books on the second floor, which consists primarily of government documents use a different call number system, all the books in Killam Library use Library of Congress Classification system to generate the call numbers. Books in our tasks were chosen from the third and fourth floors. Although the interior design and signage on these floors are almost identical, their layout is quite different.

3.1.3 Study Protocol

The exploratory field study was designed to explore two key topics. First, the first and second research questions mainly to explore how do library patrons orient themselves and navigate in an environment that is filled with indistinct landmarks? Second, with libraries

gradually becoming physical-digital hybrids by allowing library users to access to book information digitally, how can mobile devices assist patrons in locating physical books?

The design of this study can be seen in Table 1. (i.e., their experience of using library) were recruited (see Section 4.1). Before the study, a pre-session questionnaire was sent to them in order to know their background and experience of using the library. Pre-session questionnaires (see Appendix F and Appendix G) were designed to capture details of our sample in four key aspects. The first aspect was to know participants' general demographics including gender, department of study, and educational background; second, we asked about participants' familiarity with the Killam Library (where the field study was conducted). Researchers categorized the library's areas based on the areas labeled on the map provided on library's website. Participants described their familiarity with each area on a standardized Likert scale; third, participants filled in their previous experiences of borrowing books from the Killam Library, including their three most familiar topics, how frequently they borrow, and the most recent book they had checked out; fourth, we asked about participants' experience with using mobile devices to assist with borrowing books.

To account for the expertise of library staff, small changes were made to the questionnaire (see Appendix G) to focus on their level of work experience so that we could look for relationships between their experience and their efficiency at completing tasks. Talking to the supervisor of library staff gave us an understanding of the work staff members are responsible for, which ranges from "tidy-up" activities (i.e., re-shelving and organizing books), "pick-up" (i.e., placing books on the shelves that had been left out by students), "sorting" (i.e., sorting returned books by call number to prepare re-shelving), "shelving" (i.e., returning books to the bookshelves to their correct position by call number), and "shelf reading" (i.e., walking through aisles to ensure that books are in the correct order by call number). Library staff evaluated their frequency of performing the different tasks on a Likert scale ranging from "I've never done this before" to "More than once a week".

Study Process	Data
Collecting participant's background	Pre-session questionnaire (Appendix F and G)
Preparation (Walking participants through the study, demonstrating the mobile device)	1. Consent form (Appendix C)
Finding books in participant's familiar domain	1. Audio recording 2. Field notes 3. Data logging 4. Post-task Questionnaire (Appendix I)
Refinding task (refinding the first book in last set of tasks)	1. Audio recording 2. Field notes 3. Data logging
Finding books in participant's unfamiliar domain	1. Audio recording 2. Field notes 3. Data logging 4. Post-task Questionnaire (Appendix I)
Refinding task (refinding the first book in last set of tasks)	1. Audio recording 2. Field notes 3. Data logging
Semi-structured interview	1. Santa Barbara Questionnaire (Appendix J) 2. Semi-structured Interview (Appendix K)

Table 1. Study process and expected data

At the beginning of the study, a researcher met the participant at the entrance of the Killam Library. After providing their consent, the researcher explained to the participant what types of tasks they would be asked to complete and what resources they would be able to access throughout. Participants were told that they would be conducting two sets of book finding tasks. Each set would contain four tasks—one set of tasks with books on topics they are familiar with and another set with books on topics they are not familiar with. These familiar and unfamiliar domains were selected based on information the participants provided during a pre-session questionnaire. For tasks in the participants' familiar domains, we chose books from their top three familiar topics. We counterbalanced all tasks, with half of participants beginning with tasks in their familiar domains and the remainder beginning with books in unfamiliar domains.

During the study, participants were asked to locate specific books in the Killam Library with access to all the resources it has. Additionally, a mobile phone (i.e., a smartphone) was provided and participants were informed that they could use all of its functions including the camera, electronic notepad, and web browser throughout the study. In addition, the Killam Library's mobile website was demonstrated to participants. This website is optimized for display on small devices like a mobile phone and provides the same information as the website that is accessed from desktop computers. Although our participants were provided with this mobile device, they were told that it is completely their choice to use it or not. Participants were asked to try out the mobile device for a few minutes to ensure that they were comfortable with it and would not avoid its use due to unfamiliarity. We made sure that all participants were aware that they had full access to all the resources of the Killam Library including desktop computers and library staff. By doing so, we made our best efforts to create a realistic environment for participants so that we could observe their natural behaviour when navigating through the library with (or without) the help of mobile device. Participants were then equipped with audio recorders and were asked to speak aloud throughout the study so that we could better understand their thought process.

To keep the task's difficulty at the same level for all participants, we chose the books equally far apart between each task (description of each task see as follow). This ensured that any variability in the difficulty of locating books would not be due to variability of the tasks. The first two tasks in participants' familiar domains chose books that were located on the same bookshelf. The first book was chosen from the top row of the bookshelf while the second was in the middle range of the book shelf, closest to the participant's eye level. Books were selected in this way for two reasons. First, we wanted to identify differences in browsing behaviour for books within and outside of eyesight range. Second, we hoped to understand more about their searching strategies. Placing the first and second task on the same bookshelf can examine whether participants would be using call number only or the combination of book titles and call number while searching. We are curious that when browsing a huge number of books, what piece of information our participants value the most. Books for the third and fourth tasks were chosen from an area of the book stack

room far from the location of the first and second tasks, requiring participants to conduct a thorough exploration of the book stack room.

The books for the third and fourth tasks were chosen from different parts of the book stack room so that we could observe participants' navigation behaviors. The book for the third task was intentionally misplaced at the end of the shelf (either left end or right end) where it was supposed to be. As can be seen in Figure 1, the yellow rectangle in Figure 1 A indicates the original location of the book and the yellow rectangle in Figure 1 B shows where we placed it. According to our participants, misplaced books are known to be a common problem. We believe that understanding how participants overcome this problem can provide insight into what information (i.e., call number or book title) they further require when run into misplaced book situation. After they finished the four tasks in each domain, participants were asked to find the book from the first task without using any resources other than their memories. The purpose of this tasks was to determine what information registered in the participants' memories, specifically how they remember specific books and form mental representations of their environment. Tasks in the participants' unfamiliar domains were the same; however, the books were located on a different floor to avoid a learning bias from navigating the same floor. We suspected that there might be an order effect for refinding tasks. For example, after doing the first set of tasks, participants may be primed to the possibility that there might be a refinding task in the second set of tasks. This might cause them to pay an inordinate amount of attention to their surroundings to prepare for a future refinding task. Also, we note that there is a difference between recalling from long term memory and short term memory. As Nulsen, Fox and Hammond (2010) suggested that the short term memory has an impact on the long term memory; Therefore, we believe that the information that registered in our participants' short term memory can provide us a general sense of the information that they may register in their long term memory when it comes to finding books.

After participants finished all tasks, participants asked to fill out Santa Barbara Sense of Direction Questionnaire (see Appendix J) to get to know their abilities of maintaining orientation (see Section 3.1.3.4), then a semi-structured interview was conducted to discuss

their experience of doing this study and their general experience of locating books in a library.



Figure 1. Books were misplaced (from location A to B)

3.1.4 Data Collection and Analysis

A prior study conducted by Hahn and Zitron suggests "the in-person library experience...cannot be reduced to numerical data, since the story to be told is the individual experience in navigation resources in the library" (2011, p. 29). We also found another study, in which researchers used numerical data (i.e., percentage) to evaluate the connectivity and integration (i.e., used to characterize the potential social life within a spatial setting) to suggest a good design of space syntax in the libraries (Zook, Bafna, Greene & Reyes, 2012). In our study, we hoped to know participants' behaviors of navigating through the library with/without the help of mobile devices. Therefore, we believe the value of conducting this exploratory field study lays in its ability to draw out a

basic understanding of what students need while locating books in a library. This way, we can come up with guidelines for a mobile indoor navigation system that helps library users with book finding task rather than following arbitrary rules based on our assumptions.

In our study, we collected qualitative data through multiple sources in an effort to observe experiences from our participants during the process of locating books in the Killam Library with the help of mobile device. The value of this qualitative data is that it can present a comprehensive description of our participants' behaviour, which we could not achieve through numerical data (e.g. time to locate a book) alone.

We used various sources: audio recordings, field notes, questionnaires (before, during and after the session) (see Appendix F, Appendix G, Appendix I and Appendix J), data logging through the phone, and semi-structured interviews (see Appendix K) to collect data. During the study, we primarily focused on observing our participants' behaviour. In order to gain an understanding of how they navigate through the library and their search strategies for locating books once they have found the general area. We need to understand where our participants placed their attention during each task. In order to have minimal influence on participants' behaviour, rather than constantly interrupting the tasks to ask questions we requested that participants use the think-aloud method throughout. This was especially important for us to understand their interaction with objects or tools they used during the tasks. There were some special considerations associated with collecting data in a real-world library setting. First, given the quiet environment of a library, participants may feel uncomfortable speaking aloud during the study. Second, the presence of others in the library – potentially even people known to them personally – has the potential to alter their behaviour. Third, being in a public place equipped with an audio recorder may lead to feelings of embarrassment for participants, especially when being trailed by a researcher taking notes. In addition, participants' behaviour during the tasks are hard to predict. Sometimes they would walk quickly away from the researcher and this made it difficult to take notes until they stopped in a new location and were stationary for a short time. Therefore, collecting data from multiple sources was very important for this study. It allowed us to acquire a better sense of how participants progressed during each task than any single source alone would have made possible.

3.1.4.1 Audio Recording

We equipped each participant with an audio recorder from the beginning of the study until the end of the semi-structured interview. This was done to obtain a thorough perspective on their navigation strategies in an environment that is full of similar landmarks. The audio recordings were later transcribed by our researchers.

The quality of the audio recordings varied. As mentioned above, some participants kept their voices exceptionally low to avoid interrupting other users of the library. This was the primary reason that we could not hear some participants' voices clearly. However, we were able to confidently transcribe the majority of dialogue and the overall quality was likely higher than it would have been had the study taken place in a noisy, populated urban environment.

3.1.4.2 Field Notes

During the tasks, a researcher closely followed the participant so that they could clearly observe the participants' behaviours. While doing so, they took notes related to the tasks and made observations on the participant's comments and behaviours. As taking notes while trailing participants is difficult, we designed a coding sheet to enter observations more quickly and consistently.

Originally, the coding sheet contained three sections. The first section was a library map of the current floors. We designed our tasks so that the target were distributed on different floors. Considering that the library's organization is based on placing books by category, we arranged one set of tasks on the third floor and the other set on the fourth floor. This way, we were able to observe not only how participants navigated through the book stack rooms but also how they traveled between floors and how they orient themselves on different floor with indistinct landmarks. We hoped that by comparing each participant's path on the map along with their behaviours we could analyze how and why they chose that path. Thus, we could get a better understanding of how they utilised the landmarks (e.g., the signage) in the rooms. The second part of the coding sheet contained a list of landmarks that we had identified in the library, saving the time of repetitively writing down the same landmarks. The third part of the coding sheet was divided into three small sections

including recording difficulties encountered during the tasks, how they overcame these problems and other task-related behaviours.

During our pilot study the coding sheet's map section did not work out as well as we had hoped. It was difficult to keep track of the participant's path as they moved throughout the library, especially when our researcher was occasionally lost as the participants due to the lack of distinct landmarks. Additionally, the paths are often overlapped and it became difficult to distinguish them and understand how the participant moved throughout the room. Therefore, for the actual study we removed this section from the coding sheet and used only the list of common landmarks and list of problems encountered and problem-solving behaviours observed (see Appendix H).

3.1.4.3 Data Logging

We also recorded all actions performed on the mobile device during the tasks. Prior to the study, participants were informed that they were able to use all of its functions, including the camera, electronic notepad, and web browser with the libraries' mobile website. Therefore, we had all pictures they took, searches they conducted through the browser, and information recorded on the electronic notepad. Analyzing these records shed light on their interactions with the mobile device in a library setting. As libraries increasingly provide more materials in both physical and digital formats, this helped us to understand the current role of mobile devices while navigating a library environment and envision what their role may be in the future. Although searching for books' information using a mobile website was not the focus of our study, it did influence search strategies occasionally.

3.1.4.4 Questionnaires

We used three questionnaires for our study: a pre-session questionnaire (see Appendix F and Appendix G), post-task questionnaire (see Appendix I), and the Santa Barbara Sense of Direction questionnaire (see Appendix J). As mentioned previously, the pre-session questionnaire provided us with general background information on our participants, including their familiar domains and their previous experience with using the library. This helped us to plan appropriate tasks for each participant and to compare their results to look for differences between inexperienced, experienced users and library staff.

The post-task questionnaire was administered after each task to ask our participants about their experiences during the task they had just completed. These questionnaires were added to ensure that participants were reflecting, only on their most recent task and not confusing it with their overall experience resulting from all of the tasks. Thus, participants were asked to fill out the post-task questionnaire immediately after they finished each task when they still had the experience fresh in their memory. This short questionnaire asked participants to reflect on how difficult the task was and what tools they used to help. The first question was addressed by having our participants evaluate the task on a scale from "extremely difficult" to "extremely easy". As to the second question, participants checked items from a list that we provided or add items themselves to indicate what objects or landmarks they used to find the book. We also asked them to explain how they used the items so that we could conduct a further discussion on these topics later in the interview session.

The Santa Barbara Sense of Direction questionnaire includes fifteen questions for participants regarding their spatial and navigation abilities, their preference of describing directions, and their previous experience of using maps and giving directions (Hegarty, Richardson, Montell, Lovelace & Subbiah, 2002). Each question was asked on a scale from one to seven. One indicates participants strongly agree with the statement, while seven indicates participants strongly disagree with the statement. By including this scale, we can compare the results collected from our study with the participants' self-reported abilities of navigation to look for any correlations between the two. Prior research has made use of the SBSOD to get a sense of their participants' spatial abilities. For example, Takemiya & Ishikawa (2013) investigated the decision points in wayfinding and found that high scores on the SBSOD corresponded to better spatial abilities during wayfinding.

3.1.4.5 Semi-Structured Interviews

A semi-structured interview (see Appendix K) was conducted after participants finished all the tasks to further discuss their overall experience during the study and to discuss their experience of using libraries in general. For their experience in this study, we were mostly interested in discussing the difficulties that were encountered while locating books, the wayfinding tools and landmarks used along the way, the features utilized on the mobile

device, and their navigation experience when they were in an environment filled with indistinct landmarks.

3.2 PROTOTYPE EVALUATION STUDY

3.2.1 Introduction

After conducting the study in the Killam Library, we had collected a vast amount of data from multiple sources including audio recordings, field notes, data logging, questionnaires, and semi-structured interviews. Analyzing this data allowed us to acquire an understanding with respect to the processes of locating books from library users' perspectives. We generated the guidelines (see Section 4.6) for designing a mobile indoor navigation system to facilitate book finding experience for library users and developed a low-fidelity prototype based on the guidelines. It should be noted that libraries contain different characteristics. The characteristics of the Killam Library may be different from other libraries. For example, some libraries may have better signage and organization. Our prototype was designed to give directions to library users based on the Library of Congress system (call number system) and has little connection to the physical layout of a library. Therefore, despite the different features libraries may have, we believe that our prototype can address the difficulties of finding books across different libraries. To meet our initial intent of working towards a context-aware system on the factory floor, we would need to further abstract the guidelines so that they would apply to a different context. For example, the guideline of incorporating personal landmarks, in a library setting, applied to the books they checked. But in the factory setting, their landmarks might be different considering the tasks mechanics have done before and their nearby environment,

We carried out a follow-up study to help us answer the research question – how can we inform the design of contextual mobile application to help patron navigate in a library. Initially, we wanted to conduct a focus group in GV (Graphic Visualization) lab giving participants the prototype and asking them to finish the tasks, similar to the field study (finding books in their familiar domains and unfamiliar domains) so that we can observe the interactions between participants and our prototype. However, simulating library environment in GV lab is of great difficulty, especially in the study we placed our focus on participants' navigation process. Additionally, we suspected that in a lab setting, participants can hardly experience the features provided by the prototype. Therefore, we

decided to shoot a video to demonstrate all the features provided by this prototype through a common book finding task in the Killam Library (Yu, 2013.).

By showing this video in a focus group setting, we hoped that participants can associate the prototype features with their previous book finding experience. It was followed by a focus group discussion mainly discussing three points – the features they considered helpful, improvements for existing features and their thoughts on future improvements based on this prototype that could solve their difficulties encountered while locating books in the library. We conducted three prototype evaluation groups with experienced library users, inexperienced library users and library staff individually.

3.2.2 Participants and Setting

The focus group took part in the Graphics Visualization (GV) lab of the Mona Campbell building at Dalhousie University. Three sessions were held: one with two experienced library users, one with three inexperienced library users, and one with two library staff member for a total of seven participants. Similar to the field study, we defined inexperienced students as students who borrowed books from the Killam Library less than twice a month; experienced students as students who borrowed books from the Killam Library twice a month or more. All participants had experience using a mobile device and had borrowed books from the Killam Library recently. Recruitment notices were sent to Dalhousie library faculty and students. Before meeting with the researcher, participants were asked to fill out the same pre-session questionnaires as were used in the field study so that we could classify them into the same groups and ensure that our samples were consistent between the two studies.

3.2.3 Study Protocol

In this study, we wanted to evaluate the features in a low-fidelity prototype designed for library use. We asked our participants (inexperienced users, experienced users, and library staff) to provide feedback and make suggestions on our initial design ideas presented in the prototype. Our goal was to collect participants' feedback towards this prototype in order to evaluate our guidelines regarding the design of an indoor navigation system for book finding tasks.

3.2.3.1 Video Demonstration

Three focus groups were conducted to collect feedback from participants on the proposed functionality of our prototype and the validity of the guidelines. This was done by first demonstrating a video shot in the Killam Library (Yu, 2013). In the video, we presented a scenario of looking for a book called "La Nouvelle France: the making of French Canada: a cultural history" with the help of the prototype. Due to the camera's quality, it is hard to present the view of the prototype on the phone during the video. Therefore, when demonstrated to our participants, we broke the whole video into several shorter videos. After presenting each features in the video, high-quality screenshots showed in the last video was displayed to allow participants to acquire a clear sense of the prototype. Participants can ask any questions towards the functions provided by the prototype anytime during this study. We believed that showing the video to present all the functions of the prototype allowed our participants to efficiently grasp the use of the prototype and fast associate the video with themselves using the prototype in a library setting. This was followed by a discussion led by a researcher mainly focused on their impression of the prototype regarding the advantages of using it compared to their previous locating book experience (especially the finding books in their familiar domains and unfamiliar domains), the improvements for existing features and future suggestions.

3.2.3.2 Focus Group Discussion

A group discussion was conducted after we demonstrated the video to participants. This discussion (see Appendix P) was to get feedback from participants in the following order. First, participants were asked to talk about the helpful features of this prototype and the difficulties that they envisioned themselves encountering while using such an application. Next, participants were asked to talk about their difficulties of locating books in a library and how this prototype could improve the experience. During it, researcher particularly brought up the tasks we did for the field study in order to see whether participants think this prototype can bridge the "gap" between finding books in their familiar domains and their unfamiliar domains. Finally, we asked for specific constructive suggestions towards the features and changes to introduce in future prototype based on what they had been shown. Conducting a group discussion with our participants allowed us to acquire a better understanding of the interaction between future users and our prototype. In the meantime,

we were able to get their opinions and see whether the prototype we developed was seen as being consistent with the guidelines we created from the exploratory field study.

3.3 DATA COLLECTION AND ANALYSIS

All data we collected in this study was from the focus group discussion. We believe the value of conducting this prototype evaluation study is to get feedback from our participants regarding its features and examine the guidelines. This way, we can acquire a general sense of participants' adoption of this prototype and suggest improvements for the future system. The data we collected is qualitative. The advantages brought by qualitative data allows us to present the details of the study and give readers a holistic view of participants' impressions of the prototype.

CHAPTER 4 FIELD STUDY EVALUATION

4.1 INTRODUCTION

While our observations showed that participants exhibited many individual differences in their behaviours and experiences while locating books, there were also some important commonalities. This chapter will discuss these observations, which can be broadly classified into three categories: their usage of mobile devices for recording information, difficulties encountered while locating books, and resources used during navigation. We conclude with a discussion that summarizes our findings and proposes four guidelines for the design of mobile indoor navigation systems to support in book finding activities.

4.2 FIELD STUDY DATA

Before discussing our main findings, we will first present the data collected from our exploratory field study. We have organized this data into three sections: participant demographics, the post-task questionnaires, and the post-study interviews. All important details will be shared in this section, along with descriptions of interesting patterns we observed during the field study.

4.2.1 Demographics

4.2.1.1 Participant Distribution

The field study had three groups of participants: eight inexperienced students, seven experienced students, and five library staff. With the exception of one inexperienced participant who was a Masters student, all of our participants including library staff were undergraduate students. We defined experienced students as those who had borrowed books from the Killam Library at least twice a month over the past year and inexperienced students as those who had borrowed books from the Killam Library less than once a month. Students were studying in disciplines including Computer Science and Management students (see Figure 2). There were a total of 6 females and 14 males (see Table 2).

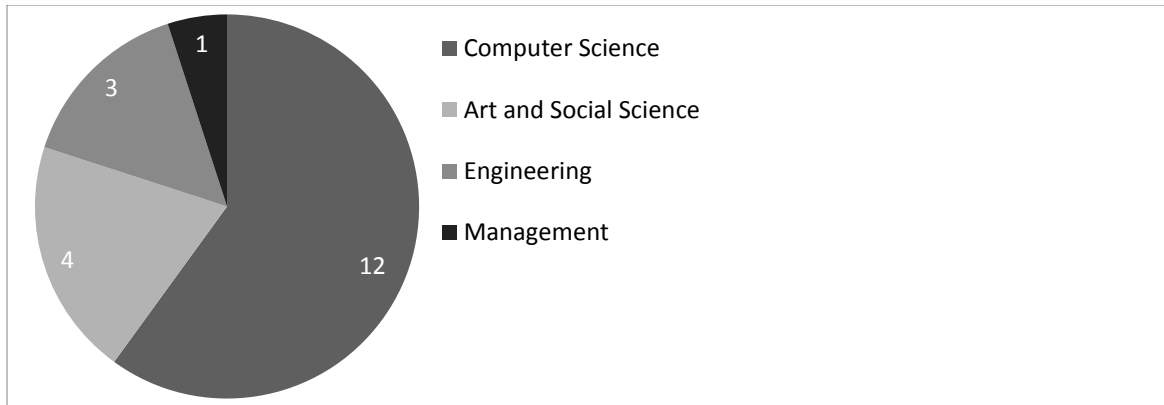


Figure 2: Participant distribution by faculty

Study Groups	Computer Science		Art and Social Science		Engineering		Management		Total
	Female	Male	Female	Male	Female	Male	Female	Male	
Inexperienced Students		6			1	1			8
Experienced Students		6			1				7
Library Staff			4				1		5

Table 2. Participant distribution by faculty and gender

4.2.1.2 Familiarity with Library and Resources

Participants were asked to rate their familiarity with the library and its resources from 1 (not familiar at all) to 5 (extremely familiar). As can be seen in the highlighted area of Table 3, all inexperienced, experienced students, and library staff were familiar with the circulation desk. For study areas, both experienced and inexperienced students reported being very familiar with both the third and fourth floor of the library. As can be seen in the highlighted row (Table 3), although inexperienced students' average score of their familiarity with the book stacks was fairly high (3.20), this is still noticeably lower than that reported by the experienced students (4.03) and library staff (5.00).

Areas	Inexperienced Users (8)	Experienced Users (7)	Library Staff (5)
The Information/Reference Desk	4.66	4.91	5
The Circulation Desk	4.75	4.84	5
The MCNAB Reading Room	2.2	3.35	4.51
The Graduate Study Area	3.12	4.21	4.7
The Study Tables/Carrels 3rd Floor	3.84	3.94	5
The Study Tables/Carrels 4th Floor	4.52	4.48	5
Average For The Study Tables/Carrels	4.18	4.21	5
Learning incubator and networking center	1.22	2.26	3.92
The Book Stacks 2nd Floor	2.74	3.21	5
The Book Stacks 3rd Floor	3.51	4.12	5
The Book Stacks 4th Floor	3.36	4.78	5
Average For The Book Stacks	3.20	4.03	5
Archives & Special Collections	2.20	2.65	4.23
Government Documents	1.76	1.14	4.49
Journals and Newspapers	2.34	3.45	4.34

Table 3. Level of familiarity with areas of the library

4.2.1.3 Frequency of Borrowing Books

Table 4 shows the frequency that participants had borrowed books in the last six months by group. As can be seen, three inexperienced students had not used the library in the last six months. The experienced students we recruited reported their frequency of using the Killam Library as ranging from twice a month to once a week. As would be expected based on their work, all library staff had visited the library more than once a week.

	More than once a week	Once a week	Twice a month	Less than twice a month	Haven't used library in last 6 months
Inexperienced users				5	3
Experienced Users		2	5		
Library Staff (Visited)	5				

Table 4. Participants' frequency of borrowing books from the Killam Library

4.2.1.4 Mobile Device Use

We asked participants whether they had used mobile devices to previously look up and find books in the library. As can be seen in Table 5, only one experienced student had done so.

	Used mobile device	Never used a mobile device
Inexperienced users		8
Experienced users	1	6
Library staff		5
Total	1	19

Table 5: Mobile device usage in the library

4.2.2 Study Tasks

As mentioned in Chapter 3, we chose books in participants' familiar and unfamiliar domains based on their responses to the pre-session questionnaire. For example, one computer science student's familiar domains included web design and human-computer interaction. We then selected books for this student's unfamiliar domain from the top three familiar domains of students from other departments (e.g., Art and Social Science). Researchers emailed participants to ensure that our selections were in their familiar domains. The domains selected for each participant can be seen in Table 6, Table 7, Table 8 and Table 9. All the data was collected from the pre-session questionnaire.

Computer Science	Familiar Domains (Third Floor)	Unfamiliar Domains (Fourth Floor)
P1	Web Design	History of Renaissance
P2	Web Design	History of Renaissance
P3	Web Design	History of Renaissance
P5	Human Computer Interaction	History of Renaissance
P6	Web Design	History of Renaissance
P7	Network Security	History of Renaissance
P8	Human Computer Interaction	History of Renaissance
P9	Human Computer Interaction	History of Renaissance
P10	Human Computer Interaction	History of Renaissance
P11	Network Security	History of Renaissance
P14	Web Design	History of Renaissance
P15	Web Design	History of Renaissance

Table 6: Tasks for computer science students

Engineering	Familiar Domains (Third Floor)	Unfamiliar Domains (Fourth Floor)
P4	C Programming	Web Design
P12	Air Pollution	Human Computer Interaction
P13	Air Pollution	Human Computer Interaction

Table 7: Tasks for engineering students

Art and Social Science	Familiar Domains (Fourth Floor)	Unfamiliar Domains (Third Floor)
P16	History of Renaissance	Human Computer Interaction
P17	Old and Middle English Literature	Human Computer Interaction
P18	English Literature in the sixteenth century	Human Computer Interaction
P19	History of Renaissance	Human Computer Interaction

Table 8: Tasks for art and social science

Management	Familiar Domain (Fourth Floor)	Unfamiliar Domain (Third Floor)
P20	Financial Management	Web Design

Table 9: Tasks for management

We designed two sets of tasks for participants: finding books in their familiar domains and finding books in their unfamiliar domains. Each set contains four book finding tasks and one refinding task. In addition, the third book in each set was intentionally misplaced. As mentioned before (section 3.1.3), we maintained the spatial relationship between all tasks to keep the difficulty at the same level. The library’s resources were available to participants utilize in all but the refinding tasks, where they relied on their memories alone. Details can be seen in the section 4.2.2.1 and section 4.2.2.2.

4.2.2.1 Finding Books

Task 1: Locating a book on the top row of the bookshelf

The first book that participants had to locate for both familiar and unfamiliar task sets was located in the top row or bottom row of the bookshelf. This forced participants to scan the entire bookshelf. This case, we believe the book in one of the task would at least be outside of our participant’s visual range. As can be seen in Table 10, two inexperienced students and one experienced student found it difficult to compare the call numbers during the first

task, as the books were placed too high. One inexperienced student had the same problem while doing this task in their familiar domain.

	Familiar Domain			Unfamiliar Domain		
	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)
Hard to see the call number clearly	1			2	1	

Table 10: Observed difficulties in finding a top row book

Task 2: Locating a book in the middle shelf

In the second task, participants had to locate a book that was in on a middle shelf of the same bookshelf where the book from the first task was located. This task allowed us to acquire an understanding of what resources participants use to locate books. We expected that some participants who looked for books based on title, as opposed to call numbers alone, may have noticed the second book while searching for the first one. We were aware that there may be participants who searched by book titles but overlooked the second book. Therefore, this observation was further confirmed in the post-task questionnaires (see Appendix I), which shows what resources they used for the previous task.

	Familiar Domain			Unfamiliar Domain		
	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)
Found the wrong book on the catalogue due to the generic name				4	1	

Table 11: Experienced difficulties in finding a book with generic name

Task 3: Locating misplaced books

The misplaced books were near their original positions (see Figure 3). More specifically, the misplaced books were only placed either at the left end or right end, however they remained at the same shelf. Our goal was to identify what information library users may

seek when they are unable to find a book in its expected location. In addition, we expected this task to help us better understand what resources are used while searching for books, which may be indicated by how participants noticed the books were misplaced. As can be seen in Table 12, especially in the case of familiar domains, three inexperienced students and one experienced student did not notice that the book was misplaced at all. Detailed discussion about what resources participants used to locate the books is in section 4.4.

	Familiar Domain			Unfamiliar Domain		
	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)
Misplaced book task	3	1				

Table 12: Participants who did not notice the misplaced books

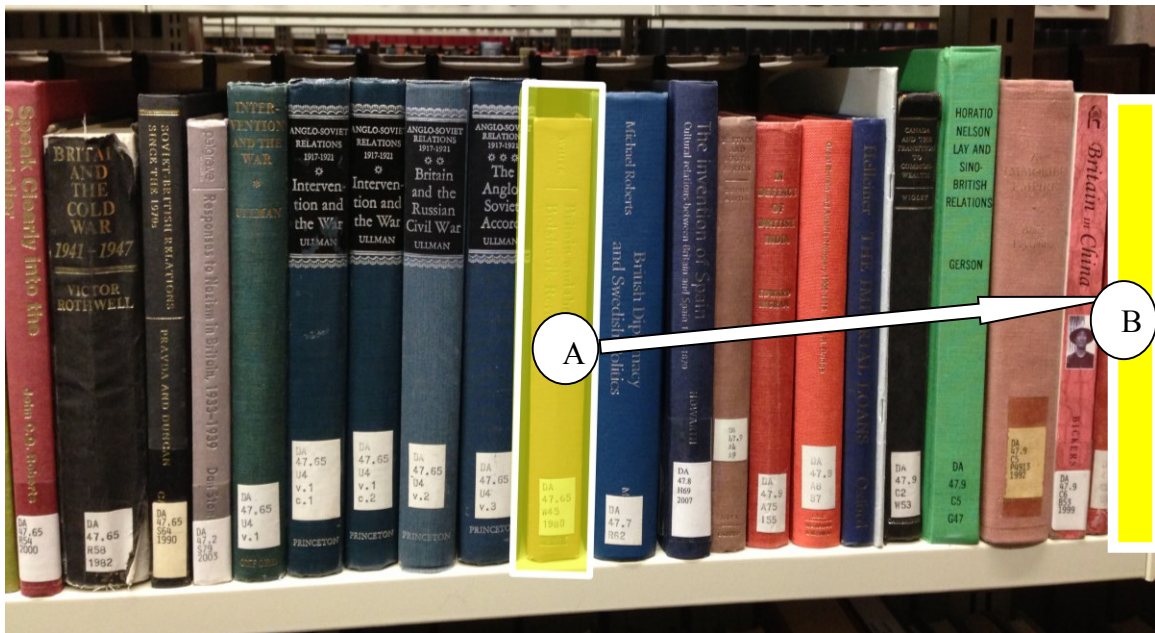


Figure 3: The book in its correct location and misplaced location.

Task 4: Books across the book stack room

The books in task 3 and task 4 were chosen in different areas of the book stack room so that researchers can observe participants' navigation behaviors.

The books in tasks 3 and 4 were chosen in different areas of the book stack room so that our researcher could observe the navigational behaviours of the participants. With the exception of three inexperienced students who abandoned the first task due to their lack of

experience with using call numbers (see Table 13), all of the participants were able to finish their finding book tasks within a reasonable amount of time. We noted that the biggest difficulty they encountered throughout all tasks was learning the arrangement of books by call number within the book stack room and on each bookshelf. We will discuss this difficulty in-depth in section 4.3.2

	Familiar Domain			Unfamiliar Domain		
	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)
Do not know which floor to go	2					
Did not compare call number from the first set	1					

Table 13: Participants' abandoned tasks

4.2.2.2 Refinding Books

For each set, after participants finished the four tasks described above they were asked to once again find the book from the first task. During these refinding tasks, participants were not able to utilize any of the resources in the library but instead relied on their memories alone. These tasks provided insight into what details of the environment and the targeted books registered in participants' minds while locating books. With the exception of one inexperienced student who could not remember, all participants successfully returned to the book from the first task.

The resources that participants used during the refinding tasks are shown in Table 14. As can be seen there, the book's title was used more by participants who were completing refinding tasks in their familiar domains. Memories of actions, such as reaching up to a book placed on the top shelf, also helped them to narrow down their search. Additionally, the image on the book's cover was used to recall and locate the book. No one used the book's call number to relocate it. Before this study, we suspected that there might be an order effect since participants were asked to refind the book when they finished the first

set of tasks. However, we did not see a pattern in the following table (Figure 4) with respect to the resources participants used to refind the books.

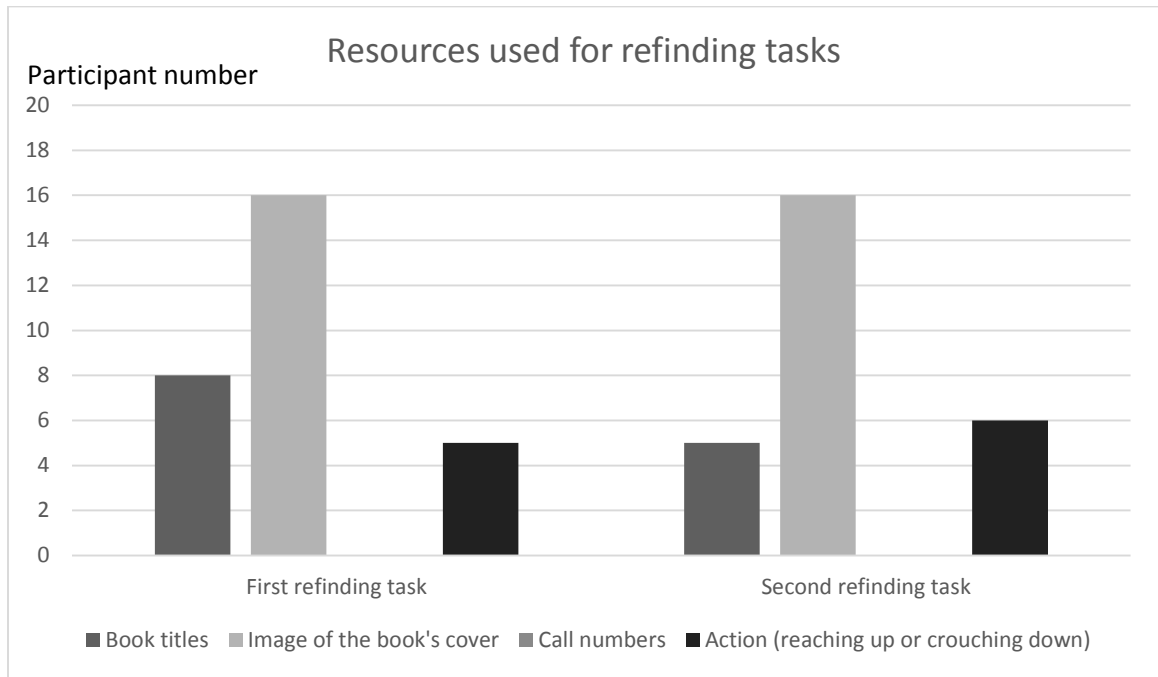


Figure 4: Resources used for the first and the second refinding task

	Familiar Domain			Unfamiliar Domain		
	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)
Book Title	5	4	4	2		
Image of the book's cover	5	6	4	6	6	5
Call number						
Action (reaching up or crouching down)	2		1	4	2	2

Table 14: Resources used for refinding tasks

4.2.3 Post-Task Questionnaires

After performing the tasks, participants completed a post-task questionnaire. We asked them to rate the difficulty of each task (excluding refinding tasks) and to tell us what tools and landmarks they used to help them locate each book. They evaluated each task from

“extremely easy” (1) to “extremely difficult” (5). Table 15, shows the average reported difficulty for each task by participant group.

As can be seen in Table 15, participants rated tasks in their familiar domains as easier than those in their unfamiliar domains. While the difference in average score between these sets of tasks was not large enough to reach statistical significance, participants did report feeling more comfortable finding books in their familiar domains and made comments like "I found finding books here [in familiar domain, I feel more comfortable]".

	Familiar Domain			Unfamiliar Domain		
	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)	Inexperienced Student (8)	Experienced Student (7)	Library Staff (5)
Task 1	4.12	4.51	5	2.51	3.12	4.72
Task 2	4.34	4.67	5	2.87	3.66	5
Task 3	3.38	3.14	3.59	2.35	2.98	3.47
Task 4	4.51	4.54	5	3.12	3.72	4.76
Mean	4.08	4.21	4.64	2.71	3.37	4.48
Mean in total	4.68			3.80		

Table 15. Reported difficulties of tasks

4.2.4 Santa Barbara Sense of Direction Questionnaires

SBSOD (Santa Barbara Sense of Direction Questionnaire) scale is designed to measure the construct of self-reported sense of direction. More specifically, it can measure people’s abilities of characterizing spatial cognition at the environment scale of space (Hegarty, Richardson, Montell, Lovelace & Subbiah, 2002). After analyze all the data, SBSOD scores for inexperienced students, experienced students and library staff are 3.39, 4.02 and 4.34 accordingly (see Figure 5, Figure 6 and Figure 7). However, we could not find any significance difference in terms of their spatial abilities between inexperienced students, experienced students and library staff. ($p = 0.116 < 0.05$).

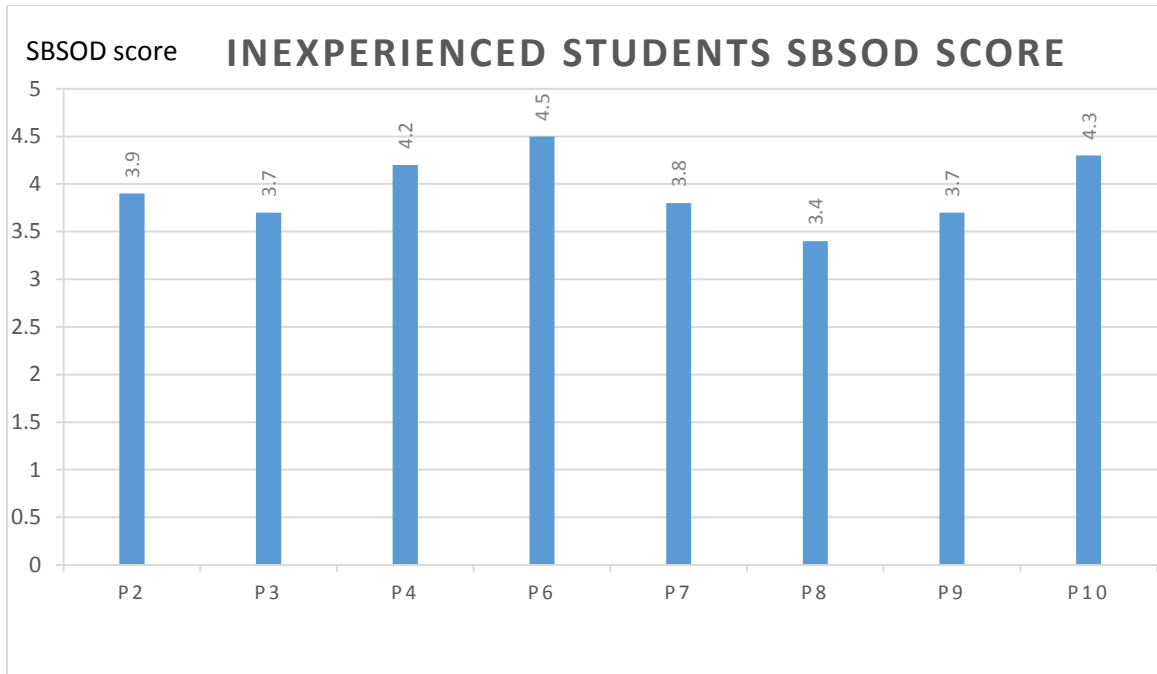


Figure 5: Inexperienced students SBSOD score. Mean SBSOD score for all inexperienced student is 3.93, SD = 0.366

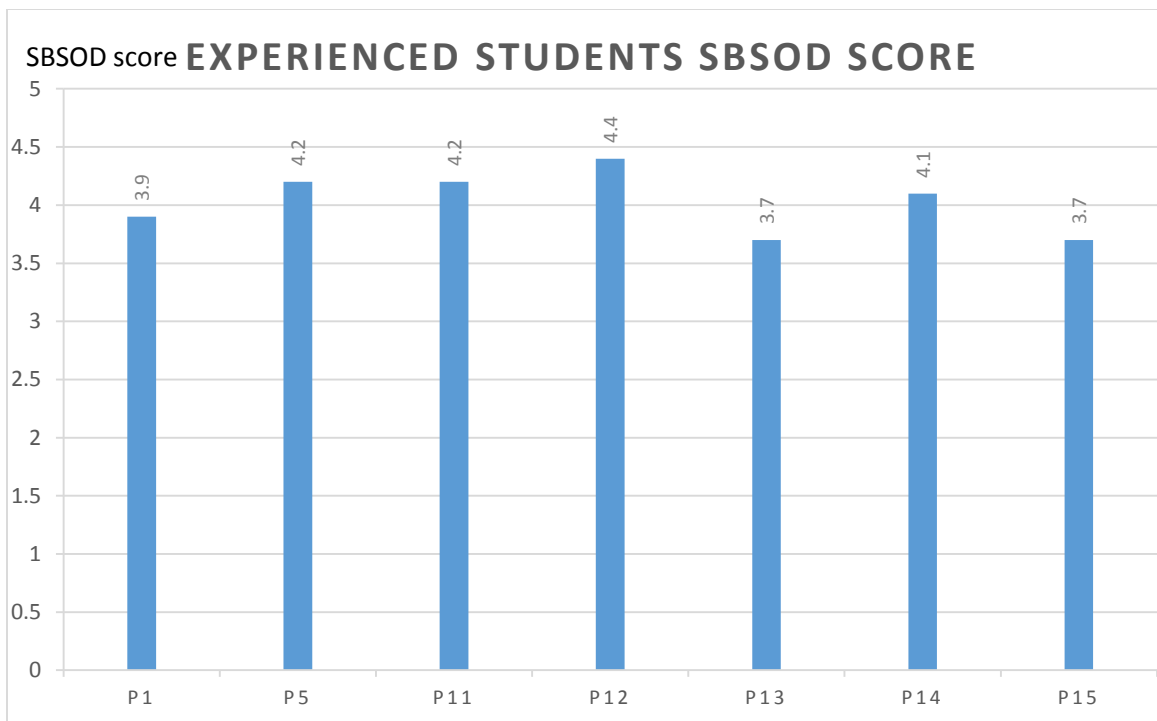


Figure 6: Experienced students SBSOD score. Mean SBSOD score for all experienced is 4.02, SD = 0.366

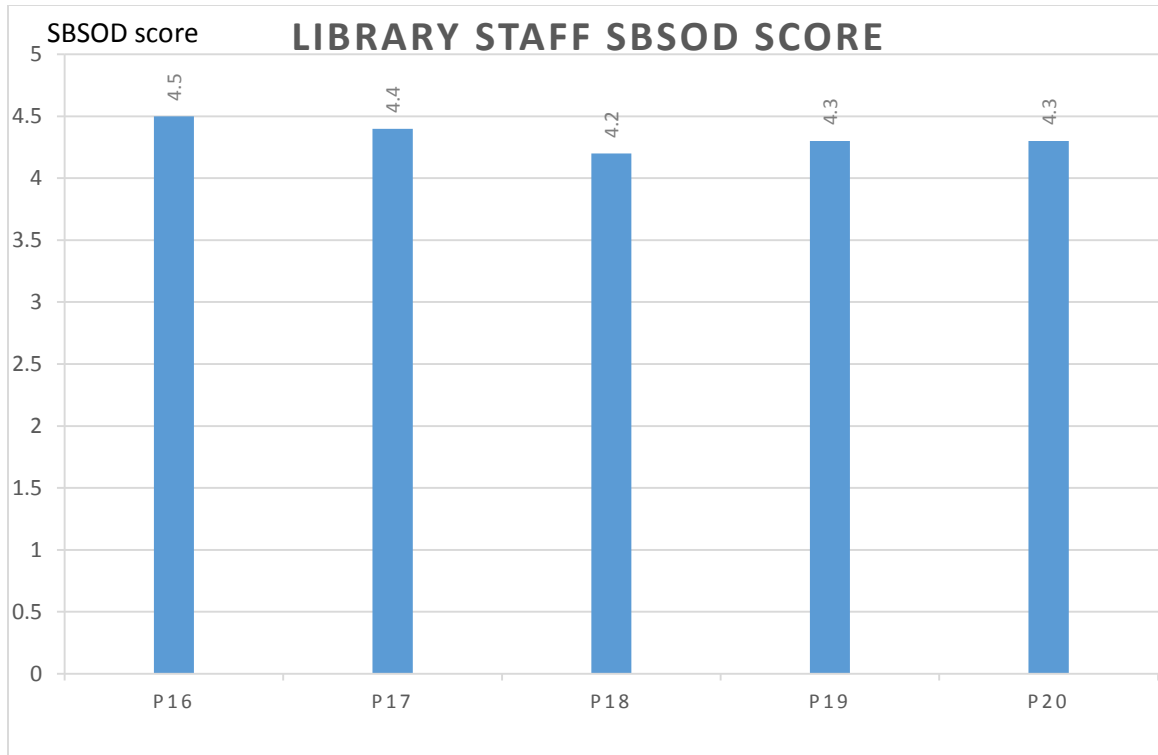


Figure 7: Library staff SBSOD score. Mean SBSOD score for all library is 4.34, SD = 0.11.

4.2.5 Post-Study Interviews

After the participants finished the tasks and questionnaire, they participated in a semi-structured interview. We asked them about their experiences with locating books during the tasks, namely: the difficulties that they encountered; how they used the mobile device; other tools, strategies, and landmarks used; and if they became lost or disoriented at any point. We also asked them about their previous experiences in the library and for recommendations on how finding books could be made easier. In this section we will detail the main themes of these interviews.

4.2.5.1 Difficulties Encountered

We asked participants about the difficulties that they encountered while locating books in their familiar and unfamiliar domains. Table 16 presents the top four difficulties participants reported. We found that their reported difficulties closely matched our observation, with the exceptions that no participants recalled difficulties with using maps. As well, the participants also noted some difficulties that we had not observed, such as not being aware of the location of stairs or library staff.

	Inexperienced Users (8)	Experienced Users (7)	Library Staff (5)	Total
Misplaced book	8	7	3	18
Disorientation due to limited landmarks	8	3		11
Locating signs	8			8
Studying letters' pattern by using call numbers	8	4		8

Table 16. Participants' reported difficulties

We also asked participants to tell us of a previous experience that they had in the library where they had encountered difficulty (see Table 17). Many inexperienced students noted finding signs (e.g., directory, letter range in book stack room) in the library is hard. All participants (inexperienced students, experienced students and library staff) found running into misplaced book situation is frustrating. As well, all participants think that the library lacks of distinct landmarks, which can cause disorientation.

	Inexperienced Users (8)	Experienced Users (7)	Library Staff (5)	Total
Misplaced books	8	7	5	20
Limited landmarks	8	7	5	20
Using call numbers	8	4		12
Locating signs	8			8

Table 17. Difficulties participants encountered when looking up books before

We also asked participants why they had given up on the misplaced book tasks. Their responses can be summarized into three categories. First, they were unable to obtain further information regarding the misplaced book from any resource. For example, when coming across a misplaced book they wanted to know whether or not the book had been checked out of the library (see Table 18) Except for one inexperienced student who abandoned the task immediately, the remainder of the participants referred to the mobile device and reloaded the page to check if the book was still available in the library. Second, according to participants' previous experiences, finding a misplaced book in a library is very time consuming and the chance to find it is small. Therefore, some participants hoped to know if the book was misplaced in the nearby area or somewhere far away. They expressed a willingness to keep looking, provided that they were assured that the book was nearby. Third, participants' lack of

domain knowledge was mentioned by two experienced students and all library staff. As one experienced student said during the task: "I'm not sure where this book possibly could be. I saw some similar books here and there. I wish I knew more about this domain, at least, I can pay more attention to the areas where it might be. Or distinguish it better based on the titles. If someone mistakenly put it into a wrong section, the title may stick out."

	Book's availability	How far the book is misplaced	Knowing the misplaced book's category information
Inexperienced students (8)	7	6	2
Experienced students (7)	7	5	4
Library staff (5)	5	4	5

Table 18. Information participants wanted after encountering a misplaced book

4.2.5.2 Tools, Strategies, and Landmarks Used

Table 19 shows the different resources participants reported using to locate books. The top three strategies (call numbers, landmarks, and view-action pairs) were used by all three groups of participants. View-action pairs were mostly mentioned for those tasks that required refinding books. Inexperienced students often used book titles while looking in their unfamiliar domains, whereas few experienced students and library staff used the titles.

Resource Used to Locate Books	Inexperienced Students (8)	Experienced Students (7)	Library Staff (5)	Total
Call numbers	8	7	5	20
Landmarks	8	7	5	20
View-action pairs	8	7	5	20
Book titles (familiar domains)	6	4	2	12
Images of books' covers	1	3	3	7
Book titles (unfamiliar domains)	5	1	0	6
Library maps	1	1	0	2

Table 19. Resources that participants used during the tasks

More details on these strategies, such as how they were used are provided in Section 4.4, where we have combined our general observations, with the questionnaire data and interview data.

4.2.5.3 Recommendations for Future Navigation Systems

When discussing participants' recommendations to improve the book finding process including from both digital and physical perspective, we received a variety of responses. We noted that our participants were less interested in improving the library physically (e.g., adding signage). According to them, the change from physical aspect still mostly counts on their experience of using it. It helps mitigate the difficulties of using a library, however, it does not change how library users interact with libraries. Table 20 presents the five most common suggestions.

	Inexperienced Users (8)	Experienced Users (7)	Library Staff (5)	Total
Displaying current location	8	7	5	20
Notification for misplaced books	6	5	5	20
Providing navigation instruction in book stack room	8	7	5	20
Showing book categories on the system	7	3	2	12
Highlighting important signage	8			8

Table 20. Recommendations for indoor navigation systems

4.2.6 Field Study Combined Results

4.2.6.1 Mobile Device Usage

Although only one participant reported having previously used a mobile device to look up call numbers, 17 of 20 participants (see Table 21) chose to conduct their search by using Dalhousie Libraries' mobile-optimized website. This website, which functions much like the library's standard website, had been introduced to participants at the beginning of the study session. Two inexperienced students and one experienced student accessed the standard website from a desktop computer in the lab on the ground floor for their first task. For subsequent tasks they opted to use the mobile device, as they were uncertain of the location of desktop computers in other areas of the library. No difficulties were reported or observed while participants used the mobile website to look up call numbers. We noted that introducing mobile devices to participants in the beginning of this study might be the reason that we observed a high adoption of mobile device. As mentioned above that we were curious to know participants' adoption of mobile device in a library setting.

Therefore, in other words, we wanted to know that when being introduced to mobile device, whether our participants are willing to accept using the mobile device or not.

	Inexperienced Students (8)	Experienced Students (7)	Library Staff (5)
Mobile Device	6	6	5
Desktop	2	1	0

Table 21. Mobile device adoption

4.2.6.2 Recording Information

During the study we observed changes in participants' methods for recording book information as a result of the presence of the mobile device. After acquired the call numbers through either mobile devices or desktops, participants could record it by making notes on a piece of paper we provided, taking a screenshot using the mobile device, or creating a note in the mobile device's electronic notepad. Prior to conducting the study, we expected that participants would prefer the capabilities of the phone to taking notes on paper, considering the increasing tendency of people using mobile devices for taking notes. At the beginning of the study, however, most participants chose to record the call number on paper.

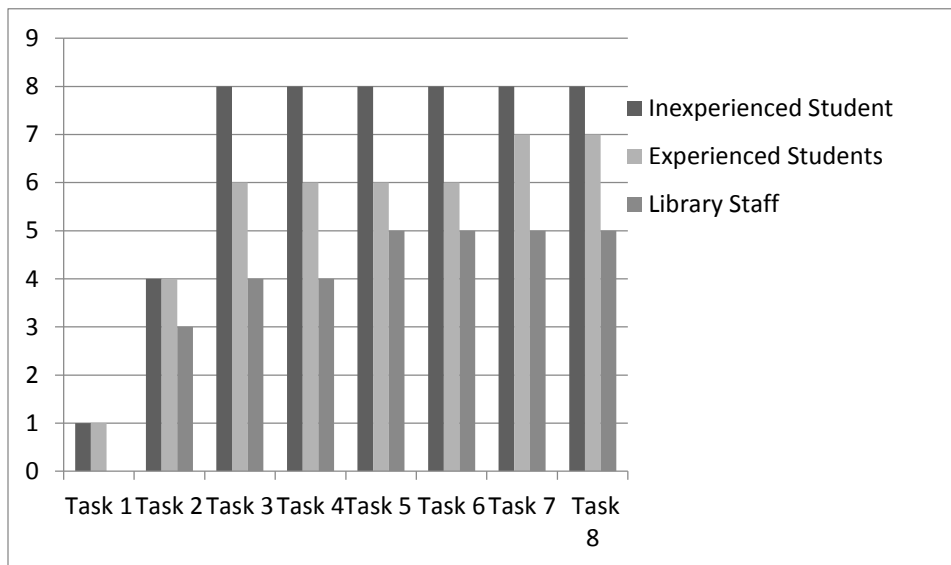


Figure 8. Using mobile device to record book information

For the first task, fifteen of seventeen (see Figure 8) participants who used the mobile device to look up the book wrote its details down on paper, despite having this information

available at all times on the device. Those who used a desktop computer to search for the book did the same. Only two participants, took a screenshot of the results page containing the book's call number. Most participants wrote the call number along with partial book information (e.g., author name or book title) on a piece of paper. When asked, these participants reported that they chose to write on paper as they did not want to hold the mobile device at all times. In addition, some participants reported that switching applications on a phone can be difficult and this made accessing the electronic notepad bothersome. As one participant noted: *"I have to find where the notepad is on the phone. I know where the notepad is, but then I have to switch between [the] notepad and this website. I think it's more convenient to just have it on the paper."* Surprisingly, after writing the details on paper, we observed some participants referring to the mobile device rather than their notes. This occurred more frequently as the tasks progressed, until by the end of the session all participants had stopped writing down the books' details on paper and were simply referring to the information displayed on the device's screen. Most participants held the phone throughout the study without difficulty, refuting their earlier concerns about it being inconvenient or unwieldy.

4.3 DIFFICULTIES OF LOCATING BOOKS

4.3.1 Finding Signage, Directories, and Maps

The Dalhousie Killam Library has signage, including directories and maps, to assist patrons when navigating. The inexperienced students in our field study had the greatest difficulties locating signage that could assist them in identifying the floor for a given call number. There is a directory (see Figure 9) located beside the elevators on each floor specifically for this purpose. Library users can see which floor a book is on by comparing the first letter of its call number with the ranges shown for each floor in the directory. While a set of library maps is posted on the wall behind the circulation desk, these maps are mostly unnoticed by patrons and are primarily for the use of the librarians who sit in this area.

Five inexperienced students struggled greatly with locating signage, likely due to their unique behaviours while seeking these signs. While looking around for signage, their attention was drawn to objects with prominent attributes, such as big advertisements with

bold colours. An analysis of the audio recordings shows that four inexperienced students constantly mentioned irrelevant objects such as long lines in front of the circulation area, a photocopier machine, and advertisements for dining. Three inexperienced missed a directory located beside a bulletin board that they commented on while walking by.

We hypothesize that these failures to see the directory were the result of several contributing factors. First, the directory is a simple white board consisting of lines of plain text (Figure 10) that is visually indistinguishable from its surroundings and does little to draw attention. Second, as noted by inexperienced students during the subsequent interview, being unfamiliar with the appearance and location of signage makes it easy to overlook what seems apparent to those with more experience. Inexperienced students stated that it would be easier for them to identify signage in the future. Third, the presence of a mobile device can distract participants from their surroundings, as we observed some participants walking past signage while looking down at the mobile device. Further confirmed in the interview, these participants referred back to the mobile device in hopes of obtaining helpful information.

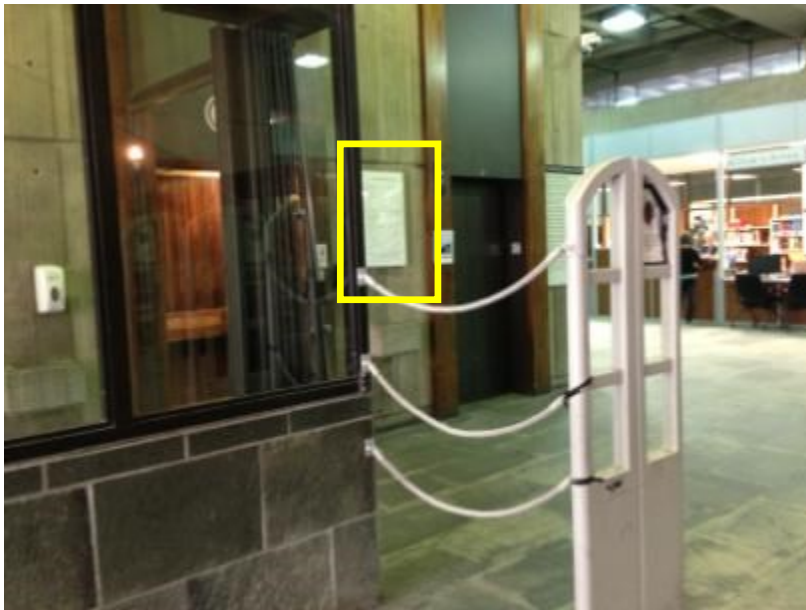


Figure 9. Directory on the ground floor

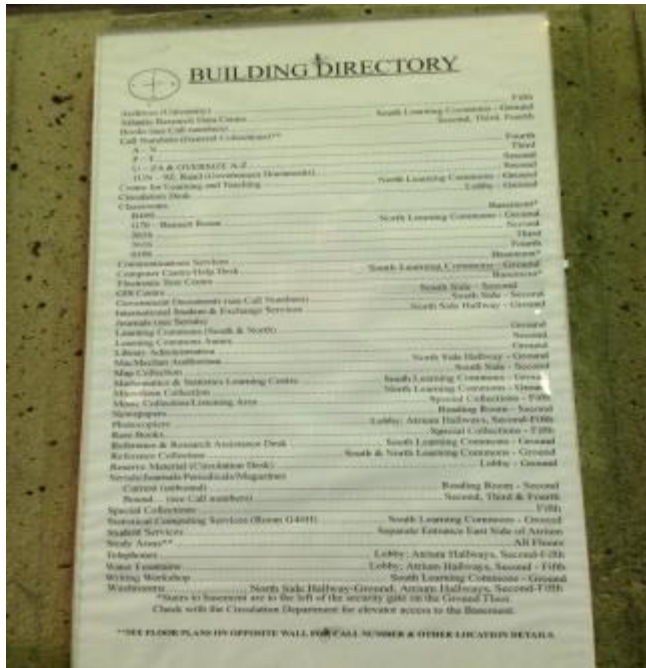


Figure 10. Directory posted on the ground floor

Failing to locate signage, and therefore being unable to determine which floor a book was on, resulted in confusion and frustration for inexperienced students participants. This is not surprising given their experiences. For example, two inexperienced students who were unable to locate signage on the ground floor continued their search on the second floor experienced frustration. During their search, these participants frequently overlooked signs that would have been of assistance (e.g., letter ranges on the wall). There were several times where they stood directly in front of a set of library maps and neglected to see these as their attention was focused on the mobile device. It was not until they had wandered up to the fourth floor that they saw a large sign indicating the range of call numbers they were seeking. As would be expected, these participants rated the task as extremely difficult in the post-task questionnaire and expressed confusion and frustration during the interview. Three other inexperienced students who asked the library staff for help still rated the task as difficult. Inexperienced students who found the signs easily rated the task as neutral and easy (Figure 11). Had they not been taking part in a research study, it seems likely that they would have abandoned their search long before the fourth floor.

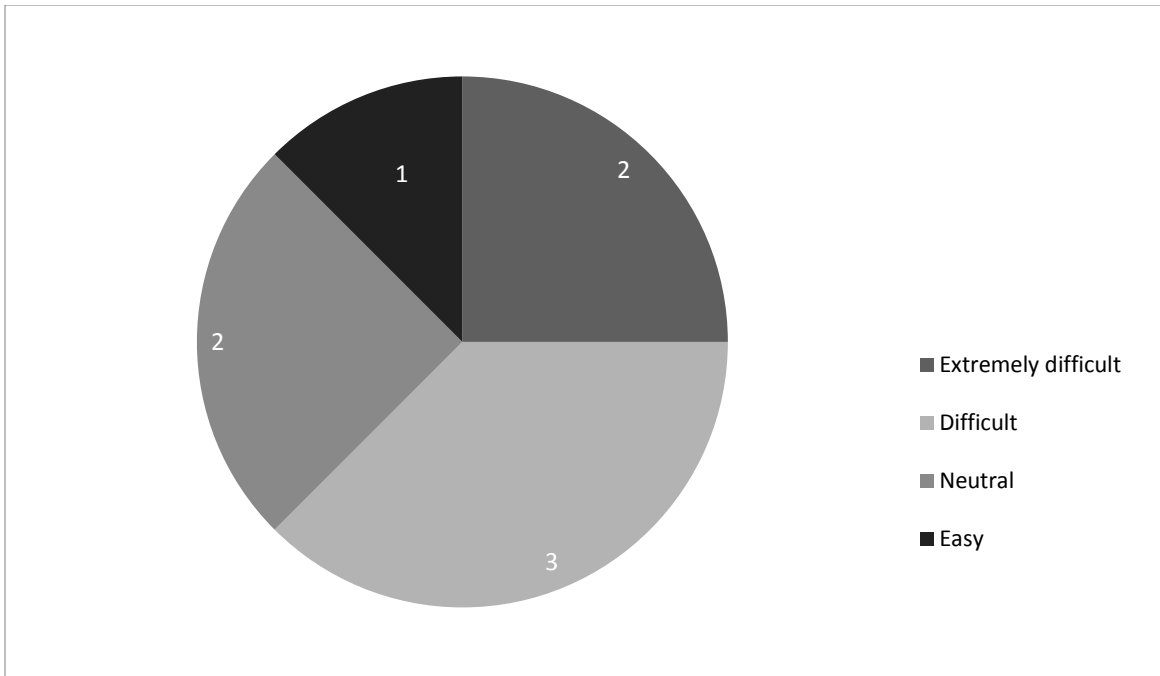


Figure 11. 5 Inexperienced students rated the task as extremely difficult after failed to locate the signages. 3 inexperienced students who did not have problems locating sinages rated the task as neutral and easy

Experienced students and library staff had an entirely different experience with using signage, as they encountered no significant difficulties in locating signage during any of their tasks. After finding the call number, they immediately proceeded to the directory and used it to determine which floor their desired book was on. With the floor identified, they proceeded to take the elevator directly to the correct floor without incident.

4.3.2 Learning the Bookshelves' Organization

4.3.2.1 Difficulty Understanding Call Numbers

Throughout the process of locating a book, the book's call number was the only resource that participants depended on. These numbers were used throughout the process, from first identifying which floor the book was located, to locating the general area the book would be in, to eventually finding the desired book in its place on the shelf. Call numbers are important to library patrons; in our study three inexperienced students asked a librarian for help in locating a book and all expressed an interest in how call numbers are formed and what each portion of the call number corresponds to.

The participants made extensive use of call numbers for locating books in both their familiar and unfamiliar domains. However, they still encountered difficulties while using call numbers. When we categorized the comments participants made during the tasks we identified two main causes of these struggles.

First, call numbers are lengthy and consist of letters and digits that rarely make sense to students. All participants, library staff included, found call numbers to be too complex to memorize. This combination of low comprehension and memorability made it necessary for our participants to constantly check the call numbers of their desired book to keep it in their short term memory. Without a meaningful way to distinguish between the subsets within each call number, participants could easily skip one set of the numbers while comparing. During the search, we constantly heard participants guess the meanings of the letter of call numbers. For example, all participants from the computer science department who needed to look for a book called *La Nouvelle France: The Making of French Canada* with a call number *F1030 M793 2000* (one of the books in their unfamiliar domain) guessed that the F stood for *French* before their theory was disproven by non-French books existing in that section.

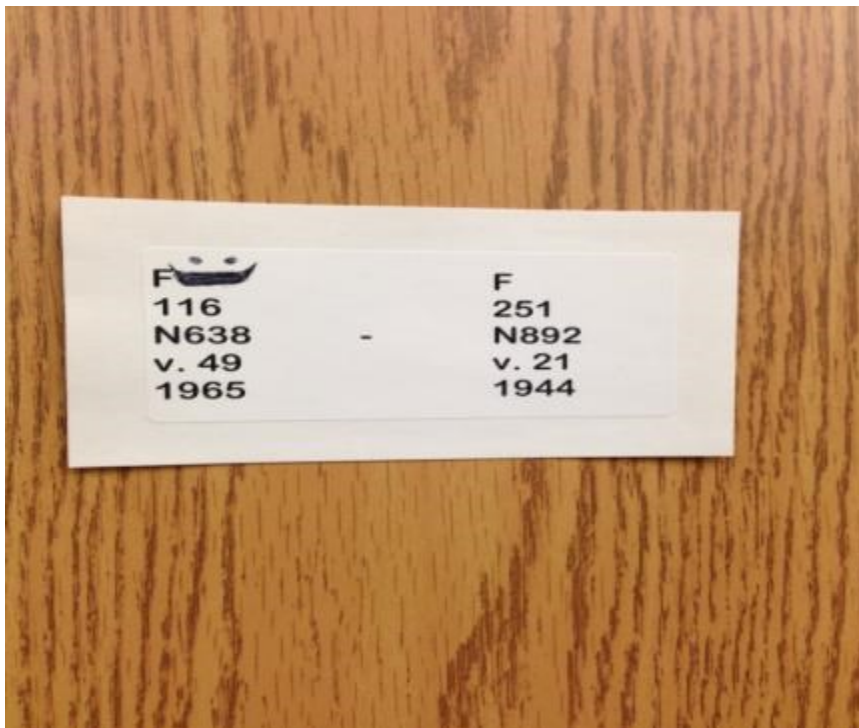


Figure 12. Tag on the end of the bookshelves

Second, call numbers are affixed to books variously depending on the height and thickness of each book's binding. This makes it difficult for library users to quickly skim the call numbers of a grouping of books. The call numbers are also presented in various way on the tag (see Figure 12), with the length of letters on each bookshelf ranging from one set to several. This variation is the result of differences in the number of collections one category has and the number of subcategories that category contains. The more collections a category has, the wider its letter range is; the more subcategories a category contains, the more sets of letters it displays on a bookshelf. Comparing letters was a tiring and repetitive process as participants needed to compare letters set by set while walking by book stacks. We rarely observed participants stopping to compare the call numbers carefully unless they walked into sections they had not expected. Participants noted that they found it easy to get the order of adjacent letters confused, which is likely the reason that both inexperienced and experienced students spoke the letters aloud in alphabetic order as they were navigating.

4.3.2.2 Wrong Side of the Aisle

After identifying the correct floor and general section, participants then had to locate the exact aisle their desired book was in. Each aisle is labelled with the range of call numbers that it contains. Mistakes, such as going into the wrong aisle or the wrong side of the aisle, were often observed during the study. For example, in one task participants were asked to locate a book with the call number *F1030 M65 2000*. The aisle containing this book is labelled as spanning the ranges of *F1003 C05* to *F1030 M64* on the left side and *F1030 M64* to *F2011 B37* on the right. Three inexperienced students did not see this distinction and looked at the wrong side of the aisle. As they walked further into the aisle they realized that the call numbers were getting further from their target. One student went back to the end of the aisle to confirm the range, while the other two went to the opposite side and explored the call numbers. Although all three were able to locate the book eventually, this misstep added a significant amount of time and frustration. In the post-task questionnaire, these participants rated the task as "difficult" as opposed to the rating by other inexperienced students of "neutral". A typical comment on this issue was that *"I should've paid more attention to the second number here. I was expecting only a small collection of books start[ing] with F1030 M something, so I thought even though I headed into the*

wrong side, I could easily find the book on the other side because as the tag says, the orders should be continuous."

4.3.2.3 Skipping Sets of the Call Number

Another common issue we observed was participants skipping the relevant set of the call number in favour of another set. For example, one participant was looking for the call number *F1030 M64 R200* on a bookshelf that ranged from *F1030 M64* to *F1030 N90*. He skipped the second set and began looking *for F1030 R200* within the aisle. It took a great deal of searching and walking through both sides of the aisle before he realized that he was looking for the wrong set. Skipping sets was not always accidental, as was the case with one inexperienced student who was unsure of what order the sets should be read in and said that *"maybe G83 [the first set of the call number] doesn't mean anything, maybe we should be comparing D83 ... there are too many sets of letters, I don't know which set to compare... I found a range says D2-- D153, let's try here"*.

Although only one experienced student searched the wrong side of the aisle due to accidentally skipping a set of call numbers, other experienced students reported having encountered this issue previously. During the interview, they expressed how confused they were when they made this mistake in the past and that they wish there was a better way for them to keep track of the set they are looking for at any given time.

4.3.3 Getting Lost in the Book Stack Room

4.3.3.1 Disorientation and Changed Behaviours

While navigating through the book stack room, all inexperienced students reported feeling disoriented at some point. Disorientation happened when participants navigating through the book stack room, which was the process before localized search. Therefore, we did not take into account the difference between book tasks. Instead, we mainly focused on comparing the process of navigating through book stack room between each task. We learned that these disoriented feelings were reported when they were completing tasks in unfamiliar domains. Three experienced students also reported feeling disoriented during the tasks in their unfamiliar domains (see Figure 13). We hoped to understand two key aspects of this issue. First, we wanted to know under what circumstances participants

started feeling disoriented. Second, we wanted to see how these feelings would influence the participants' behaviours.

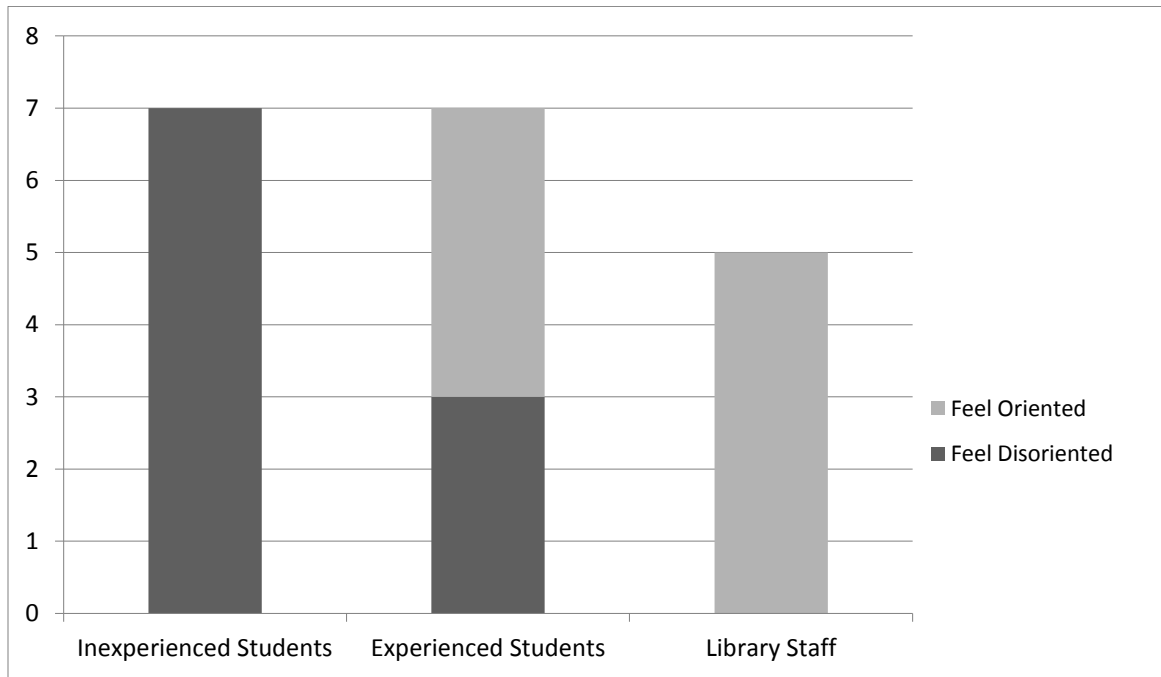


Figure 13. The number of participants who felt disoriented vs. not disoriented in the tasks

To answer the first question, we referred back to the audio recordings and discovered that disorientation was experienced most often when participants encountered letters that were unexpected. For example, one inexperienced student spoke aloud the letter G while walking through the bookshelves and then questioned “*why do all the books start with D here, where is [the] G section*”. Similar situations were discovered with other participants who felt disoriented during the study. One experienced student reported a sense of disorientation after changing floors. According to this participant, he assumed the bookshelves on this floor followed the same pattern as those on the previous floor. This assumption turned out to be wrong, causing him to constantly come across sections he didn't expect. However, once he realized this problem and adjusted his mental model of the floor's organization he was able to complete the rest of the tasks smoothly.

We were also curious about two factors—the sections' locations and the surrounding landmarks—in the locations where participants reported feeling disoriented. Compared the tasks during which participants reported disorientation feelings, we found no common

areas between participants, suggesting that feelings of disorientation can occur throughout the library and are not concentrated in certain areas. Next, we looked at landmarks in these problem areas and found that the problem areas contain mostly indistinct bookshelves. Through the audio recordings, we noticed that participants paid little attention to their surroundings, focusing instead on the letters on the bookshelves, which may have contributed to their feelings of disorientation.

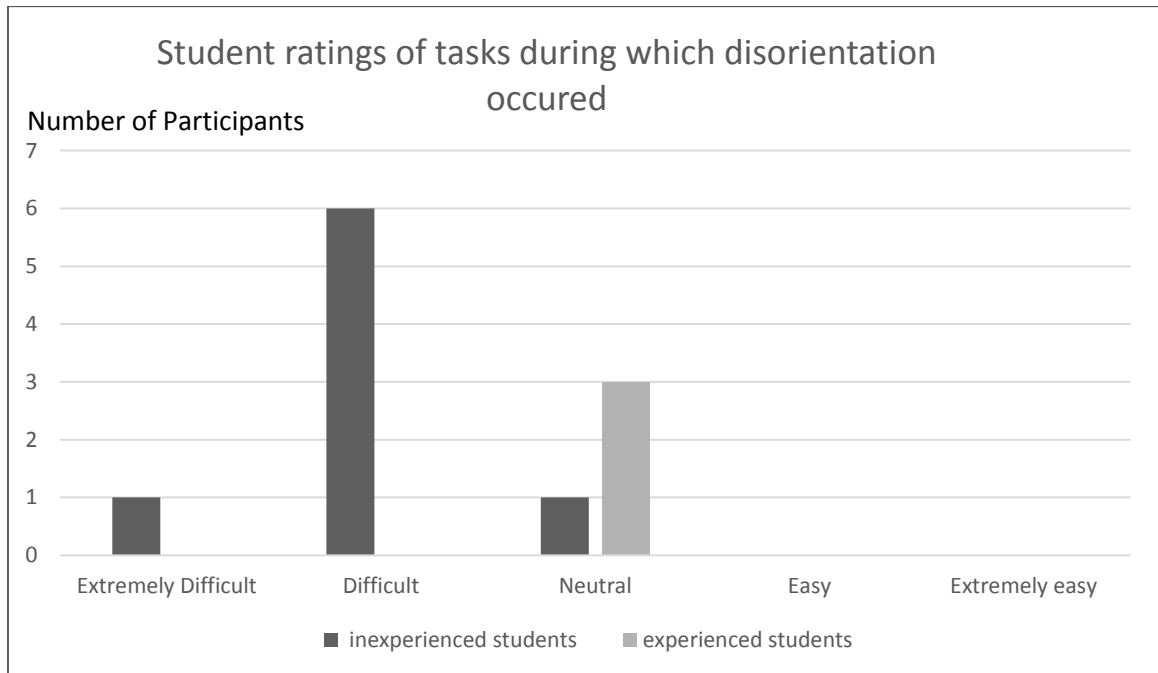


Figure 14. Tasks ratings for students during which disorientation occurred

To answer the second question about participants’ behaviors after experienced disorientation, we observed that when participants experienced disorientation they became visibly frustrated and confused. This was demonstrated most clearly when participants, after determining for certain that they were in the wrong aisle, continually walked back and forth in the aisle and checked books on the bookshelves. This behaviour seemed to come from the need to take some sort of action, however unproductive, rather than accept that they were lost. Frustration and confusion were also reflected in answers provided on the post-task questionnaires that were administered after a task in which disorientation was exhibited: participants who experienced disoriented feelings rated the tasks as "difficult" and one inexperienced student rated one task in his familiar area to be "extremely difficult" as he had given up on the task entirely (see Figure 14). Compared to the inexperienced

students, the experienced students who reported a sense of disorientation were able to regain their orientation in a shorter period of time. We noticed that, rather than checking the call numbers or titles of nearby books, they tended to walk back to the ends of the bookshelves to refer to the aisle’s labels to reorient themselves. In their post-task questionnaire, even after encountering unexpected sections they still rated the task as neutral (see Figure 14 and Figure 15).

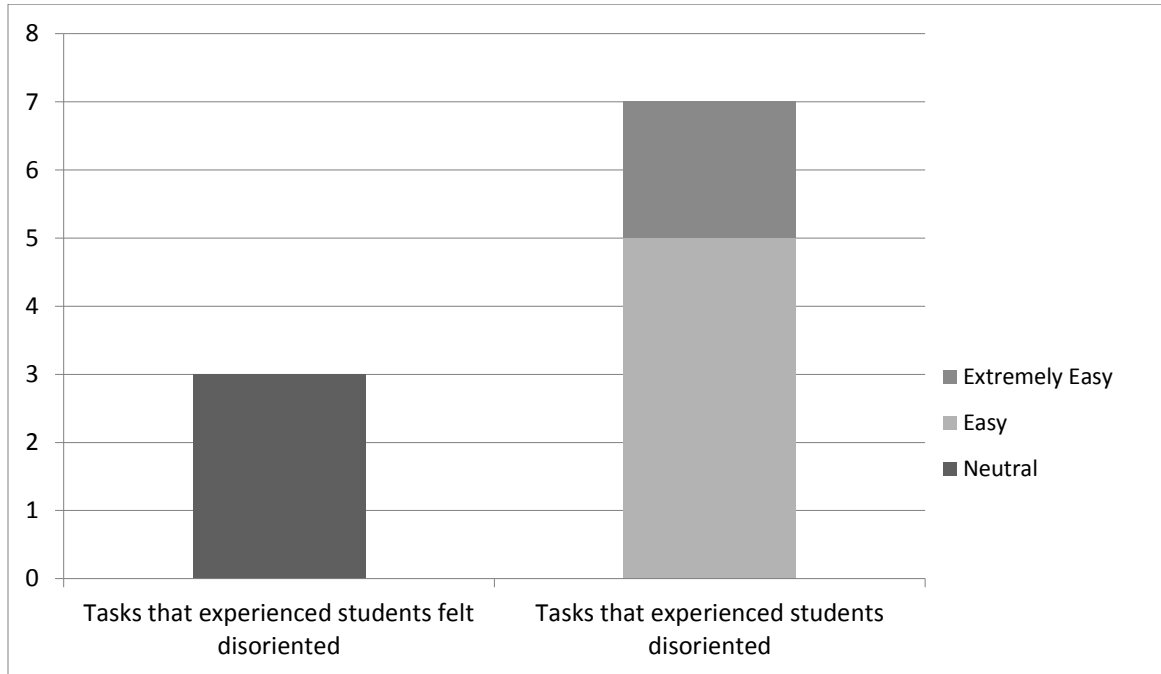


Figure 15. Tasks rating after experienced students felt disoriented vs. oriented

4.3.3.2 Limited Mental Representations

We suspect that disoriented feelings during tasks were due to participants having incomplete mental representations of the book stack rooms. This can be seen through the observation that in unfamiliar domains, participants determined their direction based almost entirely on the letters' patterns they detected in nearby call numbers. Participants’ abilities of forming a clear mental representation of current environment is positively related to the landmarks. However, being in participants’ unfamiliar domain, which filled with indistinct bookshelves limited their context and their pattern identification relied on a relative small range of shelves. Conversely, in book stack rooms that participants were familiar with not only areas they had visited previously but they also demonstrated knowledge of topics in the surrounding areas. Knowing the topics helps them to remember

the locations of those sections more clearly. As one experienced student from the computer science department described during a task, *"I'm very familiar with part of the Q section—QA mostly—and the TK section because I took a human computer interaction course and web development course. I borrowed books from this library for those two courses before."* According to some students, they keep track of their current location in relation to the sections they are familiar with in order to maintain a sense of orientation. Their knowledge of the book stack room is still limited when compared to that of library staff, who experienced no disorientation during the tasks.

4.3.3.3 Regaining a Sense of Orientation

After encountering an unexpected section and reporting feelings of disorientation, four inexperienced students followed their path back to sections they had visited earlier (see Table 22). According to our participants, these sections felt less "intimidating" as they were arranged in a way that participants could more easily understand the letters' orders. Once they were in the more familiar sections, participants started relearning the letters on the surrounding bookshelves in an attempt to understand why the unexpected bookshelf was placed there. When asked by the researcher why they were not studying the call numbers' order in the unexpected section, these participants said that the patterns in the unexpected section seemed disconnected with the patterns they had learned before. However, two experienced students did learn the call numbers' order in the section where they became disoriented. After gaining an understanding of the section's layout they resumed their navigation process. Although in the interview most participants stated that they would go back to the entrance of the room to start the process over if they felt disoriented, only one participant returned to the entrance during our field study. Three inexperienced students started conducting random searches after reporting feelings of disorientation. Fortunately, they happened upon the section they were looking for during the random search.

	Heading back to sections where they can apply the letters' patterns	Learning letters' patterns in the section where they got lost	Random search	Go back to the entrance
Inexperienced Students (7)	4	1	3	0

Experienced Students (3)	0	2	0	1
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Table 22. Participants' reactions to disorientation

We also found that participants started feeling a sense of orientation once they relearned the letters' ascending/descending orders. The following quote is of an inexperienced student becoming re-oriented: *"Oh boy, I'm so lost here, I don't know where I should go next...It's all books with G here (Walking back and forth in the same aisle). Anyway, I'll go back to the D section...DA, DB, so this aisle should be going from D to E or F, that way, yes, that's why there's G."* After relearning this pattern, this participant continued the search and found the target book successfully. To prevent disorientation, it is important that users are aware of their current location at all times.

4.3.4 Misplaced Books

Each participant was given two books to locate (one in their familiar domain and one in their unfamiliar domain) that was intentionally misplaced by our researcher. The misplaced books were near their original positions (see Figure 16 and Figure 17). Misplaced book situation can also happen due to the library's system. For example, when a book is checked out, the system will not update a book's status until after it has been checked out for three hours. In this study, our goal was to identify what information library users may seek when they are unable to find a book in its expected location. In addition, we expected this task to help us better understand what resources are used while searching for a book on a shelf. In the rest of this section, we will be presenting some interesting behaviours from participants regarding how they reacted to the misplaced books to illustrate the resources they use while locating books.



Figure 16. The book in its correct location

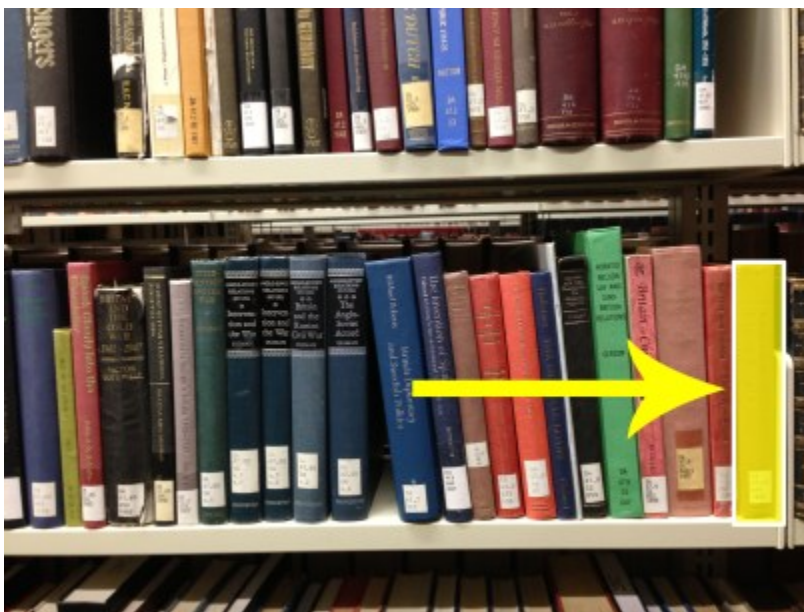


Figure 17. The book after being misplaced by our researcher

All participants exhibited some frustration and confusion when they realized the book was out of place. For two inexperienced students we observed prominent differences in their reactions to misplaced books in their familiar and unfamiliar domains. This differences are mainly reflected in the frustration and confusion participants showed during the task, and whether they noticed that the books were misplaced or not. While two inexperienced students and three experienced students gave up on finding the misplaced book in their

unfamiliar domain (see Figure 18), no one gave up looking for the misplaced book in their familiar domain.

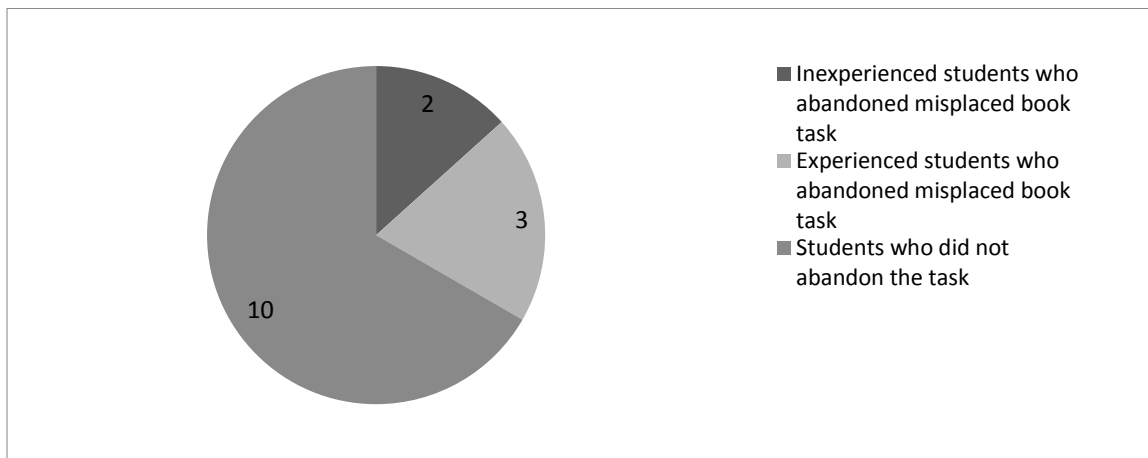


Figure 18. Proportion of students who abandoned misplaced book tasks

The following example is of an inexperienced student who encountered a misplaced book in his unfamiliar domain and abandoned the task. When our researcher asked why he had given up on the task, he replied *“This book is not where it's supposed to be. It could be anywhere. I tried to check the titles, but I know nothing about French history, I don't think I can find it”*. Surprisingly, when doing the misplaced book task in his familiar domain, this inexperienced student neither gave up on the task nor even noticed that the book was misplaced. This is because when locating books in his familiar domain, instead of call number, this participant searched by book title. His different reactions towards the misplaced books can be seen in his post-task questionnaire as well, where he rated the misplaced book task in his unfamiliar domain as "very difficult" as opposed to "very easy" for the misplaced book task in his familiar domain. Among those five participants who abandoned the misplaced (see Figure 18) tasks in their unfamiliar domains, two inexperienced student participants gave up almost immediately after they realized the book was misplaced. Three experienced students gave up after a short attempt of looking for the book based on other information, such as the book's title or the image of the cover. These behaviours were interesting as they indicate resources and attributes that may be used while looking for any book, which we will discuss next.

4.4 RESOURCES USED FOR NAVIGATION

In the following section, we describe the observed and noted resources that our participants used to navigate in detail. If the resource was utilized differently in participants' familiar domains and unfamiliar domains, examples will be presented in order to allow readers to easily compare the usage (see Table 23). Each item in Table 23 will be discussed in more detail in subsequent sections.

Resources Used to Locate Books	Inexperienced Students (8)	Experienced Students (7)	Library Staff (5)	Total Number
Call numbers	8	7	5	20
Landmarks	8	7	5	20
View-action pairs	8	7	5	20
Book titles (familiar domains)	6	4	2	12
Images of books' covers	1	3	3	7
Book titles (unfamiliar domains)	5	1	0	6
Library maps	1	1	0	2

Table 23. Resources that participants used during the tasks

4.4.1 Library Maps

Although disoriented feelings were reported by all inexperienced students and three experienced students, only one inexperienced student and one experienced student tried using the library maps to regain their orientation. Participants had two ways to access the Killam Library maps. First, a set of maps displaying floor layouts for the first to fifth floors is located on each floor directly across from the elevators (see Figure 19). Second, participants could access maps from the libraries' website using their mobile device. The two participants who wanted to use maps both walked back to the elevator room to use the mounted floor maps. Difficulty using these maps was reported by both participants.

From our notes and the audio recordings, we observed the inexperienced student standing in front of a set of library maps trying to recall the path he took and all the areas he had been previously. This was difficult; he could not remember which section he was in before walking back to the elevator room. Therefore, instead of finding a path that would resume from the point where he felt disoriented, he chose to memorize a new path from his current

location to get to his destination. Unfortunately, when he once again entered the stack room he was unable to remember this path and could not utilize it. During this process, it never occurred to him that he could use the mobile device to take a picture of the maps in the elevator room for reference.



Figure 19. Library maps mounted in the elevator room

The experienced student had similar difficulties in determining where on the map he had previously been, and so also decided to create a new path from the elevator room. Differently, this student took a picture of the map showing the current floor's layout. Upon returning to the book stack room, despite paying close attention to the map on the mobile device while navigating he moved in the opposite direction he intended. After continuously encountering unexpected sections, he realized his error and commented that *"It was confusing to use this map. I was just about to say how these sections are not what it says on the map, then realize I held the map in a wrong way."* Eventually he went back to the entrance of the book stack room and started the whole process over.

4.4.2 Images of the Books' Covers

One inexperienced student, three experienced students, and three library staff used the images of the book covers on the mobile website to assist in locating books successfully. From our observations, they did not focus on specific details such as images or text, but

instead used the primary colours as their reference. By using this main colour, participants could quickly skim through rows of books and easily skip the rows that didn't contain books of the desired colour. As one participant said during the task when asked how they quickly excluded a shelf from their search "*the picture on the website says the book is red, and I didn't see any red ones here.*" Using the colours of the image was considered by our participants to be an efficient way to narrow down the search area. By using this strategy participants felt that they had a smoother searching experience, which was confirmed by our observations that they checked and compared call numbers less frequently than other participants who did not use this strategy during the tasks. However, the strategy did not significantly help participants with book finding tasks in terms of time. During the interview, these participants expressed that where available (not all books on the website have a corresponding cover image) they prefer using the images in combination with call numbers to narrow down the search areas rather than using call numbers alone.

4.4.3 Book Titles

Book titles are another resource that participants used to locate books. Interestingly, we noted that book titles were used differently by participants when conducting book searches in their familiar and unfamiliar domains.

4.4.3.1 Unfamiliar Domains

In the post-task questionnaire, five inexperienced students and one experienced student said that they used book titles while searching for books in their unfamiliar domain (see Table 5). Book titles normally come into use in two ways. First, participants often used book titles to confirm that they found the right book. Second, when participants could not locate the book by the call number, they would first attempt to understand the meaning of the book title before browsing the titles of nearby books in an attempt to determine if they were in the right general area.

4.4.3.2 Familiar Domains

Compared to the use of book titles in unfamiliar domains, participants considered book titles to play a more significant role in locating books in their familiar domains. As with the unfamiliar domains, participants again used book titles to confirm that they had found

their desired book. We observed that, with being able to understand the books' titles (since we chose books for each individual based on their reported familiar domains in a pre-session questionnaire), participants were less dependent on call numbers to locate the book. This is because being able to perceive book titles gives participants a sense of nearby categories. Participants could easily tell that they were approaching the right section by reading the titles of books nearby.

For example, an inexperienced student noted that when doing the first task in his familiar domain, he said "*[Those books are about] database, those are [about] operating system...Here are all the books about object-oriented, then human computer interaction and user interface design books are down here. I guess the book I am looking for must be somewhere near the bottom area.*" In contrast, when this student was doing tasks in his unfamiliar domain, he made comments like "*I guess it is all history books*" that indicate an inability to distinguish between subcategories. When approaching the right section in their familiar domains, participants recognized specific subjects. We believe this transition from not knowing to knowing nearby subjects may be the reason why almost all participants reported feeling more comfortable doing tasks in their familiar domains, even for one inexperienced student who had never borrowed books from his familiar domain previously.

After narrowing down the searching area to one bookshelf, six inexperienced students, four experienced students, and two library staff used book titles (see Table 5) to locate the book successfully in their familiar domains. None of our participants used titles to locate the book in their unfamiliar domains. In the audio recordings, we heard participants stopped in front of a bookshelf repeating the last two or three sets of the call number. We then heard them reading aloud book titles while locating the book. However, when the book had a generic name participants had to switch back and forth between call numbers and book titles. When using book titles to search for books, we observed that participants were less likely to go back to the sections they had browsed previously to confirm they had not missed the book. When asked about this behaviour during the interview, participants admitted that they felt that it is easy to miss the book by only using call numbers. In contrast, when participants ruled out sections based on the books' categories they felt more confident that the book would not be in that section.

We asked participants whether or not they noticed nearby topics when looking for books in their unfamiliar domains. Three inexperienced students, six experienced students, and all library staff reported that they neither used the book title nor noticed the nearby categories during book finding tasks in their unfamiliar domain. When they could not find the book by its call number, one inexperienced student who noticed the category during the second task in his unfamiliar domain said *"even though I did, I didn't get any clues where the book might be and then I switched back to just using the call number"*. And the other inexperienced student claimed having only noticed some titles during the first task, before he realized that trying to understand an unfamiliar category did not seem to help him narrow down the searching area and he gave up using book titles. The audio recording of this participant confirmed his explanation of not using book titles in his unfamiliar domain. *"Those titles don't make sense to me at all [he was looking for a book named "La Nouvelle France: The Making of French Canada"]". You at least can see the signs about call numbers everywhere in the library to hint where to go next. I don't know how to pronounce the French part here"*.

4.4.4 Landmarks

4.4.4.1 Landmarks Identified by Students

We identified several potential landmarks on the third and fourth floors of the Killam Library, which have different placement of bookshelves but the same landmarks. Each floor has an elevator room, which connects the book stack room and the study area. In the elevator room, there is a large bulletin board across from the elevators where library patrons can learn about school events, elective classes, and tutors' availability. A set of library maps for the first to fifth floor are placed on the left side of the bulletin board. Two signs indicating the letter ranges on each side of the book stack room are placed at the entrance. No signs are placed in the study area. There are doors on either side of the study area connecting the study rooms and the book stack rooms. A photocopier and a fire extinguisher are placed next to the door. In the book stack room, book stacks take up the majority of the available space. On each end of the book stacks, two identical signs (see Figure 20) indicate the range of call numbers contained in the aisle. On some book stacks,

there is an additional sign indicating the general letter range followed by an arrow pointing at the direction. Carrels are placed against the wall on every side of the book stack room.



Figure 20. Signs on the book stacks

From our field notes and interview data, we categorized indoor landmarks and other navigation information that participants used to form a mental representation of the floor layout during the tasks. The most significant categories of landmarks were books with outstanding features (see Figure 21), elevators, and stairwells. There was only one experienced student participant who used the location of elevators and stairwells as indoor landmarks during the tasks. This participant said that *"I always visualize my current location in relation to the elevators and the stairwell. This way at least I would vaguely know how deep I am in the book stack room"*. We asked students why they referred to these landmarks so rarely. Some inexperienced students were not aware of the locations of the stairs, while others found it difficult to judge any direction while they were immersed within the bookshelves and lost reference to the elevator and stairwell. Most students reported that keeping track of their location in relation to these landmarks required too much attention during the tasks.

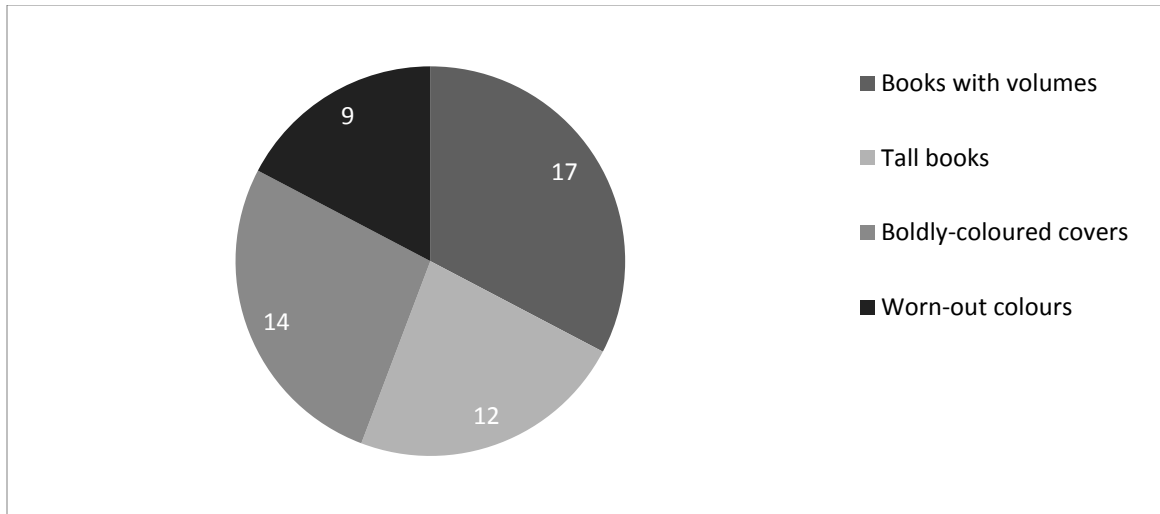


Figure 21. Book attributes that attracted participants' attention

Compared with the elevators and stairwells, outstanding books are much less remarkable in terms of their physical features. However, all inexperienced students and five experienced students considered outstanding books to be helpful in recognizing the areas they had been and identifying paths that had taken. To our surprise, general indoor landmarks such as doors, bulletin boards, signs, and fire extinguishers, which were identified in the study (Radoczky, 2007) were not mentioned by our participants.

With outstanding books playing such a large role as landmarks, we asked questions in the interview to gain insight into the features that books should possess to be considered good landmarks. These features could be categorized as physical attributes of the book and the participant's personal connections with the books. The physical attributes included books with outstanding covers (e.g., boldly-coloured, very old), large sizes, or collections of similar books. These features are consistent with the definition of landmarks as "an object or structure that is prominent and contrasting to the background" (Lynch, 1960, p. 348). As to the personal connection aspect, participants mentioned that they easily noticed books they are familiar with or had borrowed previously. Some participants pointed at these books or read the titles aloud to indicate that they had borrowed the book before. For example, one participant explained that he noticed a book because he *"had this book for ten years in my office...I stared at it every day"*.

Unsurprisingly, identifying books as landmarks due to the participants' familiarity with them happened most frequently during tasks in their familiar domains. According to our participants, this is mostly because they can understand book titles in their familiar domains better. Especially when skimming through books, they can register their familiar information better than unfamiliar information or lengthy and confusing call numbers.

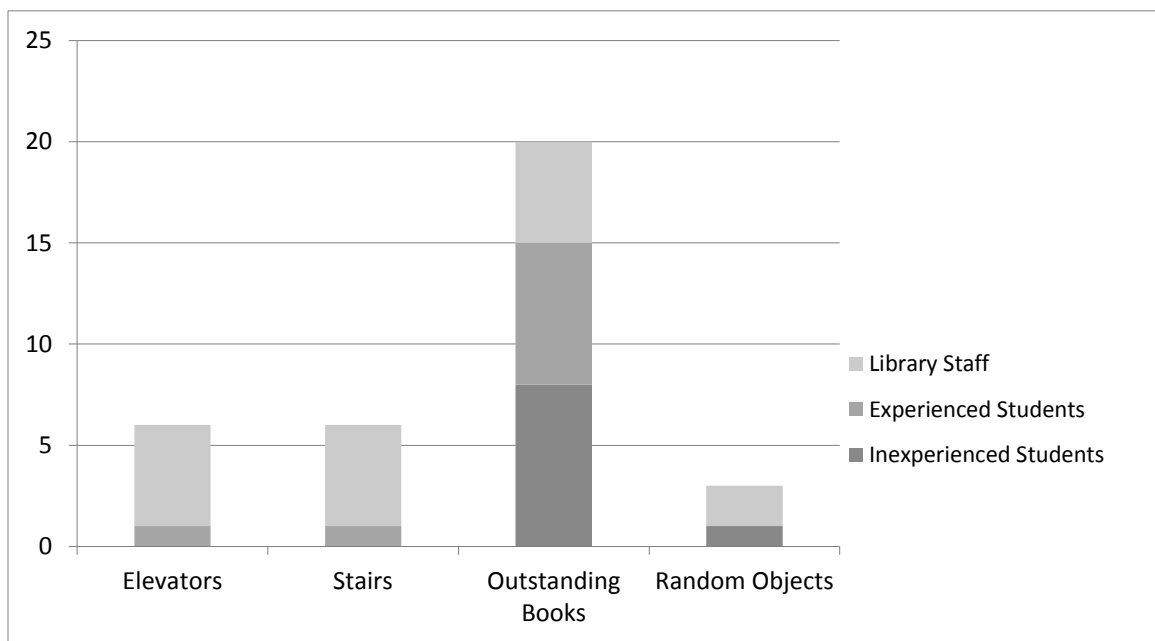


Figure 22. Landmarks identified by participants

4.4.4.2 Landmarks Identified by Library Staff

As can be seen in Figure 22 outstanding books and the locations of elevators and stairwells were also identified as indoor landmarks by library staff. Similar to student participants, library staff consider "outstanding books" as useful landmarks for helping them efficiently recognize the areas they have been previously. However, all library staff (as opposed to only one student) used the location of elevators and stairwells to estimate their current locations during the tasks. We speculate that the high use of these landmarks is due to their regular use of these elevators and stairs. They related in the interview that they often have to travel in the library with a cart of books several times a day and normally use the separate staff elevator. Therefore, instead of the main entrance to the book stack room, library staff are used to beginning their tasks from the staff elevator. Unlike most students who had a hard time pointing out the locations of the elevators and the stairwell during the tasks,

library staff were always able to tell where these were located. When traveling without carts, library staff report preferring the stairs to elevators for efficiency. This was confirmed in our study as all of the library staff chose to use the stairs as opposed to most students who used the elevators. At the end of each task, we observed no difficulties in navigating from their location to the nearest stairwell. Pazzaglia et al. (2001) mentioned the concept of high-survey individual (people who have a good mental representation of the current environment during navigation) and landmark-centered individual (people who are depended on identifying and recognizing landmarks to navigate). As we have discussed previously, landmarks such as the locations of the elevators and the stairwell were used by one experienced student and all library staff during the book finding tasks. We believed that our participants with more experience exhibited behaviors as a high-survey individual as opposed to participants with less experience who behaved more similarly as landmarks-centered individual. We were also curious to know whether high-survey individuals implies better spatial abilities. We found there is a significant difference in SBSOD in terms of their spatial abilities between participants who identified stairs and elevators as landmarks and participants who did not ($p = 0.024 < 0.05$).

Nevertheless, four inexperienced students, five experienced students, and all library staff considered that being able to calculate their current locations in relation to a fixed point (e.g., the location of the elevator and stairwell) is of great importance for obtaining an awareness of orientation in an environment (see Figure 23). This specifically refers to the distance between landmarks, especially the outstanding books and the area they are familiar with. According to our participants, vaguely recalling the path between the books they looked for and the area they were familiar (or relatively familiar) was particularly helpful when doing the refinding tasks. Since participants were not able to remember the call numbers, following this path allowed them to judge how they had gone into the aisle so that they could estimate the general location of the books.

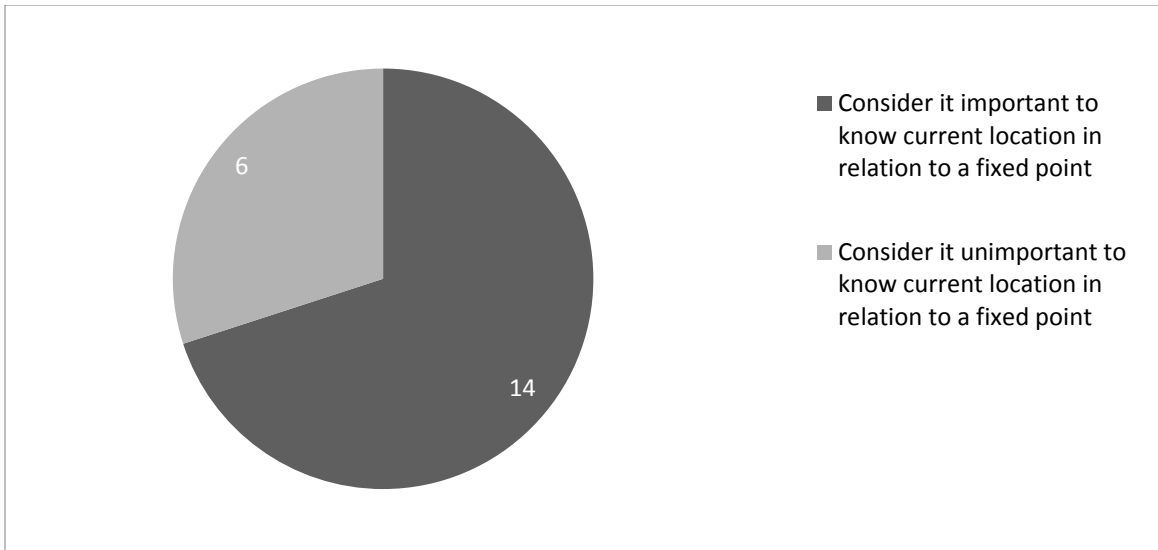


Figure 23. Importance of knowing the current location in relation to a fixed point

4.4.5 Refinding Using “View-Action Pairs”

After completing the last task in each domain (i.e., their familiar and unfamiliar domain), participants were asked to relocate the book from the first task without assistance from the mobile device, maps, or any other tool. For these special tasks, participants were only able to depend on their memories of having recently located the book. As memory abilities vary greatly among individuals, our goals were not to compare participants' memory abilities but instead to see what information was recalled by participants during these tasks.

We identified the common use of “view-action pairs”, which Lovelace et al.(1999) explained to be the most basic block of route knowledge from most participants. Following is an example on how our participants used “view-action pairs”. In audio recordings, participants made comments during the refinding tasks included *"I remember I turned right here"* and *"I remember seeing that book before"*. The book, in this case, is the landmark this participant identified previously, which stands for the “view” in view-action pairs. The action is the turn that this participant made when he saw the landmark during navigation. View-action pairs were used to piece all of the incomplete mental representations of the current floor plans together to form a relatively complete one that enabled them to relocate the book.

In addition, memories of actions helped them reduce their search range to specific shelves. For example, when facing the bookshelves, some participants remembered either reach up high (with the use of a stool) or crouch down to get the books. One recording is typical of most experiences: *"Okay, where is it, where is it? I remembered I kneeled down here. I don't remember the name, but I vaguely remember the cover color and the location. Here's the book."* Only one inexperienced student gave up the refinding task in his unfamiliar domain because he could not recall any of the book's attributes. However, he did successfully navigate to the aisle where the book was. Nineteen participants finished the refinding tasks successfully.

4.5 DISCUSSION

The data we collected from this field study helped us to answer the following research questions:

- A. How do library patrons locate specific books within environments filled with indistinct landmarks?
- B. What difficulties do library patrons face while locating books in a library?
- C. Do library patrons use mobile devices while locating books? If so, how are they used?

We answered the first question by observing how participants oriented themselves within the book stack rooms, which are filled with indistinct landmarks. Being immersed in the book stack room, without having an awareness of their current location or distinct landmarks to refer to, limited participants' abilities to form a mental representation of the space. This led to disorientation and confusion for many of our participants. They did, however, identify some landmarks which can be classified into three categories. All three categories of landmarks are highly related to the current environment – the Killam Library. This discovery suggests that the landmarks identified by our participants are depended on the characteristics of the environment. This is also consistent with the finding in study (Frankenstein, Brussow, Ruzzoli & Holscher, 2012), as they concluded from their study that the process of identifying landmarks is associated with the goal in the current environment.

1. Book Characteristics: all participants identified outstanding books (e.g. large sizes, bright colours) as landmarks. This included books that stood out due to the participant's individual familiarity with them.
2. Elevators and Stairs: the location of the elevator and stairs were identified as landmarks by participants with a large amount of experience using the library.
3. Personal Meaning: Various other items, such as graffiti, served as landmarks for some of our participants. We concluded that although the types of landmarks are similar for most people, the specific items considered as landmarks vary widely based on personal experience and relevance. Any system that is designed to assist library patrons in navigating will need to account for these large personal differences through customization and personalization.

Our second question was addressed by noting specific difficulties that participants experienced during their book finding tasks. These troubles were for the most part caused by call numbers. While navigating a large room filled with indistinct bookshelves, the target book's call number served as the primary resource. However, call number consist of several sets of seemingly-random digits and letters that our participants were consistently unable to understand, remember, or utilize efficiently while locating books. Incorrect perceptions of the bookshelves' arrangement based on call number resulted in our participants frequently entering the wrong aisle or moving in the wrong direction entirely. Learning the arrangement of books and comparing call numbers is an intensive and tedious process. Mistakes, such as jumping sets, frequently hindered the book finding experience. Having the wrong perception of the bookshelves' arrangement was common and led to strong feelings of disorientation when participants encountered unexpected sections.

As to our third research question concerning the current use of mobile devices while locating books, we observed a high adoption rate of the mobile device. Participants generally reported having positive experiences with using this device, particularly while searching for call numbers from within the book stack room. Mobile devices were especially helpful when encountering misplaced books, as they could be used to quickly to verify the book's availability to determine if further searching was necessary. However, while the usage of mobile devices was high at the end of the task, we observed an initial

hesitance to use this device as participants preferred to record the books' information (e.g., call number and book title) on a piece of paper despite having this information available for reference on the phone at all times. Additionally, our participants used neither the phone to access library maps directly nor the camera to refer back to physical maps from other locations. With the high adoption of the mobile device in this study, we feel there is a great opportunity to assist library patrons in locating books by providing improved mobile devices and applications that could serve as forms of indoor navigation to reduce the complexity of this task.

In the next section, we will propose a set of guidelines based on our research that may applied to the design of such future systems.

4.6 GUIDELINES

Based on the findings in this field study, we propose four guidelines that could help the design of mobile indoor navigation systems to assist library users with book-finding tasks. In this section we will introduce each of these guidelines and provide a brief description of common difficulties experienced by our participants that could be alleviated by systems that incorporate these design guidelines.

4.6.1 Highlight Important Signs in the Library

Most inexperienced students have rarely or never borrowed books from the library. They are familiar with the areas involved with borrowing books, such as the circulation desk. However, due to they lack of experience of borrowing books, they had not previously paid attention to signage provided for borrowing books. This lack of experience makes it difficult for them to locate signs in the library. This is consistent with a prior study by Sorrow and Hirtle (1999) that found that signage can be easily missed, particularly when people are not familiar with the environment and have few clues about where signs may be located. Failing to locate important signs in the library can cause confusion and frustration for library users. Therefore, we recommend that indoor navigation systems incorporate techniques that will draw users' attention to signage that may be useful in navigating the library.

4.6.2 Divide Sections into Meaningful Subsections

Library staff are able to identify nearby sections and those that are farther away by dividing the book stack room into smaller sections and subsections. From their previous experiences with navigating in the library, staff have a general sense of the letters' distribution in each section. This knowledge exists in both their familiar and unfamiliar areas and aids their navigation in both, although they may have to pay more careful attention in unfamiliar areas to determine which direction to go in. Furthermore, their recognition of the "zigzag" pattern (i.e., when the letters are increasing in one aisle, the letters must be decreasing in the two adjacent aisles) allows them to spend less time identifying the ascending/descending order of each aisle. We advise that indoor navigation systems be designed to model how library staff divide the book stack room into smaller sections.

We believe the use of clear section divisions, along with clear visualization of the letter ranges and zigzag pattern, may help users more easily form a mental representation of the current floor while navigating, even with their view blocked by bookshelves. Based on the results of the Santa Barbara Sense of Direction questionnaires, we found that most of our participants consider retaining an awareness of their current locations in a book stack room to be of significant importance. Systems that are designed to increase this awareness will be most likely to satisfy users' goals for navigating the library.

4.6.3 Include Relevant Landmarks and Orientation on the Map

In our interviews we learned that most participants consider library maps to be helpful for providing an overall view of the arrangement of book stacks on each floor. However, due to not knowing fast access (i.e., through phone), only two participants referred back to library maps when feeling disoriented. Both participants experienced difficulties of using it.

There are three common reasons that maps are not used to navigate libraries. First, our participants reported that accessing the maps is inconvenient. In the case of the library we studied, maps were located in an elevator room that was difficult to find once participants were immersed in the book stacks. Second, utilizing a map requires users to memorize a path through an environment that is unlikely to have any distinct landmarks. This makes it

highly likely that the map user will miss a turn or otherwise stray off of the desired path. Third, maps require too much cognitive effort to relate the user's current location to her location on the map. For these reasons, most of our participants felt that existing maps were unhelpful in navigating the library.

The largest problems with maps can be overcome by including landmarks and automatically orienting the map to match the user's orientation. Highlighting the objects that users are sensitive to can build the connections between users and library environment to help them navigate. Considering that meaningful landmarks vary widely between library users, we recommend allowing users to define their own landmarks to the navigation system.

4.6.4 Label Sections Based On General Topics

In our field study, all inexperienced students and six experienced students expressed that they felt more comfortable and confident searching for books in the domains that they have more knowledge of, even if they had not borrowed books from that area previously. Participants reported feeling more comfortable when conducting a localized search in their familiar domains as well. This difference appears to be a result of their improved ability to understand the titles of books nearby and group this into meaningful categories.

In order to provide a similar experience to users in unfamiliar domains, we recommend that the bookshelves be partitioned into sections with titles that could be understood by a general audience without specific domain knowledge (e.g. French History, Database Design). This clear categorization provides the understanding necessary for people to navigate unfamiliar areas in ways more similar to how they navigate familiar areas. For example, someone looking for a book on French history could quickly exclude nearby sections on German history without requiring any detailed knowledge of either subject. Considering the fact that the last several digits of call numbers can change drastically even in small areas, we recommend labelling quite small subsections on individual shelves. This may help library users avoid missing the desired book, as many of our participants (five inexperienced students, four experienced students, and three library staff) expressed a

desire to know the location of each range before starting a localized search for their target book.

In the next chapter we will introduce a low fidelity prototype that was designed using these guidelines. We will present their major features and then in Chapter 6 will present the results of focus groups who evaluated the prototype features.

CHAPTER 5 DESIGN REQUIREMENTS AND PROTOTYPE

5.1 INTRODUCTION

The results of our field study informed the design of a prototype for locating books in the library. In order to apply the first two guidelines (i.e., highlighting important signs in the library and dividing sections into meaningful subsections), our prototype was designed to present a clear view of the environment with important information highlighted at all times. This prototype presents the views of the book stack room from different angles: overall view of book stack room and turning point indicator. In order to apply the last two guidelines (i.e., including relevant landmarks and orientation on the map and labeling sections based on general topics), this prototypes allows users customize the representation of the floors to their liking by adding landmarks of their own. It also display book category information and fish-eye view of bookshelves to support localized search process. These four guidelines are incorporated carefully in this prototype to help users during each phase, from navigating through the book stack room to physically locating books on the bookshelf. This prototype aims to support the natural way that library users locate books in the library.

5.2 PROTOTYPE VIEWS

5.2.1 View 1: Overall View of Book Stack Room

The first view presents users an overview showing the general location of the book relative to their current location. This view can be switched between bird's eye view and augmented reality view. When users first attempt to locate a book in the library they require an. A bird's eye view can provide users with an overall view of the book stack room and allow users to be aware of their current location in relation to their targeted area (see Figure 24). An augmented reality view allows users to associate the current physical view with arrows pointing where to go without increasing their cognitive load (see Figure 25). Both the bird's eye view and augmented view are shown in an orientation that is consistent with the view that users are able to see in the library (i.e., based on user's current location, the range of

the view shown on the prototype is the same as user's eyesight range). In our prototype, the bird's eye and augmented views are used for finding the general location of a book while an augmented view alone is used for more localized search.

We applied the concept of section division in order to present a clear view of the book stack room. This involves dividing the book stack room into smaller sections, which was one key difference between library staff and students as they attempted to maintain an awareness of orientation in a book stack room (as discussed in Chapter 4). Our prototype divides the book stack room based on blocks of bookshelves. In addition, we included library staff's expertise into this view, providing letter ranges (Figure 24 A) along with arrows (Figure 24 B) indicating the ascending/descending order, which is placed at the bottom of each section of bookshelves (see Figure 24).

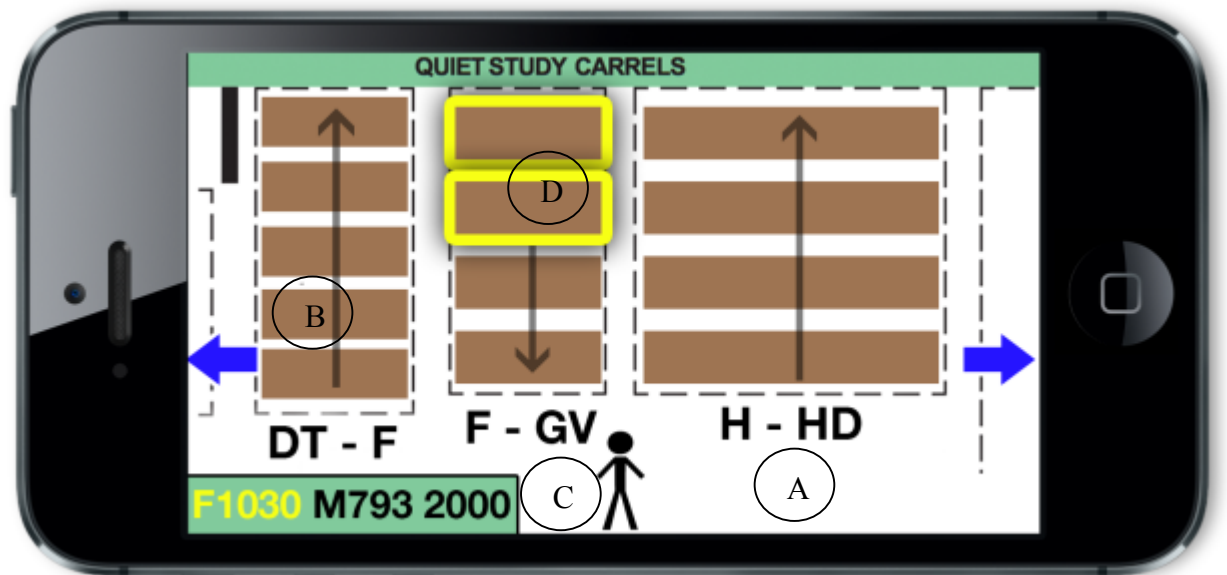


Figure 24. Bird's eye view of the book stack room. The letter ranges (A) and arrows (B) provide awareness of the numbering scheme to participants. The highlighted stacks (D) represent the location of books associated with the subset of the call number (C).

We believe that dividing the book stack room while keeping the blocks of bookshelves intact is better than dividing the book stack room based entirely on the letters. This is because the letters may end in the middle of the bookshelf, presenting jagged partitions that may cause confusion. We showed bookshelves in this view as opposed to merging them into a big square as the library map does so that users can have a better sense of how

far they have gone into the aisle when they are walking by those bookshelves. Users can see the overall book stack room in bird's eye view (see Figure 24) or use an augmented reality view (see Figure 25) with arrows directing them where to go during this process. We expect that users would alternatively use the bird's eye view and augmented reality views in alternation to maintain a clear sense of their current location in relation to the targeted section as they are navigating.

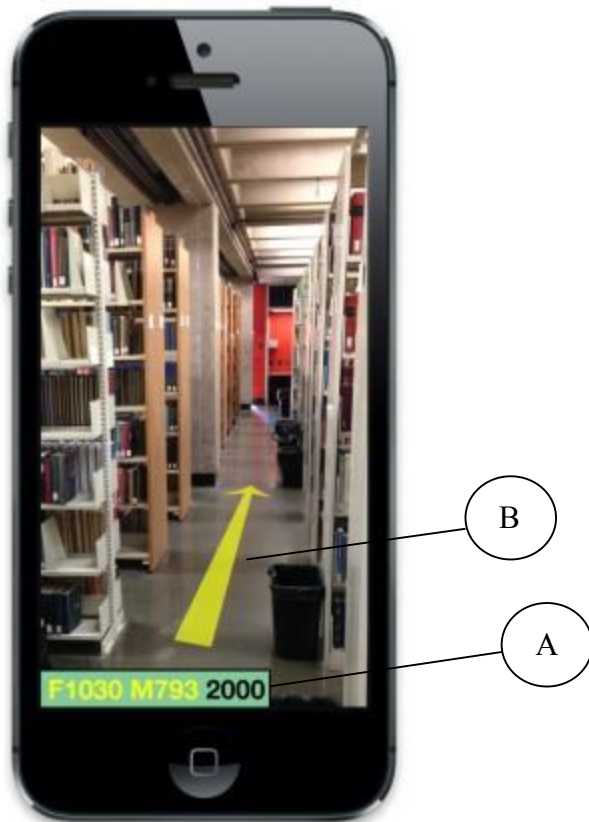


Figure 25. Augmented view down a row of bookshelves. The book's call number is provided for reference at the bottom of the screen (A) with an arrow (B) indicating the direction the user should go.

5.2.2 View 2: Turning Point Indicator

As was observed in our field study, turning into the correct aisle is often a difficult task that requires constant reference to call numbers and searching for signage on the bookshelves. Our prototype presents an augmented reality view that directs users to turn into the correct aisle (see Figure 26). We consider this to be an extension of the directions provided in the first view, but in this case the arrow (see Figure 26 B) presents a specific

turn as opposed to a general navigation direction. This view presents the sides of the bookshelves as library users walk by, with highlights on the side of the bookshelf (see Figure 26 C) that contains the target book and a large arrow indicating the turning direction. Highlighting the side of the bookshelf spares users from having to compare call numbers to determine which of the two ranges (one for each side of the aisle) their book is located within.

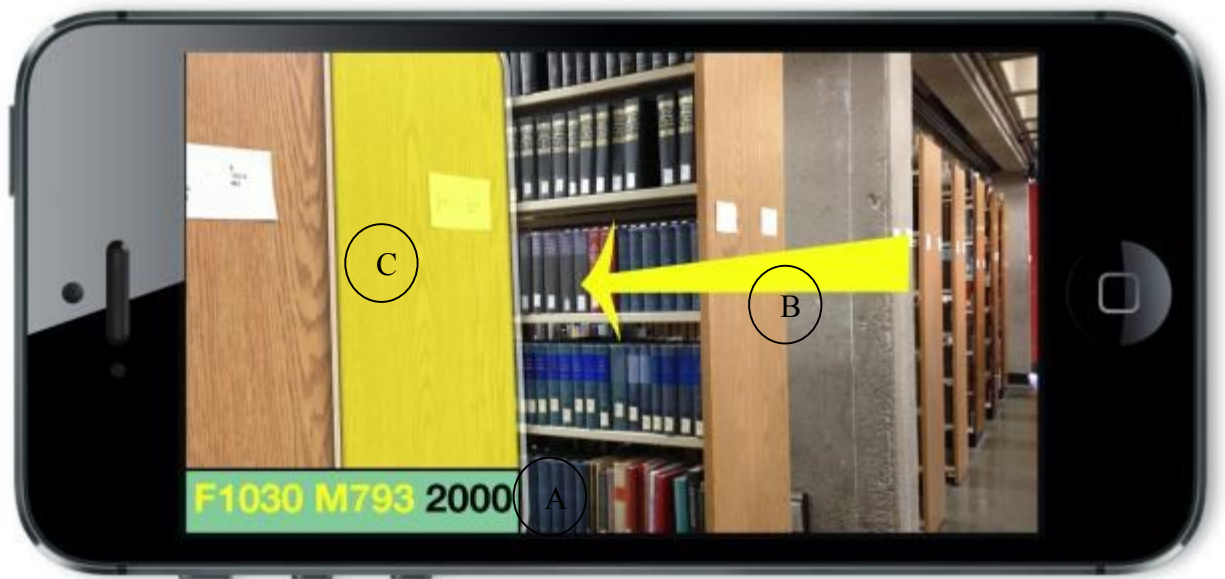


Figure 26. Turing point indicator. Turning point indicator with the target side highlighted. The highlight on the side of the bookshelf (D) represents the location of books associated with the subset of the call number (A). Arrow (B) indicates which turn users should make.

As this view (in both the bird's eye view and augmented view discussed above) is intended to lead users in the general direction of their target book, we have intentionally minimized the level of extraneous detail to allow users to focus on navigation. In consideration of the limited size of a mobile screen (Reilly et al., 2008), this prototype only presents library user's current perspective. If the target section is out of view, a small arrow (Figure 27 D) would appear indicating that the user should pan their camera to bring the target into range. We believe that with the assistance provided by this prototype, users can easily focus on information that is highly related to the task they are doing in a real book stack room.

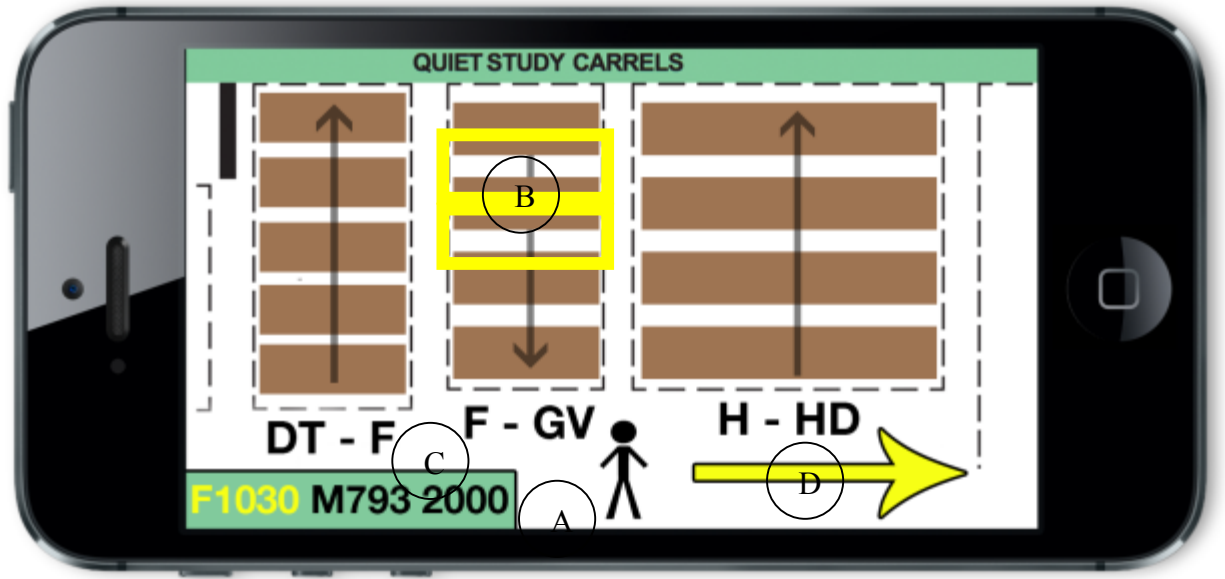


Figure 27. Indicating the target area is outside of the current view

5.2.3 View 3: Bookshelf with Category Partition

This view is designed to assist in the localized search process for finding a specific book in an aisle of bookshelves. It uses an augmented reality view to display the bookshelves that library users encounter after they enter the aisle. As this view of the bookshelves is the most important for performing a localized search, the bird's eye view is not provided at this time. One significant feature provided in this view is that bookshelves are visually partitioned into sections based on the books' categories (Figure 28 A B). To differentiate the different book categories, color coding is applied along with an overly semantic text overlaid. Although this layer does partially occlude a user's view of the books underneath, we believe that the additional layer of information related to the categories is more helpful for several reasons.

First, according to our participants, it is easy to lose track of where they are looking when facing a large number of similar-looking books. Second, magnifying the books on the bookshelves to achieve a better view on a small mobile screen may create visual clutter. We believe that by minimizing each individual books' details by grouping them based on category serves to reduce the visual clutter on the mobile screen while providing the essential information that library users need at that moment. Similar to the turning point indicator, if the targeted area is out of the current field of view a translucent arrow will

appear the screen to indicate the direction a user must walk to bring their targeted book into scope.

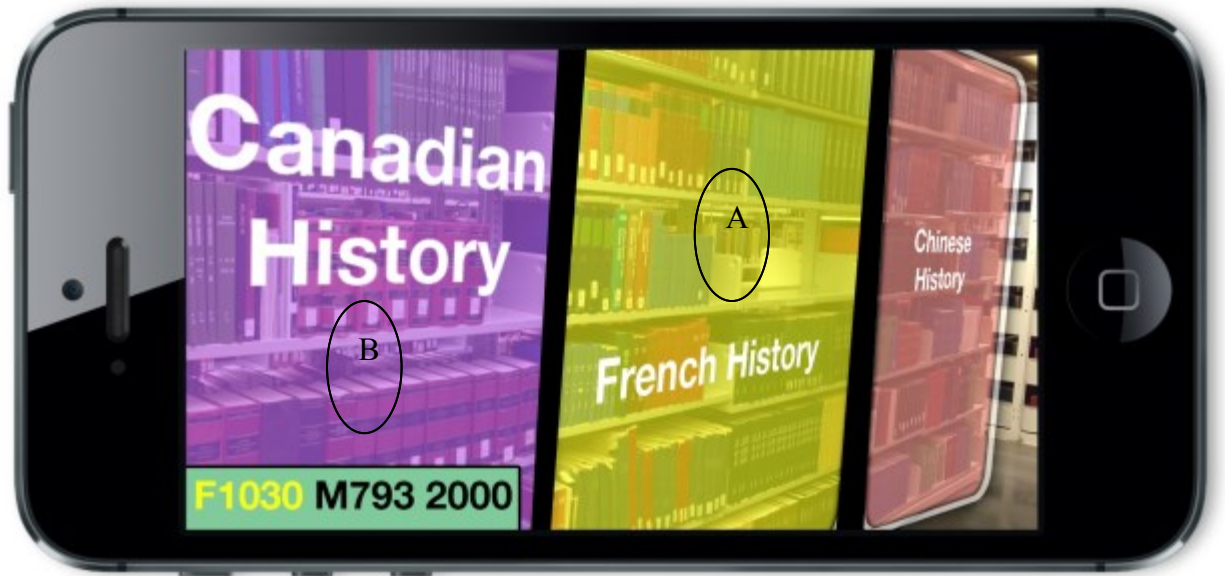


Figure 28. Augmented view of a bookshelf with general categories shown. A and B are sections that partitioned by the prototype based on the categories of the books that underneath

5.2.4 View 4: Fish-Eye View for Searching Localized Areas

To further support localized book searching, a fish-eye view was incorporated to help users identify their target book and those books immediately surrounding it. This is done to support the final part of the searching process, during which library users compare the call numbers on each book with the one they are seeking. In our prototype, users can tap on the shelf containing their target book to bring up the fish-eye view. This view displays the target book and those books immediately surrounding it (see Figure 29). Users can change the view by sliding their fingers along the screen over that aisle. If the book that users are looking for is in the fish-eye bubble, the prototype will automatically highlight it to notify users. This view is designed based on the behaviors that we observed in the field study, participants used book attributes, such as shape and colour, to narrow down the searching range. We believe presenting them with a clear view of the neighbouring books provides helpful context (e.g., outstanding books near the targeted book) that users can use to locate the book in a purely visual manner without comparing the call numbers of the books at all.



Figure 29. Fish-eye view of a shelf with the target book highlighted in yellow

5.3 PROTOTYPE FEATURES

While the four views described above illustrate the general usage of this prototype for locating a book, there are a number of additional features that we have incorporated in hopes of solving the difficulties that library users frequently encounter.

5.3.1 Call Numbers

As was discussed in the previous chapter, participants experienced great difficulties in using call numbers to locate books. Not only are these numbers too lengthy to remember, but they also consist of several sets (three sets at least) of seemingly random letters and digits that participants were unable to make sense of. Library staff can quickly associate the call number with information, such as which floor the book is on and which section it belongs to. However, they are unable to associate call numbers with direct interpretable information as well. Mistakes, such as skipping sets within a call number, occurred frequently and hindered the book finding experience. Additionally, the letter ranges on the end of bookshelves can be difficult for library users to locate and compare. When running into a wide letter range, they have to study the range carefully to see if the call number can fit into it. Sometimes library users may miss the correct aisle due to a mistaken comparison.

For the rest of this section, we discuss in more details regarding how the prototype displays call numbers, use them to narrow down the search region, and connects with book category.

5.3.1.1 Displaying Call Numbers

In our field study we noted that participants frequently check their call numbers. While call numbers may be less important to users of this prototype, we wanted to support existing search behaviours by providing constant access to the call number. As such, it is displayed in a consistent location in the bottom left corner at all times (Figure 27 A).

5.3.1.2 Using Call numbers to Narrow the Search Region

Participants navigated by focusing on one subset of the call number at any given time. Our prototype supports this behaviour by allowing a user to tap any subset of the call number to focus their search on that region. These subsets are also highlighted automatically during the navigation process. The subset highlighted determines the size of the highlighted area and can be adjusted through the number of sets that users highlight. For example, when only the first set is selected (see Figure 27 C), two book stacks are highlighted on the screen at the same time. After selecting the next set of the call number to narrow the search, only one side of the bookshelf is highlighted (see Figure 30 E). This feature imitates the natural book searching process and helps to break down the comparison process. The participants in exploratory study, prefer seeing the destination get more specific as they approach. We followed the example of vehicle GPS navigation systems, where drivers that are far away from their destination are shown their target as a large circle. As they drive closer, the circle becomes smaller. By doing the same, library users are able to narrow down the searching area gradually as highlighted destination becomes smaller as they get closer to their target book.

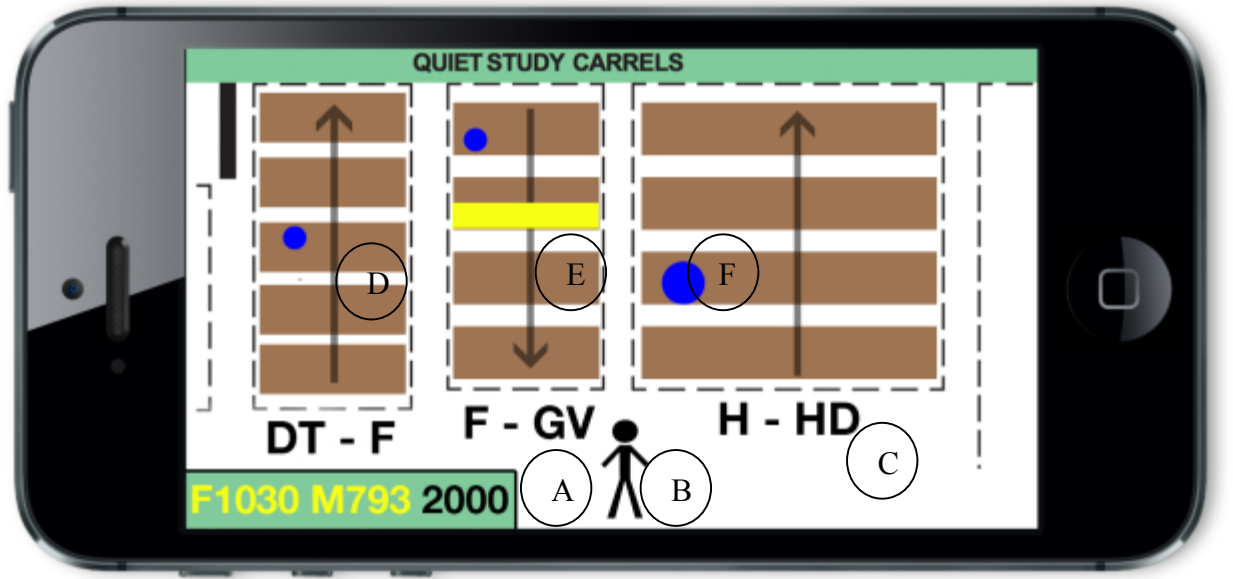


Figure 30. Highlighting of the correct side of the aisle (A) when the second set is highlighted (A). Letter ranges (C) and Letters' ascending/descending order (D) are incorporated in this prototype. The landmarks (F) in this bird's eye view is reduced to a circle

5.3.1.3 Connecting Call Numbers with Book Categories

For the third view (an augmented view of the bookshelf with categories) we have presented the call number to communicate the connection between call numbers and book categories. Highlighting more sets of the call number would further partition the book categories until it contains only the subcategory of the target book (see Figure 31). The subcategory containing the target book is highlighted in yellow to associate it with the call number. For example, when user highlights the first subset of call number (see Figure 28 C), this prototype highlights the middle sections indicating the book belongs to that section-- French History (see Figure 28 A). When user highlights two sets of call number, the middle section further is partitioned into French Revolution (see Figure 31 A) and Ancient Regime (Figure 31 B), and only French Revolution section is highlighted.



Figure 31. Further partitioning of the augmented bookshelf view based on call number subset

5.3.2 Personal Landmarks

When we analyzed the landmarks reported by participants in the field study, we found that although the characteristics of landmarks (i.e., outstanding books) were similar for all participants there were no common landmarks between participants. Not only were we not able to identify shared landmarks, but we also noticed that the landmarks were distributed in different areas of the book stack room for each participant. We found landmarks to be highly useful in navigating, but also highly variable.

Showing landmarks on the current floor is of great value in helping library users to maintain a sense of orientation. We believe that by allowing users to add personal landmarks we can aid in the recall of view-action pairs (see Section 4.4.5) without requiring users to be physically in the area to recall these. With no shared landmarks to include by default, our prototype instead provides flexibility to users by enabling them to add landmarks based on their own preferences and personal experiences. Users can see their custom landmarks in all but the fish-eye view, where we felt they may distract from more relevant details. User-added landmarks are shown as simple highlighted circles (see Figure 32 A and Figure 33 A). This is done in order to avoid creating visual clutter by presenting too much detail information of landmarks. Users can tap on any highlighted point to see more details. The size of each dot is determined by the number of landmarks in that immediate region. For

example, if a user has added five landmarks in a single aisle a larger dot will appear there to show that aisle's importance to them. The book they are attempting to locate is always highlighted in a more prominent colour to reduce the likelihood of the landmarks distracting from their primary task.

As adding landmarks could be time consuming for users, the prototype also adds some landmarks automatically based on the user's library record. Books that they have previously checked out are included as landmarks without any need for data entry by the user. This feature was designed based on the behaviour observed in the field study where some participants identified books as landmarks if they were familiar with them. Taking the library users' familiarities into account, we expect that the books they have borrowed before could serve as useful landmarks.

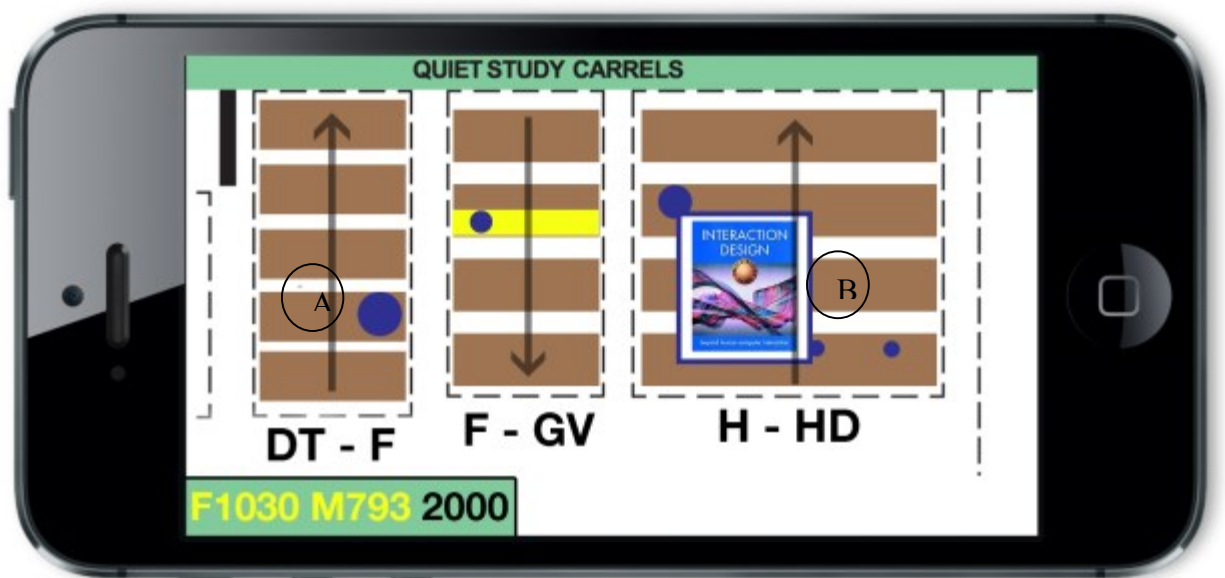


Figure 32. Bird's eye view with personal landmarks shown as dots

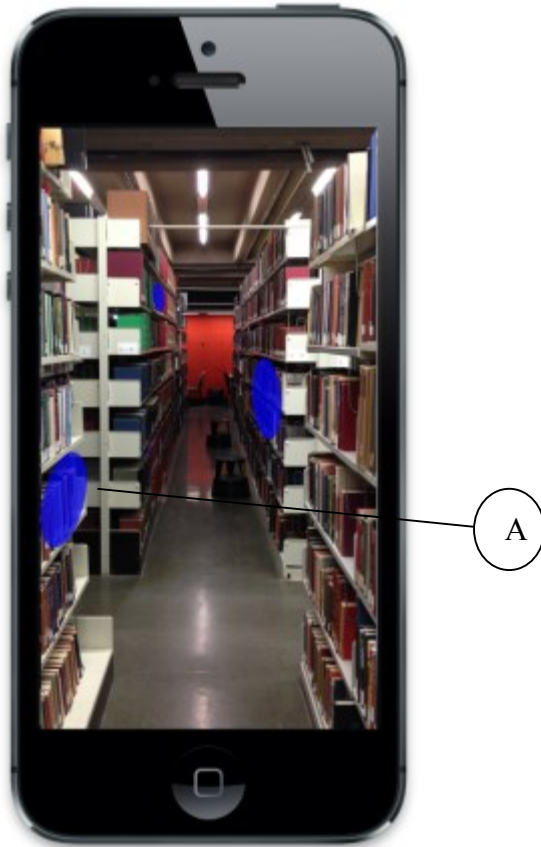


Figure 33. Augmented view with personal landmarks shown as dots

5.3.3 Visual Category Partitions

As we mentioned for View 3 (see section 5.2.3), the prototype can render bookshelves in different colours based on book categories with semantic text placed on top of each region. We believe providing book category information has two main advantages. First, it provides an interpretable resource for library users, which can create a sense of familiarity that is similar to locating a book in an area in which the user has prior knowledge. Second, dividing the bookshelves based on the books' categories allows participants to quickly exclude the irrelevant sections and focus their attention on the books in the target category. Additional benefits may result from this view based on our observations of behaviours in the field study. We observed that when participants missed the book during a localized search, some of them insisted on going to the other side to check more books. Even when participants had determined which side of the bookshelf the target book was on, they still habitually checked the other side from time to time to ensure they were in the correct area.

By displaying the book categories on the bookshelves in an augmented view we can reassure users that they are in the correct section during their search.

5.3.4 Highlighting Important Signage

Due to their limited experience of borrowing books, inexperienced students had hard time locating important signs (e.g., directory, library maps) in the library. We observed from the field study, failing to locate signs hinders their process of locating books, which creates frustration. Therefore, this prototype supports library users, especially inexperienced library users locate the important signs through highlighting it automatically. Users can capture the nearby environment through the camera, as long as the signage comes to the current view, it will be highlighted (Figure 34 A). In addition, users can bring up more detailed signage by clicking on it (Figure 34 B).



Figure 34: Highlighting the directory. View was captured through camera, it will automatically highlight important signage (A). User can see more detailed information by clicking on it (B)

5.3.5 Direction Orientation

The last feature we incorporated in this prototype is the use of direction-oriented views. In our field study, one experienced student who used the library map was led to the wrong side of the book stack room because the direction he was facing did not match how the map was oriented. With few landmarks to rely on, having the map automatically orient based on the user's position and movements is essential for providing understandable directions. The bird's eye views in our prototype are designed to be oriented so that the top of the screen corresponds to the direction farthest from the user's current location. We expect this

to be far more helpful than a printed map, which is difficult to orient in the absence of landmarks and provides no indication of the user's current position as they navigate an area.

5.4 SUMMARY

This prototype was designed to adhere to the guidelines we defined (see section 4.5) based on the findings of our field study. These guidelines stated that an indoor mobile navigation system for use in libraries should: highlight important signs in the library, divide sections into meaningful subsections, include relevant landmarks and orientation on the map, and label sections based on general topics. While designing the prototype system we included a number of features to ensure our system would implement these guidelines.

First, we highlighted important signs in the library by capturing the user's current perspective through the phone's camera and automatically highlighting important signs within their view (e.g., directory, library maps). Additionally, after user walk into the book stack room, the targeted area is always highlighted as it is the focus of navigation. Second, in order to present a clear overall view of book stack room to participants we divided the room based on blocks of bookshelves along with other navigational details (i.e., letter range and letters' orders) to assist users in forming a clear representation of the book stack room while navigating. Third, our design emphasizes the importance of displaying landmarks on the representation of the current floor. Considering the fact that library users' criteria for landmarks vary, this prototype enables users to add the landmarks based on their own preference. Also, library user's familiarity with topics increases the chance of identifying books they are familiar with as landmarks. Therefore, this prototype also supports tying to user's library record to display books the user has checked out previously as landmarks. The second portion of this guideline was included by having the augmented reality and bird's eye views automatically adjust to match the user's current orientation. Last, we partitioned bookshelves by category and clearly labelled each section in an effort to make groupings of books more recognizable and understandable. This allows users who are conducting a localized search to utilize their knowledge of book categories to quickly exclude sections, rather than relying on the call number alone to narrow the search region.

This increased knowledge of nearby book categories allows users in unfamiliar areas to benefit from many of the same searching strategies that those navigating in familiar areas are able to utilize. By designing the prototype to adhere to each of the guidelines we defined through our initial research we hoped to create a system that could greatly improve the book finding process for library users. In the next chapter we will describe the evaluation of this prototype and discuss the feedback we collected from inexperienced students, experienced students, and library staff.

CHAPTER 6 PROTOTYPE EVALUATION STUDY

6.1 INTRODUCTION

The Prototype evaluation study was conducted in the graphics visualization (GV) lab of Dalhousie's Mona Campbell building to briefly evaluate the prototype (chapter 5) and examine the guidelines (section 4.6) that we proposed based on the exploratory field study. We recruited three groups of participants to match those from the field study: 3 inexperienced students, 2 experienced students, and 2 library staff (Table 24). Except for the two library staff who are currently studying English, the participants were from the Computer Science Department at Dalhousie University. As discussed fully in section 3.2.2, we first demonstrated our prototype to our participants, then held a group discussion about the features of the prototype and how they think this prototype could help them with book finding in familiar and unfamiliar domains.

In this chapter, we discuss the results of these focus groups including the features participants liked, what they felt could be improved or added, and their thoughts on systems based on this prototype that could solve their difficulties encountered while locating books in the library.

Participant	Experience of using library	Department
P1	Inexperienced Student	Computer Science
P2	Inexperienced Student	Computer Science
P3	Inexperienced Student	Computer Science
P4	Experienced Student	Computer Science
P5	Experienced Student	Computer Science
P6	Library Staff	Art and Social Science
P7	Library Staff	Art and Social Science

Table 24. Participants' experience levels and department

6.2 PROTOTYPE FEATURES

In this section, we present participants' feedback on the various features mentioned as the most helpful ones of the prototype for looking up books in a library (see Appendix P). These features include highlighting: automatically highlighting the important signage in a library (Section 6.2.1), direction-orientation: automatically orienting the map to match the

user's orientation (Section 6.2.2), visual category partition: partition bookshelves based on book categories (Section 6.3.3), the fish-eye view: showing a realistic view of the books on the shelf with highlighted target book (Section 6.2.4) and adding personal landmarks: allowing users to incorporate their personal landmarks or display books they checked out before (Section 6.2.5).

6.2.1 Highlighting

All participants thought that the prototype would be helpful when locating books in a library enhancing their navigation through the book stack room and helping them to a localized search. They expressed thoughts such as that *"this prototype seems to know what information I need to know now and later"*, which we interpret as meaning that the prototype provides relevant information during each process without overwhelming the user. This is done through the call number feature (see Section 5.3.1). Users can control the accuracy of the information through highlighting subsets of the call numbers. The more sets of call number is highlighted, the more detailed information would be displayed on the prototype. One inexperienced student said that *"after I walked into the book stack room, details such as which side of [the] bookshelf the book is on or which shelf the book is on are not very much needed at that moment. Instead, I only want to know where I am at and which aisle I should be heading into"*. This student expressed appreciation of being able to control the level of information display on the prototype. Also, highlighting relevant information, such as the directory location and the direction the user should go next, was frequently mentioned by all three experienced students as a positive feature by inexperienced students. During our discussions in this study, inexperienced students gave us some examples of their difficulties noticing signage in the library. This example is consistent with our observation from the field study that inexperienced students spent a relatively long period of time locating the directory and felt frustrated during this process. Due to these difficulties, our prototype's ability to highlight important signs was spoken of highly by inexperienced students. One student said that *"I might not use some information on those signs, but it is always good to know where the important signs are and I can use it if I really need to"*.

6.2.2 Direction Orientation

This feature, which helps library users navigate through the book stack room, was most discussed by all experienced students and library staff. Direction orientation is one of the features that participants considered to be most helpful for navigation. Participants expressed their appreciation of this feature by discussing how frustrating when they lose orientation in a library. One library staff member, during group discussion, told us that she often struggles to recognize her direction and judge the distance between each section. When she first started working in the library, even with the help of the library map, she constantly ran into unexpected sections and felt disoriented. Two experienced students, who had used the library map previously, expressed that not being able to determine whether they are facing in the direction that the map is oriented is the main reason they gave up on using those maps. With no distinct landmarks in the book stack room, participants considered the incorporation of a direction-oriented feature to be of great importance in an indoor navigation system.

6.2.3 Visual Category Partitions

Visually indicating changes in categories, a feature intended to aid in localized book searches, was considered as the most helpful feature in this prototype by all inexperienced students, experienced students, and library staff. We found that inexperienced students appreciated this feature for different reasons than experienced students and library staff did. When presenting the feature to them, two inexperienced students excitedly told the researcher that they think *"this feature makes all the resources in the library more helpful"*. They believe that it would help narrow down the searching areas and, more importantly, bridge the gap between finding books in their familiar and unfamiliar domains. While looking in their unfamiliar domains, not being able to see connections between the books on the shelves and the book they are looking for is the biggest problem they face. As we observed in the field study, due to the inexperienced students' unfamiliarity of using call numbers, they would habitually search for other resources that they could rely on to locate the book, such as the book's category. Therefore, providing the books' categories imitates the experience of finding books in participants' familiar domains so that they can acquire a general sense of what part of the bookshelf has the book by reading book titles.

We observed from the field study, although experienced students and library staff can achieve more efficiency by purely using call numbers. All experienced students and library staff in our study considered this feature to be helpful as well. According to them, visual category partitions not only helps them explore the library but also acts as a teaching aid for library users. Experienced students expressed that they usually come to the library with a specific goal in mind. However, they also value the experience of browsing books in the domains that they are interested in. Therefore, they expect that having this feature would help them to notice the categories of nearby books, which may attract their attention and encourage them to explore the library. For library staff, this feature takes advantage of the fact that books are arranged by category and they are also positive about its role as a teaching aid for library users, who currently have little or no idea how the books are arranged.

6.2.4 Fish-Eye View

The fish-eye view was also incorporated to support localized search. Participants described that being able to see a realistic view of all the books nearby the target book provides rich detail so that they would not have to carefully compare the call numbers on the books. Instead, participants generally described how they would identify the outstanding books in the fish-eye view and use those as reference points to locate their desired book. We believe this is consistent with the conclusion we drew from our field study. Outstanding books—such as books with great height, bold colour, or large volumes—are easily identify as landmarks. Therefore, by seeing the books nearby the targeted book in the fish-eye view, participants can identify landmarks. It is easier to find an outstanding book with attributes that you are sensitive to. Also, participants said seeing the augmented view on the prototype allows them to be sure that they are looking at the correct shelf and that this all could be done without placing their attention closely on the call numbers.

To our surprise, another issue that they faced frequently when locating books in a library was brought up in every study group by participants—misplaced books. All participants considered this feature to be helpful in misplaced book situations to some degree. They explained that by knowing the proper location of the book (i.e., which shelf the book is on), if they could not find the book they would seek librarians for help instead of wasting

their time worrying about that they might have missed it somehow. Library staff mentioned that this feature may encourage library users to interact with staff more if they can be confident the book is out of place.

6.2.5 Personal Landmarks

Participants liked the flexibility the prototype provides by allowing them to add landmarks or associate landmarks with their own library record. According to one experienced student, "Adding their personal landmarks to the map can help them navigate through the environment [the book stack room] better". Landmarks can help build connections between participants and the library. Participants described that using their previous experience of navigating in the library and their knowledge towards certain domains (e.g., knowing more about computer science) to customize the representation of the current floor allows them to highlight the information that they are sensitive to. In this way, they can navigate in an environment that is filled with identical landmarks more easily. In the meantime, they felt that seeing all of the information that they are familiar with as landmarks on the prototype might make them feel more comfortable navigating in a book stack room.

All Inexperienced students, experienced students and library staff thought that associating landmarks with their library record automatically is useful. According to library staff, there is a high tendency for library users to return to check out books they have borrowed previously. In this situation, the landmark feature allows a library user to relocate a previous book by reviewing the book showed as landmarks in the prototype so that they would not need to search for call numbers. Compared to associating landmarks with their library record, other participants considered adding their own landmarks as being useful for helping them recall paths they have taken previously. With the ability of seeing book covers in the prototype, one participant said that *"The image of the books helps me recall the areas I have been before, somehow I just remembered the path to get there once I saw this image"*.

In addition, participants expressed that showing landmarks in the bird's eye and augmented views may help them in a different way. In the bird's eye view, besides having the books presented as dots, participants can also obtain an overall view of the library. With all of the

information provided in the bird's eye view, participants found it easy to associate their memories with the view they saw to bring out the paths they had taken previously. In the augmented reality view, rather than assisting them with recalling the paths they took before, participants consider that it is more helpful in terms of expanding their interests in different domains. As we discussed above, library users are immersed in a great amount of bookshelves when navigating in a book stack room. Since the bookshelves block participants' views this limits their abilities of seeing further sections and participants' attention is easily attracted to the books on the bookshelves. Therefore, except one experienced student, participants expressed that they would be interested in seeing what books in this section they borrowed before and they may want to explore that area further, if they happen upon a section where landmarks are shown on the prototype.

In conclusion, all participants appreciated the ideas that we proposed in this prototype and how a final system based on it could support their natural processes for locating books in the library. Furthermore, participants appreciated the advantages brought by both the augmented reality view and the bird's eye view with their current location on it. With being able to see their current location, bird's eye view enables them to know their location in relation to the targeted area. The augmented view easily navigates them through the book stack room without requiring them to compare the views they see in the prototype and the current view they face. In addition, all participants felt comfortable only seeing the current view that they are facing on the prototype.

As we expected, participants do not like to see irrelevant information on a small mobile screen. However, providing them with the options that they can see more view on the left or right by clicking on the button is important.

6.3 FEATURES TO BE IMPROVED

Participants made suggestions mainly regarding two features in this prototype: first, notifying users where to make a turn (Section 6.3.1), and second the highlighting strategy we applied for the visual category partition (Section 6.3.2).

6.3.1 Additional Details to Prime for Turns

The first feature that our focus group participants mentioned they would like to see improved is to change the way in which the prototype notifies users to turn into an aisle (see Section 5.2.2). Two inexperienced students and one experienced student thought the current view may create confusion for library users. Every aisle in the book stack room looks alike and, although participants found it clear which way to turn, they were not sure about the exact intersection that the turn should be made. Directing library users into the wrong aisle could create confusion. Participants suggested showing more information through text, such as the call number on the intersection, so that they can confirm that it is the correct aisle before entering.

6.3.2 Potential Confusion with Highlight Colours

The second suggestion was made by one inexperienced student regarding the highlighting feature. In the prototype, highlighting is implemented as showing the object in a bright yellow translucent rectangle. When it comes to showing the targeted categories on the bookshelves, this participant expressed the concern that the bright yellow blended in with other colours presenting the nearby categories, which may limit its usefulness as a highlight colour. Therefore, this participant suggested that we should not apply colour codes. Instead, it was suggested that we use a single colour for the nearby categories with text on top it and only use bright yellow to highlight the targeted area. When discussing this suggestion with experienced students and library staff, they all thought that applying colour codes is appropriate and practical. All experienced students and library staff said that differentiating the targeted area by applying the same colour to other categories might be helpful when it comes to looking for one specific book. However, different colours provide library users a better view of how the books are arranged on the shelves without requiring them to read the text on a small screen. In the meantime, they considered associating the book title with its general category provided on the prototype would be easy to complete in the prototype's current state.

6.4 NEW FEATURES

Five new features were suggested by our participants mainly from three aspects: providing flexibilities to users control the displaying information (Section 6.4.1), supporting random browsing behavior in a library (Section 6.4.2 and Section 6.4.4) and displaying more book-related information (Section 6.4.3).

6.4.1 Controlling Information Shown

One additional feature suggested by two inexperienced students was to give users options to show how much information they want to see. This suggestion was made because they thought as they become more and more familiar with the library environment, they might not need as much detail as they had previously. For example, once they have experience checking out books several times, they may not need to be reminded of the location of the directory and library maps. Also, we believe that giving users control over how much information they see brings certain advantages. The less information is presented on a small screen, the more likely the user will notice the highlighted information on the prototype; however, this feature needs to be implemented with care. Losing too much information on the screen may result in there not being enough context for users during their navigation process.

6.4.2 Encourage Browsing Behaviours

A feature was suggested by all library staff, who want the visual category partition feature in this prototype to be taken a step further. According to library staff, adding the book categories on the augmented view when library users are facing the bookshelves is of great importance to help them discover and understand the library more. Therefore, library staff hope that this prototype will support library users to tag a general area and search by categories. As discussed above, there are two main goals when library users navigate a library—searching for a specific book and browsing books based on their interests. Although electronic books are becoming more and more popular, most of our participants acknowledged the importance of the library. Sometimes, library users are interested in a domain which they do not have a lot of knowledge of. In our literature review, we only found one system (Mu, 2006) that supports digital browsing based on categories. Browsing books digitally with little domain knowledge can be difficult. Keywords are helpful, but the range they are able to digitally see based on the keywords is limited. There are

advantages to being physically in the library when exploring the domains that library users are interested in. Being in the library, they can see more books by skimming them. They can pull out the books and read anything they may find appealing. One inexperienced student made a comment "*the feeling of browsing books in a real library is not comparable with browsing books digitally*", similar statements were made by our other participants.

Experienced students also suggested allowing them to apply different colours to the tagged areas. This feature was greatly discussed as they prefer being physically in a library and browsing the books rather than digitally browsing books. They feel it is a more immersive experience and also reduces their time spent browsing. Compared to physically browsing books in a library, digital browsing has certain limitations. For instance, digital searches do not support random browsing. The books on the list are fully or partially related to the keywords users put in, which can vary a lot from domain to domain. Therefore, we should take advantage of this feature by allowing participants to tag interesting areas for future exploration to overcome the limitations of digital browsing.

6.4.3 Indicating Book Availability

All participants requested an additional feature to indicate the availability of books. Participants hoped to add the book's availability status when highlighting the book in the fish-eye bubble. Participants suggested this can be implemented by, as suggested by participants, adding another colour code to the highlighted book with different colours indicating its availability status. That way, when library users neglect checking the status of books, the system can save the user's time of searching for unavailable books. According to library staff, the system that library users checking the availability of the book and that for students are different. The system will not update a book's status until after it has been checked out for three hours. Having up-to-date information could definitely help library users who may be searching the shelves for a book in the meantime. Inexperienced participants also requested that a button be added to send a request when the book is not available.

6.4.4 Location of Library Staff

Library staff hope this prototype can encourage library users to interact with staff more. As we observed in our field study, there were two participants who ran into difficulties when doing the tasks and tried to find library staff on the current floor. However, they failed to find a staff member. Staff express that this is an issue reported to them by many students. While working in a library, staff may be hard to recognize as they do not wear uniforms or badges. Thus, they suggested that showing the location of library staff on the prototype could solve this issue. Considering that only one or two library staff are typically working on each floor, this is unlikely to cause visual clutter. However, when incorporating this feature into our study, we need to take into account library staff's willingness of being tracked.

6.5 ACCEPTABILITY OF THE PROTOTYPE

All participants thought highly of the prototype, they felt it could not only shorten the time they spend on finding the information they need, (e.g., locating the directory or learning letters' ascending/descending orders), but also expand their knowledge of the library by presenting understandable information like book categories during the navigation. Inexperienced and experienced students expressed that navigating in a library to locate books is time consuming and confusing, especially when using call numbers alone. Therefore, they enjoyed the features provided by this prototype, which make call numbers less important to the book finding process. They also mentioned that this prototype could help them break the book finding experience into small steps by always presenting the most relevant information during each phase. The inexperienced students also expressed that it could also serve a teaching role by helping them to learn more about the library.

6.6 SUMMARY

We will summarize this chapter by briefly discussing the difficulties that our participants encountered in the field study and the difficulties that participants described in this study while locating books and how our prototype can help them to overcome these difficulties. For inexperienced students who are unfamiliar with using the library, it is hard for them to

locate the important signage which may be "hidden" by other irrelevant signage in the library. Inexperienced students feel lost after they acquire the call number because they have little clue regarding which floor to proceed to. When navigating in a library it is difficult to see in what sections the books are organized, increasing their chance of running into unexpected sections and becoming disoriented. The difficulties reported by inexperienced student participants in the focus group are very similar to the difficulties we observed during the field study (Section 4.3).

For experienced student participants, locating information in the library and navigating the book stack room is less of an issue but they find comparing call numbers to be tedious and difficult. The placement of the call numbers on books vary based on each book's thickness, with some call numbers having to be placed on the front cover where it can't be seen easily. These variations make it difficult for them to compare call numbers during localized searches.

The difficulty of finding a misplaced book in a library was mentioned by all participants, inexperienced students, experienced students, and library staff during the discussion. This difficulty is caused by two key reasons. First, participants are not always certain if a book is misplaced or if they are simply looking for it on the wrong shelf. Second, after determining that a book is misplaced, participants are uncertain if it is nearby (and worth looking for) or somewhere they are unlikely to locate it. This uncertainty hinders library users' book finding experiences. During the focus group, all participants expressed hope that the fish-eye view could help them to determine if a book is in its place.

We received a lot of positive feedback on this prototype from participants. As to the proposed the guidelines, our participants felt all the features listed below, which were designed based on the guidelines, addressed the issues we had found in the field study.

1. Highlighting important signs in the Library (see Section 5.3.4)
2. Divide sections into meaningful subsections (see Section 5.2)
3. Include relevant landmarks and orientation to the map (see Section 5.3.2 and 5.3.5)
4. Label sections based on general prototype (see Section 5.2.4)

This suggested that the proposed guidelines are effective. By automatically highlighting important signs in the library, our prototype solves the problem of inexperienced students' difficulties with locating signage. By displaying the user's current location and highlighting the targeted section in a bird's eye view, users may be more aware of their current position and intended navigation direction. By displaying arrows in an augmented reality view, users might navigate through the book stack room more easily as they move closer to their targeted book. Our prototype imitates library users' the natural behaviour of comparing call numbers from the first set to the last set, progressively reducing the search area. Users can choose to highlight different sets of the call number to control how wide their searching range is. Furthermore, the visual category partition feature and fish-eye view provides rich context for users to take advantage of the books' unique attributes while they locate it, rather than having to rely solely on call numbers. Finally, by directing users to the aisle and bookshelf that contains their target book, the prototype might further reduce their reliance on call numbers and make navigation a more understandable, enjoyable process.

CHAPTER 7 CONCLUSION

In recent years, libraries have become hybrid environments that provide access to materials in both paper and digital formats. Library users are increasingly searching for information in a libraries using mobile devices. This thesis has examined how the introduction of a mobile device affects library users' behaviours while navigating in a complex environment filled with indistinct landmarks. Their behaviours have been shown to be influenced by their environment, their navigational goals, and how their previous knowledge and experience relates to the current task. In this chapter, we will also talk about how our results can be generalized to other hybrid environment (e.g., factory floor).

7.1 FIELD STUDY RESULTS

During the exploratory field study (see Chapter 4), we found that indoor navigation experiences vary based on users' familiarities with the domains they are navigating. This was demonstrated by the difficulties that participants encountered while attempting to locate books on subjects they were unfamiliar with. Inexperienced students experienced the greatest difficulty in locating books in the library, including trouble with locating signage, navigating the book stack rooms, and using call numbers. Experienced students and library staff, both of which had previously navigated the library and located books, demonstrated fewer difficulties in completing the tasks. However, these participants still reported difficulty using call numbers during navigation and considered the process of comparing the call number of the desired book with the call numbers of surrounding books to be tedious. This was due to call numbers being unmemorable and incomprehensible, which is made worse as call numbers are the only resource by which they could navigate given a lack of landmarks or other navigational cues.

Different strategies for looking up books were observed between inexperienced students, experienced students, and library staff. First, we discovered a tendency for less-experienced participants to seek other resources (e.g., the book titles and book covers) to assist in locating books. Inexperienced students often read book titles to obtain a general sense of the topics in their immediate environment and compared the book they were

looking for to these topics to look for a potential match. Second, we found that library staff are able to locate books with far greater efficiency than students due to their ability to identify patterns in the bookshelves' arrangement and create a mental representation of the floor. We observed library staff navigate to sections that were visually blocked other bookshelves, unlike students who relied on the call numbers and moved more slowly. Library staff not only were able to determine the sections they were in and the nearby sections, but also those sections further away. According to library staff, their experience allows them to divide the book stack room into smaller sections. Specific knowledge, such as knowing the zigzag pattern (the letters always start from one end and keep increasing in a zigzag pattern to the other end), allows them to easily foresee the letters in the smaller sections. Their way of dividing sections helps them form a clear mental representation of the book stack room.

The results also demonstrate that the indoor landmarks identified by participants are highly related to the characteristic of the environment and user's knowledge of the environment. The landmarks identified by our participants are different than the landmarks (i.e., corridors, emergency exit panel, wooden doors) chosen by Abascal et al. (2005) to incorporate in a robot to support navigating in an indoor environment. The landmarks identified by inexperienced students, experienced students, and library staff all share similarities. All participants identified "outstanding books" as landmarks. These are books with prominent features, such as boldly-coloured covers or exceptional volume and height. Participants expressed that these outstanding books can attract their attention easily when navigating in the book stack room, making them function as landmarks. We discovered that participants' familiarities play an important role in identifying landmarks as well. According to our participants, when doing tasks in their familiar domains, their attention is easily attracted to those books, for which they have more knowledge. The helping role of landmarks was acknowledged by participants. According to them, these landmarks can help them to not only efficiently recognize the areas they have been but also recall paths they have taken previously. Participants explained that previous paths are recalled by reviewing the landmarks, which bring up memories of the movements they made at that moment (e.g., the turn they made with the direction they were facing).

Although participants identified books in the library as landmarks, we found that no identical landmarks were identified among the participants. Compared to outdoor landmarks which can physically be very distinct, indoor landmarks often stand out based on their personal meaning, which results in the identifying process being closely related to the user's background. Other indoor landmarks, such as the location of elevators and stairways, were identified by one experienced student and all library staff to help them maintain a sense of direction that they are facing at the current moment. When we asked other participants about these landmarks, their unfamiliarity of the elevators and stairs provided them with little clue of which direction they are facing. These discoveries suggested that when studying wayfinding in an indoor environment, not only should we consider the characteristics of the indoor landmarks but also the user's background.

We observed a high adoption (see Table 21) of mobile devices in this study. At the beginning of our study, seventeen out of twenty participants (six inexperienced student, six experienced student and all library staff) chose using the provided mobile device rather than accessing information through a desktop, even though most had never used a mobile device for locating books in the library previously. By the end of the study, all participants used the mobile device and reported positive experiences with using it to finish the tasks. Participants attributes their positive experiences of using the mobile device to its portability. All participants mentioned that the portability of mobile devices gives them flexibility to search for information whenever they need it in the book stack rooms. Additionally, when facing the situation that a book was misplaced, the mobile device's portability was especially appreciated. This is because it allowed participants to confirm the book's availability without returning to the desktops under the circumstance that the book is misplaced. Furthermore, we noticed that the mobile devices affected participants' behaviours. This can be seen in the transition of how students recorded the call numbers during the tasks. At the beginning, most participants chose to record call numbers on paper even though they could access this on the mobile device at all times. Participants explained that they were concerned that carrying a mobile device might be inconvenient when looking up books. However, by the last task in the study none of the participants continued to record information on paper. We also noted from our observations that participants

enjoyed the convenience of the mobile device and had not showed any signs of difficult while holding a mobile phone during the study.

We proposed four guidelines based on the data collected from the field study: highlighting important signs in the library, dividing sections into meaningful subsections, include relevant landmarks and orientation on the map, and labeling sections based on general topics. We then designed a low-fidelity prototype incorporating these four guidelines. We hoped this prototype can help library users make advantage of the library environment as well as their knowledge to facilitate a better book finding experience.

7.2 PROTOTYPE AND EVALUATION

Our indoor navigation prototype is to support book finding for library users based on the data we collected from the field study. The prototype imitates library users' natural behaviours while locating books by presenting book finding related information through four views — overall view of book stack room, turning point indicator, bookshelf with category partition, and fish-eye view for searching localized area. For the first view, it supports both augmented reality view and a bird's eye view. In the augmented reality view, users can see a realistic view in the library with highlighted information and helpful instructions throughout the processes of navigating through the book stack room and conducting a localized search. In the bird's eye view, participants can gain an awareness of their current location in relation to the targeted area at all times.

The prototype was designed with five primary features to tackle the difficulties we observed from the field study and help library users maintain a sense of orientation. First, a highlighting feature address the difficulty that inexperienced students have with locating important signs in the library. The prototype automatically highlighted the important signs in the library in the augmented view. Additionally, users can click on the highlighted information to get a closer view of without approaching it. Second, since call numbers are the only resource library users can use to locate books, we implemented the call number feature in our prototype. During the field study, we observed that participants have a habit of constantly checking the call number. Participants always started comparing the first set of the call number then move to the next set to narrow down the searching area set by set.

Thus, in order to imitate library user's natural behaviour, our prototype displays the call number at all times. In the meantime, users have the flexibility to control the accuracy of highlighted target section (from showing a general section to the details as which side of bookshelf the book is on) on the prototype through highlighting the sets of call numbers. The more sets of the call number they choose to highlight, the more accurate the area will be highlighted in the prototype. The third feature incorporated in this prototype is visual category partition, that helps categorize books on the bookshelves. Colour codes are applied that books belong to the same category are rendered in the same colour. This is done to make library users less depend on the call number as well as make the book searching process more understandable so that they can add to their knowledge of the library while looking up books. Users can also further partition book categories by highlighting more sets of the call number. The fourth feature is landmarks, where users can either add their own landmarks (i.e., the outstanding books) or associate the landmarks with the books they have checked out previously. Either way, participants reported that being able to see landmarks is helpful for navigation. Furthermore, in order to provide users with a sense of orientation throughout navigating process, the view displayed on our prototype automatically adjusted with the view that users are facing.

Participants consider that displaying landmarks in the bird's eye and augmented reality views brings different advantages—the former helps users recall their previous paths better, while the latter is helpful for exploring the library. The prototype evaluation study allowed us to collect a great deal of feedback from participants regarding their anticipated use of this prototype. All participants—including inexperienced students, experienced students, and library staff—thought that the prototype would be very useful in supporting both navigation through a library and locating books on the bookshelves. According to them, the advantages brought by this prototype is contributed by its ability of minimizing the use of call numbers while providing the most relevant information during each phase.

7.3 LIMITATIONS

This research is not without limitations. The field study was conducted mainly to observe how library users navigate through a library to locate a specific book. However, there are

other scenarios, such as navigating in a library to locate several books or general browsing in a domain/domains, which happen quite frequently in a library. As we discussed above, the goal behind navigation in an indoor environment can affect users' behaviours and their navigation strategies. Therefore, we believe that there is a strong need to conduct another field study with the focus on those different scenarios. Also, we suspected an order effect when it comes to refinding tasks. After the first refinding tasks, participants may remember some book information on purpose to prepare a future refinding task. Furthermore, we have to consider the Hawthorne effect in this study (Lazar, et al. 2010). During the field study, participants' behaviors might also change due to being followed by a researcher throughout the entire study.

Due to the limited time, we were only able to conduct a formative prototype evaluation to collect initial feedback from participants regarding our prototype demonstrated in a laboratory setting. The value of evaluating this prototype in a real library setting cannot be overlooked. In addition, the technology for indoor navigation system such as indoor GPS are still in their infancy, which results in difficulties for implementing this prototype in the field at this time.

Furthermore, we attempted to generalize the study results to create guidelines for a contextual system for "hybrid environments" (i.e., has mixed digital and physical information). Still until we evaluate different environments (e.g., a factory floor), we cannot say with certainty how well our guidelines will be transferable.

7.4 FUTURE WORK

There are many opportunities for future work to build on the knowledge we have gained here. First, although participants appreciated the advantages offered by this prototype, they did identify several issues and additional layers of information they would like included for it to assist further in locating books. For example, when creating landmarks based on an individual's library record, participants expressed the desire to also see books they have borrowed but not yet returned. Information relating to these books, such as their due dates, is also desired.

Second, the related problem of meeting peers within the library was identified by an experienced student in the focus group. Meeting with others in the library can be challenging as library users find it difficult to describe their current location within the book stack rooms, as it is filled with indistinct landmarks. Students who leave their study area to meet a friend may find it difficult to navigate back to the carrel where they were studying. We believe that our prototype's feature of dividing the room into subsections can be helpful for this situation, as these sections could be described with more recognizable information (e.g., letter range). This is just one example of a related navigational problem that could be discovered through further study.

Third, locating misplaced books was reported as one of the most frustrating incidents participants had previously encountered in the library. As mentioned above (see Section 4.2.5), participants like to know book's availability and how far the book is misplaced when encountered misplaced book situation. With these two information, participants can better decide whether keep searching or not. However, it does not solve the root of the problem. Therefore, further study needs to be conducted to understand how a system based on our prototype could help library users to identify the correct location of a missing book to verify that it is out of place. There may be opportunities to introduce technologies to further address this problem, such as by providing further support (e.g., an RFID tag to detect the exact location of a book misplaced nearby) to participants as they seek these misplaced books. Although electronic books are increasingly popular, library users still consider the physical library to be one of their most significant resources for research and learning. Library environments are ideal for conducting many types of research. As indoor navigation technology advances, the potential for exploring more functional prototypes and applications for locating books within a library presents a rich opportunity for study.

7.5 CONTRIBUTION

We believe that the results we collected from this field study and prototype evaluation can be applied to the factory floor environment due to the similarities we found between factory floors and libraries. For example, similar to how library users must locate a specific book within a large number of bookshelves, mechanics are often assigned to fix a small

component that is located within a large number of other components which may appear similar and indistinct. In addition, when locating these components the mechanics navigate using the "grid number" of the component that they refer to from a blueprint which is segmented into regions. This is similar to how library users locate books by call number. Both factory floors and libraries are often filled with a large number of indistinct landmarks which make orientation and navigation difficult. As with libraries, the use of mobile devices on factory floors is increasing as mechanics receive tasks via these devices and reference them during work. This high adoption of mobile devices suggests that, as with libraries, factories are also becoming hybrid environments.

From the field study, we noted the importance of including personal landmarks to support locating specific objects in environments filled with indistinct landmarks when designing future context-aware systems for hybrid environments (e.g., factory floor). As indoor landmarks are identified based on both the characteristics of the current environment and the users' role in the environment, we believe that more focus should be placed on understanding the behaviours of users. For example, further studies could examine in depth their difficulties in locating objects and their preferences for identifying landmarks in environments other than landmarks to support our findings.

Furthermore, we also want to highlight the importance of understanding what information preferred by people in that environment. For example, call numbers are the only existing factor in the library to support library users navigating and locating books. However, during the field study, we found that our participants tended to look for books based on its category when searching books in their familiar domains. We believe that a concrete understanding of how mechanics doing tasks and what expertise they are using to finish the tasks are essential to include in the context-aware system.

In conclusion, the design and evaluation of indoor navigation systems is an area that could benefit from additional research. These could include studies on the feasibility and usability of functional prototypes based on our guidelines, as well as ways to apply these findings to the study of related environments such as factories.

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APPENDIX A: FLOOR MAP

Services

GROUND

2nd floor

3rd floor

4th floor

5th floor

Call Number Locations

General Collections	
A – N	Fourth Floor
P – T	Third Floor
U – Z	Second Floor (South Side)
Over-size A – Z	Second Floor (South Side) after the Zs
Government Documents	
1BIS – 9Z, Rand	Second Floor (South Side)
Reference Collections	
Reference Collection A – Z	Ground Floor, Learning Commons South
Reference Index A – Z	Ground Learning Commons North
Reference Documents A – Z	Ground Learning Commons North
Microform Collections A-Z	Ground, Learning Commons North
Archives & Special Collections	Fifth Floor

APPENDIX B: DALHOUSIE RESEARCH ETHICS BOARD CERTIFICATE OF APPROVAL FOR FIELD STUDY



Social Sciences & Humanities Research Ethics Board
Amendment Approval

March 01, 2013

Ms Xiaoyu Yu
Computer Science\Computer Science

Dear Xiaoyu,

REB #: 2012-2753

Project Title: Conduct a Field Study to Evaluate Influence of Factors (information similarity and information familiarity) on Finding Tasks in Integrated Environment and Explore Contextual Cues for Finding Tasks

The Social Sciences & Humanities Research Ethics Board has reviewed your amendment request and has approved this amendment request effective today, March 01, 2013

APPENDIX C: INFORMED CONSENT

Study Title: A focus group evaluating the current prototype for helping library users with book finding tasks

Principal Investigators: Xiaoyu Yu, Masters Student, Faculty of Computer Science
Kirstie Hawkey, Assistant Professor, Faculty of Computer Science
Bonnie Mackay, Assistant Professor, Faculty of Computer Science

Contact Person: Xiaoyu Yu, Principal Investigator, xyu@cs.dal.ca
Kirstie Hawkey, Assistant Professor, kirstie.hawkey@gmail.com

We invite you to take part in a focus group at Dalhousie University for research purpose. You will be compensated \$10 for participating in this study and you may withdraw from the study at any time. Your academic (or employment) performance evaluation will not be affected by your participation. This description tells you about the risks, inconvenience, or discomfort, which you might experience during the study. Participating in the study might not benefit by exploring our prototype, we will be better informed of features that may be helpful for a mobile app for library users. You can discuss any questions you have about this study with “Xiaoyu Yu” (xyu@cs.dal.ca)

The purpose of the study is to evaluate a mobile prototype designed for locating books in a library. You need to have previous experience of looking up books in the Killam Library and are familiar with using a mobile device. Prior to meeting for the focus group, you will fill in a pre-session questionnaire online that will ask you about your past experience on finding books in the Killam library and some basic demographic questions. You will then be scheduled to meet a researcher for the focus group in the GV lab in Mona Campbell building. Each focus group contains from 3-5 participants. At the beginning of the study, you will meet with researchers who will tell you about the overall study. We will demonstrate the prototype for you. During the study, we will give you three library task scenarios that you will do using our prototype. After the scenarios, there will be a group discussion to find out about your experience using the prototype and get feedback and recommendations for the prototype design. The study should take about an hour to complete.

Researchers will video tape the session, your identity will not be anonymous to them research team. However, the data will be stored and handled in a confidential manner. All personal and identifying data will be kept confidential. Anonymity of textual data will be

preserved by using pseudonyms. The informed consent form and all research data will be kept in a secure location under confidentiality for five year after the end of this school term. A researcher is always available during the study session to answer any questions you may have or address any problems that you may experience while performing the study. No

penalties will apply if you decide to withdraw. However, the data we collected from you will be destroyed and not used in our study. If you have any further problems or issues related to the study, you may please contact the researcher Xiaoyu Yu at xyu@cs.dal.ca.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director, Office of Research Ethics Administration at Dalhousie University's Office of Human Research Ethics for assistance: phone: (902) 494-1462, email: catherine.connors@dal.ca.

"I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."

Participant

Researcher

Name: _____

Name: _____

Signature: _____

Signature: _____

Date: _____ Date: _____

"I understand and consent that my participation will be video recorded and photographed for the purpose of analysis. I understand that this is a condition of participation in the study, and I understand that this video and photo record will not be used in publication without my express consent."

Participant

Researcher

Name: _____

Name: _____

Signature: _____

Signature: _____

Date: _____ Date: _____

Please fill in the following:

<i>“I agree to let you directly quote any comments or statements made in any written reports without viewing the quotes prior to their use and I understand that the anonymity of textual data will be preserved by using pseudonyms.”</i>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<i>“I agree to let you use video and photos taken of my participation in publication or presentation of results, only after anonymizing by blurring faces.”</i>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<i>“I would like to be notified by email when results are available via a publication.”</i> If you select Yes, please provide your email address: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No

APPENDIX D: RECRUITMENT NOTICE FOR STUDENTS



Recruitment Notice

Recruitment for a Research Study in Human Computer Interaction

I am a graduate student in the Faculty of Computer Science at the Dalhousie University, currently running a research study as part of my thesis. This study is under the supervision of Dr. Kirstie Hawkey and Dr. Bonnie Mackay in the Faculty of Computer Science. We are recruiting participants to take part in a field study, which will be conducted in Killam Library of Dalhousie University. We are looking for students who have a lot of experience finding books in the Killam library (e.g., borrowed books from the Killam Library at least twice a month over the past year) AND we are looking for students who have less experience finding books in the Killam Library (e.g., borrow books from the Killam Library less than twice a month over the past year).

Before this study, we will send you a questionnaire, which asks you about previous experience of using library. Then you will be scheduled to meet with a researcher in the library to go over the study details. During the study, you are allowed to use all the resources you normally would when finding books in the library. Meanwhile, you will be provided with a mobile device and a researcher will give you a general introduction regarding the applications that you can use. However, you can choose to use it or not. There are eight finding book tasks in total, and you will be given one task at a time. After each task, there is a short questionnaire regarding previous task you just finished. We will conduct an interview with you when you finish all the tasks to talk about the general experience about this study. During the tasks, you will be audio-recording. The entire duration of the study will take about 70-75 minutes and the study will only commence after you agree to participate and sign the Informed Consent form. Your participation for this study will be compensated with \$20.

If you are interested in participating, please contact Casey Yu by email: xyu@cs.dal.ca

APPENDIX E: RECRUITMENT NOTICE FOR LIBRARY STAFF



Recruitment Notice

Recruitment for a Research Study in Human Computer Interaction

I am a graduate student in the Faculty of Computer Science at the Dalhousie University, currently running a research study as part of my thesis. This study is under the supervision of Dr. Kirstie Hawkey and Dr. Bonnie Mackay in the Faculty of Computer Science. We are recruiting participants to take part in a field study, which will be conducted in Killam Library of Dalhousie University. We are recruiting library staffs or student assistants who have done shelving tasks in the Killam Library and have experience using a mobile device (e.g., mobile phones or tablets).

Before this study, we will send you a questionnaire, which asks you about previous experience of using library. Then you will be scheduled to meet with a researcher in the library to go over the study details. During the study, you are allowed to use all the resources you normally would when finding books in the library. Meanwhile, you will be provided with a mobile device and a researcher will give you a general introduction regarding the applications that you can use. However, you can choose to use it or not. There are eight finding book tasks in total, and you will be given one task at a time. After each task, there is a short questionnaire regarding previous task you just finished. We will conduct an interview with you when you finish all the tasks to talk about the general experience about this study. During the tasks, you will be audio-recording. The entire duration of the study will take about 70-75 minutes and the study will only commence after you agree to participate and sign the Informed Consent form. Your participation for this study will be compensated with \$20.

If you are interested in participating, please contact Casey Yu by email: xyu@cs.dal.ca

APPENDIX F: PRE-SESSION QUESTIONNAIRE (STUDENTS)

Participant ID# _____

Date _____

Please answer us these questions to the best of your ability.

1. Please indicate your gender

- Male
- Female

2. Are you a/an

- Undergraduate student
- Masters student
- PhD student
- Other _____

3. What Faculty are you registered in?

- | | |
|--|-------------------------------------|
| <input type="checkbox"/> Agriculture | <input type="checkbox"/> Law |
| <input type="checkbox"/> Architecture and Planning | <input type="checkbox"/> Management |
| <input type="checkbox"/> Arts and Social Science | <input type="checkbox"/> Medicine |
| <input type="checkbox"/> Computer Science | <input type="checkbox"/> Science |
| <input type="checkbox"/> Dentistry | <input type="checkbox"/> Others |
| <input type="checkbox"/> Engineering | |
| <input type="checkbox"/> Health Professions | |

What is your major/department in this Faculty (e.g., sociology, nursing) ?

4. Please tell us two to three topics or subjects that you are most familiar with related to your major.

1. _____
2. _____
3. _____

5. Thinking of the past 6 months, how frequently have you visited the Killam Library?

- More than once a week
- Once a week
- Twice a month
- Less than twice a month
- I haven't used library in last 6 months

6. Please indicate how familiar you are with the following parts of the Killam Library (1= not at all familiar 5= extremely familiar)?

The Information/Reference Desk

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

The Circulation Desk (e.g., to take out books, get reserved readings)

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Classrooms

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

On what floor/s have you used the classrooms?

The MCNAB Reading Room (large one on second floor)

1	2	3	4	5
---	---	---	---	---

Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar
---------------------	-------------------	-------------------	---------------------	--------------------

The Graduate Study Area

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

The Study Tables/Carrels

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Which floor or section in the library do you tend to sit?

Learning incubator and networking center (second floor)

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

The Book Stacks

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

if you are familiar with book stacks area, please specify us which floor of book stacks that you are referring to.

Dalhousie University Archives & Special Collections

1	2	3	4	5
---	---	---	---	---

Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar
---------------------	-------------------	-------------------	---------------------	--------------------

Government Document Collection

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Current Journals and Newspapers Area

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Another familiar area (please add) _____

1	2	3	4	5
Not at all familiar(N/A)	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Another familiar area (please add) _____

1	2	3	4	5
Not at all familiar(N/A)	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

7. In the past 6 months, how often have you borrowed\located books in the Killam Library ?

- More than once a week
- Once a week
- Twice a month
- Less than twice a month

I haven't used the library in last 6 months

8. When did you last borrow\locate books from the Killam Library?

- This week
 - Last week
 - A couple of weeks ago
 - A month ago
 - More than a month ago
-

9. What were the subject areas of these books ?

10. Have you ever used any tools on a mobile device to help you find and locate books in the Killam Library? (e.g., the mobile web site, an app)?

- Yes
- No

If yes, please specify which tools you used.

APPENDIX G: PRE-SESSION QUESTIONNAIRE (LIBRARY STAFF)

Participant ID# _____

Date _____

1. Please indicate your gender?

- Male
- Female

2. Please specify the domains that you are most familiar with in general

- Agriculture
- Law
- Architecture and Planning
- Management
- Arts and Social Science
- Medicine
- Computer Science
- Science
- Dentistry
- Others
- Engineering
- Health Professions

Please specify any sub-domains for us (e.g., Computer Science: Human Computer Interaction)

3. What's your job title and how long have you been working in the Killam Library

- Student Assistant
 - Library staff
-

4. a) Please tell us how often you do the following tasks in the Killam Library and how often you perform the work.

Tidy-Up: Re-shelve books with incorrect subject letters on the book shelves and organize the books.

More than once a day	Once a day	Three times a week	Twice a week	Less than twice a week	N/A I've never done this task before
----------------------	------------	--------------------	--------------	------------------------	---

Pickup: Gather material from the stacks and study areas and put them back

More than once a day	Once a day	Three times a week	Twice a week	Less than twice a week	N/A I've never done this task before
----------------------	------------	--------------------	--------------	------------------------	---

Sort: Sort material from the pick-up back to the sorting areas to be sorted into the perfect the call order number before being re-shelved

More than once a week	Once a week	Three times a month	Twice a month	Less than twice a week	N/A I've never done this task before
-----------------------	-------------	---------------------	---------------	------------------------	---

Shelve: Physical return of the books to the library stack while making sure the books are in the exact call order number.

More than once a day	Once a day	Three times a week	Twice a week	Less than twice a week	N/A I've never done this task before
----------------------	------------	--------------------	--------------	------------------------	---

- Shelf Read: Ensure that material remains in call order number in the stacks, it is continually checked for errors in call order number.

More than once a day	Once a day	Three times a week	Twice a week	Less than twice a week	N/A I've never done this task before
----------------------	------------	--------------------	--------------	------------------------	---

- Others, please specify the work you have been assigned below

More than once a day	Once a day	Three times a week	Twice a week	Less than twice a week
----------------------	------------	--------------------	--------------	------------------------

5. Have you used any tools on mobile device to help you with your library tasks?

Yes

No

If yes, please specify which tools.

6. How often have you visited the following places in the Killam Library and why?

Book stacks on the second floor

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Book stacks on the third floor

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Book stacks on the fourth floor

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Learning incubator and networking center (LINC room on the second floor)

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

Graduate study room

1	2	3	4	5
---	---	---	---	---

Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar
---------------------	-------------------	-------------------	---------------------	--------------------

Other familiar areas _____

1	2	3	4	5
Not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar

5. How often have you borrow/located books as a library user in the past 6 months

- More than once a week
- Once a week
- Twice a month
- Less than twice a month
- I haven't used library in last 6 months

6. When did you last borrow/locate books from library as a library user(i.e., not as staff member)?

7. What domains/topics those books belong to?

8. Have you ever used any tools on mobile device to facilitate your book finding experience ?

- Yes
- No

If yes, please specify which tools.

APPENDIX I: POST-TASK QUESTIONNAIRE

Participant ID _____

Task No. _____

Description _____

Q1) How easy was it to find/refind the book?

1	2	3	4	5
Very difficult	Difficult	Neutral	Easy	Very Easy

Q2) What helped find the book? please check the items below if you used any

Wayfinding tool	How did this help
<input type="checkbox"/> Elevators	
<input type="checkbox"/> Stairs	
<input type="checkbox"/> Study tables along the wall	
<input type="checkbox"/> End cap of the shelves	
<input type="checkbox"/> Book categories	
<input type="checkbox"/> Book names	
<input type="checkbox"/> Signs (please specify it)	
<input type="checkbox"/> Window views	

<input type="checkbox"/> Paper	
<input type="checkbox"/> Electronic notepad	
<input type="checkbox"/> Map (picture of library map)	
<input type="checkbox"/> Map (Download from library system)	
<input type="checkbox"/> Others	

APPENDIX J: SANTA BARBARA QUESTIONNAIRE

SANTA BARBARA SENSE-OF-DIRECTION SCALE

Sex: F M Today's Date: _____

Age: _____ V. 2

This questionnaire consists of several statements about your spatial and navigational abilities, preferences, and experiences. After each statement, you should circle a number to indicate your level of agreement with the statement. Circle "1" if you strongly agree that the statement applies to you, "7" if you strongly disagree, or some number in between if your agreement is intermediate. Circle "4" if you neither agree nor disagree.

Questions to reverse code in bold.

1. I am very good at giving directions.

strongly agree 1 2 3 4 5 6 7 strongly disagree

2. I have a poor memory for where I left things.

strongly agree 1 2 3 4 5 6 7 strongly disagree

3. I am very good at judging distances.

strongly agree 1 2 3 4 5 6 7 strongly disagree

4. My "sense of direction" is very good.

strongly agree 1 2 3 4 5 6 7 strongly disagree

5. I tend to think of my environment in terms of cardinal directions (N, S, E, W).

strongly agree 1 2 3 4 5 6 7 strongly disagree

6. I very easily get lost in a new city.

strongly agree 1 2 3 4 5 6 7 strongly disagree

7. I enjoy reading maps.

strongly agree 1 2 3 4 5 6 7 strongly disagree

8. I have trouble understanding directions.

strongly agree 1 2 3 4 5 6 7 strongly disagree

9. I am very good at reading maps.

strongly agree 1 2 3 4 5 6 7 strongly disagree

10. I don't remember routes very well while riding as a passenger in a car.

strongly agree 1 2 3 4 5 6 7 strongly disagree

11. I don't enjoy giving directions.

strongly agree 1 2 3 4 5 6 7 strongly disagree

12. It's not important to me to know where I am.

strongly agree 1 2 3 4 5 6 7 strongly disagree

13. I usually let someone else do the navigational planning for long trips.

strongly agree 1 2 3 4 5 6 7 strongly disagree

14. I can usually remember a new route after I have traveled it only once.

strongly agree 1 2 3 4 5 6 7 strongly disagree

15. I don't have a very good "mental map" of my environment.

strongly agree 01 2 3 4 5 6 7 strongly disagree

APPENDIX K: POST SESSION SEMI-STRUCTURED INTERVIEW

Participant ID# ____

Date _____

Q1) What difficulties did you come across when finding books in

a) familiar domain/topics

b) unfamiliar domain/topics?

a) _____

b) _____

Q2) Did you notice other categories nearby when locating books on shelves?

a) familiar domain/topics

b) unfamiliar domain/topics?

a) _____

b) _____

Q3) Did you use the mobile device to help you locate the books? If yes, please specify how did you use it. If you didn't use mobile device, what did you use when locating books?

a) familiar domain/topics

b) unfamiliar domain/topics?

a) _____

b) _____

Q4) Based on post-task questionnaire, can you tell us more about how those tools/strategies help you locate books and why ?

a) familiar domain/topics

b) unfamiliar domain/topics?

a1) _____

a2) _____

a3) _____

a4) _____

b1) _____

b2) _____

b3) _____

b4) _____

Q4) What landmarks helped you figure out where you were in Killam library.

a) familiar domain/topics

b) unfamiliar domain/topics?

a) _____

b) _____

Q5) How did you decide the path you took when finding the books? Did this change as you did the tasks ?

a) familiar domain/topics

b) unfamiliar domain/topics?

a) _____

b) _____

Q6) Did you ever get confused/disorientated about your location in the library? Why ?

a) familiar domain/topics

b) unfamiliar domain/topics?

a) _____

b) _____

Q7) How did you re-orient yourself if you got confused in a library ?

Q8) How does knowing a certain amount of knowledge about a domain make it easier to search for books in this domain than searching books in unfamiliar ones ?

Q10). Generally, do you feel finding books in the library can be difficult at sometimes
Please explain

Q11) Describe a bad experience when you tried to find books in the past. What makes this experience stand out?

Q12) How did you solve the problems you encountered during the experience you just described ?

Q13) What could be done to improve the experience you just described?

Q14) What features would you like to have in a mobile device that assists you in locating books? And How would these features potentially helpful?

If the participants don't come up with their own suggestions or their suggestions don't match with the following:

- i. Current location
- ii. Nearby domain information
- iii. Relevant books information based user's current location

We will ask about the aforementioned features.

Q15) Do you have any other comments that you would like me to know regarding this study or other suggestions that would help you accomplish these tasks.

**APPENDIX L: DALHOUSIE RESEARCH ETHICS BOARD
CERTIFICATE OF APPROVAL FOR PROTOTYPE EVALUATION
STUDY**



**Social Sciences & Humanities Research Ethics Board
Letter of Approval**

June 03, 2013

Ms Xiaoyu Yu
Computer Science\Computer Science

Dear Xiaoyu,

REB #: 2013-3000
Project Title: A Focus Group Evaluating the Current Prototype for Helping Library Users with Book Finding Tasks
Effective Date: June 03, 2013
Expiry Date: June 03, 2014

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans*. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

APPENDIX M: INFORMED CONSENT FOR EVALUATION STUDY



Informed Consent

Study Title: A focus group evaluating the current prototype for helping library users with book finding tasks

Principal Investigators: Xiaoyu Yu, Masters student, Faculty of Computer Science
Kirstie Hawkey, Assistant Professor, Faculty of Computer Science
Bonnie Mackay, Assistant Professor, Faculty of Computer Science

Contact Person: Xiaoyu Yu, Principal Investigator, xyu@cs.dal.ca
Kistie Hawkey, Assistant Professor, kirstie.hawkey@gmail.com

We invite you to take part in a focus group at Dalhousie University for research purpose. You will be compensated \$10 for participating in this study and you may withdraw from the study at any time. Your academic (or employment) performance evaluation will not be affected by your participation. This description tells you about the risks, inconvenience, or discomfort, which you might experience during the study. Participating in the study might not benefit by exploring our prototype, we will be better informed of features that may be helpful for a mobile app for library users. You can discuss any questions you have about this study with “Xiaoyu Yu” (xyu@cs.dal.ca)

The purpose of the study is to evaluate a mobile prototype designed for locating books in a library. You need to have previous experience of looking up books in the Killam Library and are familiar with using a mobile device. Prior to meeting for the focus group, you will fill in a pre-session questionnaire online that will ask you about your past experience on finding books in the Killam library and some basic demographic questions. You will then be scheduled to meet a researcher for the focus group in the GV lab in Mona Campbell building. Each focus group contains from 3-5 participants. At the beginning of the study, you will meet with researchers who will tell you about the overall study. We will demonstrate the prototype for you. During the study, we will give you three library task scenarios that you will do using our prototype. After the scenarios, there will be a group discussion to find out about your experience using the prototype and get feedback and recommendations for the prototype design. The study should take about an hour to complete.

Researchers will video tape the session, your identity will not be anonymous to them research team. However, the data will be stored and handled in a confidential manner. All personal and identifying data will be kept confidential. Anonymity of textual data will be

preserved by using pseudonyms. The informed consent form and all research data will be kept in a secure location under confidentiality for five year after the end of this school term.

A researcher is always available during the study session to answer any questions you may have or address any problems that you may experience while performing the study. No penalties will apply if you decide to withdraw. However, the data we collected from you will be destroyed and not used in our study. If you have any further problems or issues related to the study, you may please contact the researcher Xiaoyu Yu at xyu@cs.dal.ca.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director, Office of Research Ethics Administration at Dalhousie University's Office of Human Research Ethics for assistance: phone: (902) 494-1462, email: catherine.connors@dal.ca.

"I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."

Participant

Researcher

Name: _____

Name: _____

Signature: _____

Signature: _____

Date: _____

Date: _____

"I understand and consent that my participation will be video recorded and photographed for the purpose of analysis. I understand that this is a condition of participation in the study, and I understand that this video and photo record will not be used in publication without my express consent."

Participant

Researcher

Name: _____

Name: _____

Signature: _____

Signature: _____

Date: _____

Date: _____

Please fill in the following:

<i>“I agree to let you directly quote any comments or statements made in any written reports without viewing the quotes prior to their use and I understand that the anonymity of textual data will be preserved by using pseudonyms.”</i>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<i>“I agree to let you use video and photos taken of my participation in publication or presentation of results, only after anonymizing by blurring faces.”</i>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<i>“I would like to be notified by email when results are available via a publication.”</i> If you select Yes, please provide your email address: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No

APPENDIX N: RECRUITMENT NOTICE FOR LIBRARY STAFF



Recruitment Script for Library Staff

Recruitment for a Research Study in Faculty of Computer Science

I am a graduate student in the Faculty of Computer Science at the Dalhousie University, currently running a research study as part of my thesis. This study is under the supervision of Dr. Kirstie Hawkey and Dr. Bonnie Mackay in the Faculty of Computer Science.

We are recruiting library staffs or student assistants who have done shelving tasks in the Killam Library and have experience using a mobile device (e.g., mobile phones or tablets). The focus of the research study is to evaluate a prototype designed for locating books in a library. You will first fill in a pre-session questionnaire online so that we can learn about your previous working experience in the Killam Library. Then you will meet with a researcher to go over the study details, give consent to do the study, and take part in a focus group study in the GV lab in Mona Campbell building.

This study is schedule to take place on June 7th at 10:30am . It will take about an hour. There is a \$10 honorarium for your participation in this study. If you are interested in participating in this study, please contact “Xiaoyu Yu” at: xyu@cs.dal.ca

APPENDIX O: RECRUITMENT NOTICE FOR STUDENTS



Recruitment Script for Students

Recruitment for a Research Study in Faculty of Computer Science

I am a graduate student in the Faculty of Computer Science at the Dalhousie University, currently running a research study as part of my thesis. This study is under the supervision of Dr. Kirstie Hawkey and Dr. Bonnie Mackay in the Faculty of Computer Science.

We are recruiting Dalhousie students who have looked up books in the Killam Library and have experience of using a mobile device (e.g., mobile phones or tablets). The focus of the research study is to evaluate a prototype designed for locating books in a library. We are looking for students who have a lot of experience finding books in the Killam library (e.g., borrowed books from the Killam Library at least twice a month over the past year) AND we are looking for students who have less experience finding books in the Killam Library (e.g., borrow books from the Killam Library less than twice a month over the past year). You will first fill in a pre-session questionnaire online so that we can learn about your previous experience of finding books in the Killam Library. Then you will meet with a researcher to go over the study details, give consent to do the study, and take part in a focus group study in the GV lab in Mona Campbell building.

This study is schedule to take place on 2013, June 21th at 10:30am and 3:00pm This entire study will take about an hour. There is a \$10 honorarium for your participation in this study. If you are interested in participating in this study, please contact “Xiaoyu Yu” at: xyu@cs.dal.ca and please let us know if you have had a lot of experience finding books in the library or not a lot of experience finding books in the library. You will be schedule in either session mentioned above based on your experience of using the library previously.

APPENDIX P: DISCUSSION OUTLINE

1. What features were the most helpful for the first scenario where you found a book with a familiar topic? Please tell us how you used them and why you think they were helpful.
2. What features were the most helpful for the second scenario where you found a book with an unfamiliar topic? Please tell us how you used them and why you think they were helpful.
3. What features were the most helpful for the third scenario where you found a book after getting lost? Please tell us how you used them and why you think they were helpful.
4. Did you encounter any difficulties with the prototype during the scenarios? What were they? How did you overcome them?
5. Were there any features you would like to improve? What were they and how could they be improved?
6. What additional features that the prototype did not have that you think would be helpful when you need to perform library tasks?
7. How well do you think this prototype would help you navigate the library? How could it be improved?
8. What are the difficulties you encountered when looking for books in a library? How could this prototype or features of this prototype help you with the problems?
9. Do you have any other suggestions or comments to this focus group?