A heuristic approach to wayfinding in interior environments: Exploring student experience in a mixed-use academic building

by

Eunjung Choi

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Program of Study Committee:
Jae Hwa Lee, Major Professor
Yongyeon Cho
Lisa Fontaine

The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

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ABSTRACT

The design of the built environment to improve wayfinding is integral to the experiences of everyone involved. This study delves into how interior design elements can contribute to complementing wayfinding design systems in the built environment. By understanding the navigation heuristics of occupants, interior design solutions can be instrumental in expanding and improving the overall wayfinding experience.

The literature review explored decision-making frameworks for path design, as discussed by Bode and Tong (2022). This perspective allowed us to distinguish goal-oriented and experience-oriented decision-making processes, thus shaping the tailored wayfinding design. A description of the spatial requirements and navigation heuristics that have been considered for the fundamental design process for interior designers according to the specific spatial needs of people in complex environments.

The study included three parts: behavior tracking, self-checklists, and interviews. First, the behavior tracking identified the participants' wayfinding behaviors associated with the cognitive heuristics when traveling from the designated origins to destinations. Second, the self-checklists observed the environmental cues and spatial elements when making wayfinding decisions. Third, the interviews with participants revealed the individuals' needs and preferences regarding decision-making of wayfinding.

Finally, the study discussed navigation heuristics for interior environments with revised visual cues (i.e., pathfinding, design anchor, spatial objects, and HERE) and adapted five elements for interiors (i.e., corridor, walls & partitions, intersection, rooms & space, and architectural & interior features) to consider the path design guidelines for goal-oriented and experience-oriented users. Goal-oriented navigation prioritizes reaching a destination over being actively engaged with the environment. When people have specific tasks,

pursuing objectives can increase stress when goals are not achieved. On the other hand, employing experience-oriented navigation heuristics is vital when measuring visitors' time in an indoor environment. In such contexts, designing an appealing spatial environment becomes significant, where visible and memorable design elements contribute to the overall experience within the built environment. Based on the major findings of this study, discuss what design implications are suggested.

Key terms: Wayfinding, interior wayfinding, navigation heuristics.

CHAPTER 1. INTRODUCTION

Background

The Importance of Wayfinding Design in Complex Environments

Wayfinding is fundamental to human navigation, defined as finding a destination in outdoor and indoor environments. Upon entering a building, individuals seek to understand the surrounding environment, emphasizing the significance of wayfinding design in navigating complex spaces. Kaplan and Kaplan (1982) stressed the importance of comprehending the environment and considering personal and social factors affecting navigation. Decisions on reaching the destination, means of travel, and suitable routes are crucial (Gibson, 2009).

Navigating to a destination may be straightforward, but indoor environments require clear and legible factors for optimal wayfinding performance. Cognitive and physical factors address challenges, viewing wayfinding as a spatial problem-solving task (Arthur & Passini, 1992). Successful wayfinding relies on spatial cognition, improved through repeated experiences (Gibson, 2009).

Environmental factors, including visual cues and building elements, significantly contribute to the overall wayfinding experience. Designers and architects play significant roles in ensuring effective spatial layouts for clear circulation. Simple and easy-to-read spatial aspects are crucial, and information systems like signage, landmarks, and intuitive layouts assist navigation.

In healthcare buildings, poor wayfinding can increase stress and physical symptoms (Carman & Grant, 2001). In unfamiliar environments, wayfinding problems cause frustration, anxiety, irritation, and stress, especially among the elderly (Ghamari & Sharifi, 2021). Stress

during wayfinding is not exclusive to the elderly; people of all ages, including the young generation, experience similar anxiety. Well-designed wayfinding systems offer benefits like increased satisfaction, time savings, and relaxation.

The study aims to explore navigation heuristics for an improved wayfinding experience, addressing challenges for all age groups. The research can enhance navigation experiences, promoting satisfaction, well-being, and ease of wayfinding for occupants and visitors.

Wayfinding in Interior Design

Spatial elements are crucial in influencing how individuals navigate within space. With spatial layout and programming expertise, designers should consider creating environments that foster intuitive wayfinding experiences (Aksoy et al., 2020). The strategic arrangement of pathways, landmarks, and focal points guides occupants, reducing confusion and stress in complex environments. Crafting indoor spaces allows designers to evoke positive emotions, enhance cognitive engagement, and facilitate seamless navigation.

Effective wayfinding design depends on the legibility and connectivity of indoor spaces. Designers must comprehend the built environment's nuances to create layouts that facilitate a logical flow and offer clear lines of sight to vital landmarks (Weisman, 1979). Combining interior and graphic design expertise is essential for comprehensive wayfinding solutions. The interdependent bond between spatial wayfinding design and strategies is essential in creating environments that enhance the navigation experience. Acknowledging wayfinding as a collaboration between the wayfinder and the environment underlines the inseparable connection between spatial and wayfinding design strategies (Allen, 1999).

Implementing these suggestions promotes a harmonious and user-centric approach, resulting in spaces that efficiently guide individuals and leave a positive impression on their overall experience. This study explores the interaction between interior design and wayfinding. Valuable insights can be gained by examining how interior design elements strategically employ spatial elements, implement legible wayfinding strategies, and collaborate with other disciplines. The ultimate goal is to contribute to creating built environments that promote a sense of ease, well-being, and connection for all occupants and visitors.

Impact of the Campus Environment

Campus buildings in today's era serve multiple purposes and incorporate programs similar to those of multipurpose facilities, such as healthcare facilities, shopping centers, and airports. The diverse functions necessitate the implementation of effective indoor wayfinding strategies. The complexity of the campus environment is crucial to consider, providing well-being, a sense of belonging, and positive experiences for students, visitors, and staff from different backgrounds and cultures (Laming et al., 2019).

For instance, students transitioning from rural to urban areas or from one country to another require an adaptive identity in the new environment. They need to fit into an unfamiliar space, and this process relies on a sense of belonging between the campus environment and the students (Laming et al., 2019). In addition to the facilities' effectiveness, the campus buildings' overall wellness is also important. First-year students or visitors may feel pressured due to the unfamiliar environment and require time to become familiar, especially after experiencing online classes during the pandemic. Thus, the campus environment should

be designed to support their activities and events and to assist them in navigating the complex surroundings.

One effective approach to fostering campus well-being is providing campus spaces where students can meet, participate in events and clubs, and develop connections with the school community. Public spaces should be designed efficiently and functionally to accommodate diverse majors, student groups, and individual needs. Since students often spend significant time studying and working in groups, the main building where they gather should encourage social interaction and collaboration by incorporating an efficient and well-thought-out layout.

In conclusion, campus buildings nowadays encompass a range of functions and programs, necessitating effective indoor wayfinding strategies. Considering the complexity of the environment and the diverse needs of students, visitors, and staff, incorporating early wayfinding design can lead to intuitive and aesthetically pleasing solutions (Lu, 2015). Furthermore, designing public spaces to promote social interaction and collaboration contributes to a sense of belonging and enhances the overall campus experience.

Problem Statement

Navigating public university buildings presents a major challenge to students, faculty, staff, and visitors. It is crucial to recognize the significance of proficient wayfinding systems, which involve well-planned layouts, clear signs, and interactive technologies, in facilitating navigation (Pati et al., 2015). Nevertheless, more than dependence on technological solutions is needed. Improving wayfinding in complex public buildings requires understanding the intricate relationship between navigation heuristics used in indoor environments and their interactions

with physical surroundings (Hölscher et al., 2006; Van Tilburg & Igou, 2014). Recognition of this cooperation emphasizes the importance of the synergy between human behavior and wayfinding systems.

Brunye et al. (2018) underscore the importance of objective evaluations when considering the dynamic decision-making process involved in pedestrian wayfinding. They caution against oversimplifying the impact of particular environmental factors on this process, making it critical to explore how spatial design features can support effective wayfinding in complex environments (Pati et al., 2015).

This study examines the correlation between the physical surroundings and the heuristics linked to wayfinding in public facilities situated on university campuses. By comprehensively analyzing the common influence of spatial design attributes, environmental indicators, and wayfinding strategies, the research intends to furnish valuable insights that can aid the refinement of wayfinding designs and elevate the navigation experience for all guests. This research offers practical insights for enhancing navigation systems on college campuses, thereby supplementing the existing literature on wayfinding in intricate settings.

Purpose of the Study

This study aims to describe how people navigate mixed-use interior environments using cognitive heuristics. Specifically, the study aims to uncover how spatial design elements, including visual cues, are related to the decision-making processes involved in wayfinding. Particularly, the study considers how environmental factors can either help or hinder the wayfinding experience and how people integrate their surroundings to navigate interior spaces through a trial-and-error approach to different routes in a multi-use building on a university

campus. The study can offer valuable insights into effective wayfinding design practices for various complex environments by highlighting the navigating heuristics that work best in mixed-use interior environments. By analyzing the factors that contribute to developing effective wayfinding processes, this research helps interior designers create initial design tools that promote positive emotions, safety, and well-being for building occupants.

Research Questions

1. How do people use cognitive heuristics when traveling from one location to another within buildings?
2. What is the role of visual cues and spatial elements in interior wayfinding decision-making?
3. How can interior designers apply navigation heuristics to their design process, particularly for mixed-use buildings?

Significance of the Study

This research seeks to enhance interior wayfinding design by exploring the interplay between visual cues and spatial elements. It suggests the creation of spaces that address diverse wayfinding needs and preferences. By prioritizing spatial elements over environmental cues, the study pictures improved wayfinding systems, which are particularly beneficial for individuals navigating unfamiliar surroundings, providing valuable insights for new students, families, and visitors in complex campus environments.

CHAPTER 2. LITERATURE REVIEW

Wayfinding Cognition

Wayfinding cognition is a complex process that involves cognitive functions such as memory, perception, decision-making, language abilities, learning, and attention (Ghamari & Sharifi, 2021). It includes surveys, landmarks, and route knowledge, and cognitive maps are spatial representations that contain qualitative metric information about large-scale environments. The human ability to navigate effectively in the built environment is a complex cognitive process that relies on cognitive and perceptual processes (Golledge, 2000). Wayfinding cognition refers to the mental processes of navigation and orientation within a physical environment, including recognizing landmarks, memorizing routes, and using maps and other spatial information to plan and execute the movement. Wayfinding cognition is an important aspect of spatial cognition and is studied as a branch of cognitive psychology that focuses on mental representations of space and spatial relationships (Jamshidi et al., 2020). Researchers have investigated the cognitive processes involved in finding one's way in complex environments, such as multi-level buildings, and have found that people use problem-solving heuristics to navigate unfamiliar parts of the building (Hölscher et al., 2006).

Spatial Cognition

Spatial cognition is a critical mental process that enables people to understand how to interact with their environment's spatial layout. It allows individuals to form mental representations of the environment that can be used for route planning and decision-making. Spatial cognition, including wayfinding cognition, involves the mental processes of navigation and orientation within a physical environment, which includes recognizing landmarks,

memorizing routes, and using maps and other spatial information to plan and execute the movement. Spatial cognition can be identified in nine major subdomains, including spatial memories, spatial reference frames, spatial updating, problem-solving heuristics, logical associations, information retrieval, spatial skills, working memory, and neuroanatomy (Jamshidi et al., 2020). Spatial cognition involves three steps in perceiving space or objects: mental rotation, knowledge of an object's location relative to a reference point such as the body, and spatial orientation, such as spatial navigation and wayfinding (Jacobs, 2003).

Wayfinding Behavior

Wayfinding behavior, the cognitive process used to navigate physical or virtual environments toward a desired destination, depends on cues like signs, landmarks, and maps (Passini, 1981). Legibility and familiarity with indoor and outdoor spaces play vital roles in influencing wayfinding behavior, making comprehending effective human navigation in diverse environments essential. Lynch (1960) emphasized the importance of understanding people's wayfinding behavior to design easily navigable and understandable cities.

Aksoy et al. (2020) examined the correlation between design and wayfinding decisions by analyzing hospital floor plans and their impact on the navigation patterns of first-time users. Their study revealed that different spaces' connectivity, integrity, and step depth values significantly affect wayfinding choices. High-integrity nodes strategically situated in circulation areas with a wide visual field emerged as crucial decision points for successful navigation. Meanwhile, challenges arose from the hospital blocks' symmetrical layout and directional signs' quality and colors. Factors such as narrow circulation areas, poorly designed waiting areas, and hallways were identified as negative influences on wayfinding behavior (Aksoy et al., 2020).

Thoroughly comprehending wayfinding behavior and its impact on human experience in the physical environment is crucial in designing easily navigable surroundings. This knowledge is pivotal in promoting environments that prioritize user-friendly wayfinding experiences by highlighting the significance of considering design elements that enhance navigation efficiency (Passini, 1981; Lynch, 1960; Aksoy et al., 2020).

Cognitive Map

Cognitive maps are mental representations of physical space, including the relationships between different places and the routes that connect them (Tolman, 1948; Golledge et al., 2000). These maps are created through wayfinding as occupants navigate a building or space and store information in memory. Jellinger (2000) describes cognitive maps as internal spatial representations that guide travel between humans and animals. Tolman (1984)'s research on cognitive maps in rats and humans showed how mental maps enable animals to navigate the environment and anticipate their next moves based on their understanding of the spatial arrangement. This ability to create and use cognitive maps is implicated in learning and behavior, including spatial reasoning skills, memory in navigation, and cognitive development with environmental factors. Understanding how occupants create and use cognitive maps can inform the design of spaces that are easy to navigate and improve the overall user experience. According to the research from Weisberg and Newcombe (2016), examining the individual differences in navigation proficiency and their relationship to cognitive maps was to investigate the existence of cognitive maps and the cognitive processes that support effective navigation.

Heuristics in Wayfinding

Heuristics refer to simple yet effective decision-making strategies that people employ without requiring all available information. The effectiveness of these strategies depends on the information environment and cognitive processes involved (Bobadilla-Suarez & Love, 2018). The ability to navigate, or wayfinding, is influenced by spatial representation, environmental constraints, schema-like knowledge, and information-seeking heuristics (Shin and Miho, 2000). These factors are especially important in designing navigation aids for individuals with limited spatial knowledge. Heuristics are cognitive shortcuts in decision-making and problem-solving, particularly navigating in built environments like buildings, cities, and landscapes. Common wayfinding heuristics include using landmarks, following familiar routes, and orienting in cardinal directions. While these heuristics can help people navigate efficiently, they can also introduce errors and biases. Heuristics enable individuals to make intuitive and quick decisions with minimal cognitive effort (Tong et al., 2022).

To assist pedestrians in making optimal and efficient route choices, Tong and Bode (2022) have proposed principles for decision-making. Regularly, using heuristic takes less accuracy than time and effort. However, they addressed simple heuristics are more useful when applying statistical methods with the same or more information. According to their research, two types of pedestrian routing heuristics are identified in table 1. The first assumes that pedestrians use a cue, such as a principle, rule, criterion, or strategy, to compare their options and concentrate on the features of the routes. The second considers the environment and route options. It should be noted that heuristics should not be disregarded simply because of their simplicity, as they offer a practical solution to decision-making.

Table 1 Route Choices by Heuristics (Tong & Bode, 2022).

Types	Heuristics	Descriptions
One-reason-heuristic	The least-decision-load	Pedestrians tend to choose the route with the least number of possible decision points
	The least-angle	Pedestrians tend to choose the path at an intersection which is most in line with the target direction
	The shortest distance	Pedestrians tend to choose the shortest path
	The quickest path	Pedestrians tend to choose the quickest path
	The least costly path	Pedestrians tend to choose the least costly path
Others	The action continuation	Pedestrians tend to proceed with the current course of action, ignoring other alternatives
	The initial segment	Pedestrians tend to choose the initial path with a later turn so that they do not have to turn for as long as possible along their route
	The central point	Pedestrians tend to choose the well-known parts of a building, even if this requires detours
	The hill-climbing	Pedestrians tend to complete easily obtainable subgoals that can be achieved immediately for reaching the destination
	The fine-to-coarse planning	Pedestrians tend to divide the environment into different areas, undertaking rough planning when navigating between areas and fine planning within a given area

Van Tilburg and Igou (2014) conclude that when people face multiple viable routes of equal length in known environments, they tend to prefer the route that allows them to continue their current course of action. This action continuation strategy is a cost-saving process that minimizes mental effort. They suggest that asymmetric preferences for alternatives may result from the minimization of mental effort. Another study found that people choose the smallest angle when visual cues are limited in a virtual environment. The

small angles provide a simple and effective approach to determining participants (Hochmair & Frank, 2002).

Hölscher et al. (2009) found how participants in a study adapted to the observed path selection strategies and how these strategies were integrated with information on the overall geometric structure of the building and task variations. Specifically, when presented with two equally reasonable alternative paths to the target area, participants fine-tuned their initial path selection using the minimum angle heuristic (the least-angle heuristics). Also, it said participants selected the target area rather than the final room number as their destination. This result suggests that direction-based and hierarchical decision factors overlap in this complex building environment.

Decision-Making for Route Choice

Wayfinding is finding one's way from one location to another. According to Arthur and Passini (1992), wayfinding involves three key processes: Decision Making, Execution, and Information Processing.

The availability of diverse information is critical in the decision-making process for wayfinding. Route choice decision-making involves selecting the most appropriate or optimal route from one location to another based on various factors such as distance, travel time, traffic, and road conditions. Wiener et al. (2012) emphasized the importance of environmental features for spatial learning and decision-making. Pedestrian decision-making during wayfinding is a dynamic process influenced by individual differences and environmental experience, according to Brunye et al. (2018).

Figure 1 Wayfinding Process (Arthur and Passini, 1992).

Passini's Hierarchically Structured Decision Plan (HSDP) diagram is useful for decision-making in various contexts. The HSDP diagram consists of interconnected boxes representing a decision or action. It helps individuals or groups make decisions in a systematic and organized way by breaking down complex decisions into manageable sub-decisions or actions.

Initial path straightness and relative topography are the most influential factors in route selection, according to Brunye et al. (2015). In unfamiliar environments, people choose routes with less angularity and fewer turns, even if the routes take longer to travel (Dalton, R.A., 2003). Understanding how people make their route decisions can help improve the pedestrian experience.

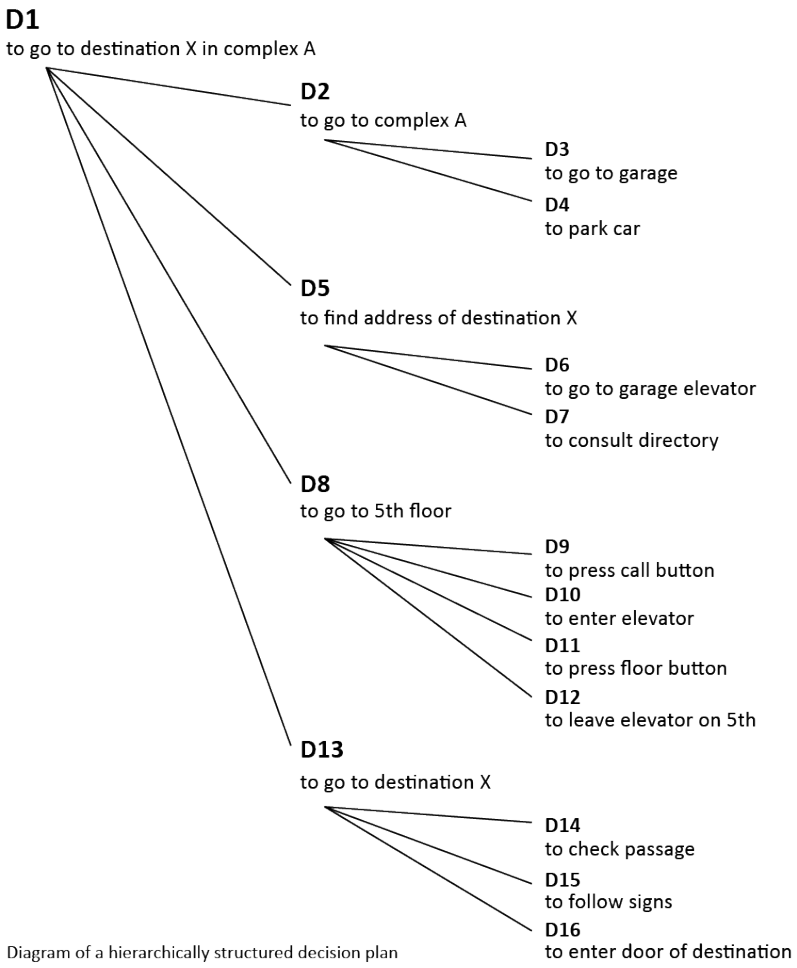


Figure 2 Decision Plans (Romedi Passini, Wayfinding in Architecture, 1984). Tong and Bode's study, "The Principles of pedestrian route choice," suggested that pedestrian route choices as the essential principles. They proposed the four stages (figure 3) regarding spatial behaviors and among the stages, the decision-making mechanisms which is not known about the precise process, but they deducted that relying on possible or available repertoire used for route choice.

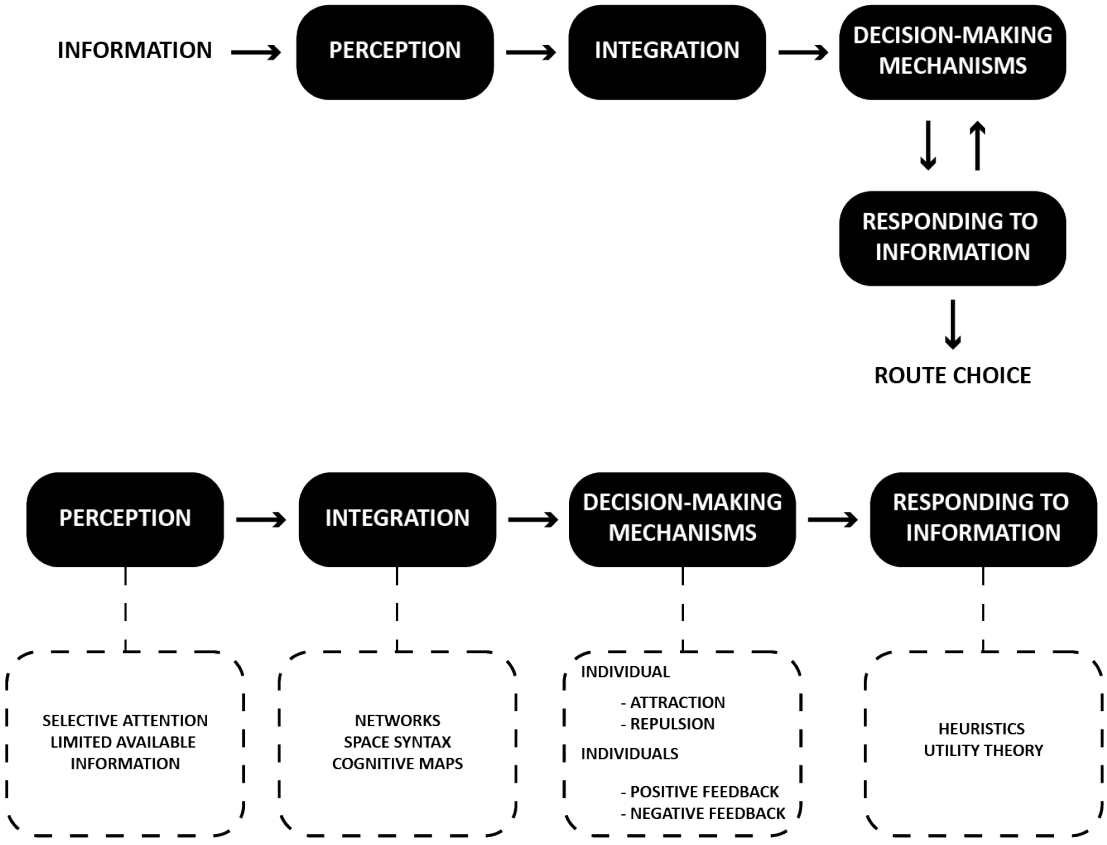


Figure 3 Route Choice Decision-Making Process (Tong & Bode, 2022).

Interior Design Elements in Wayfinding

Understanding and applying wayfinding design strategies in the built environment is crucial for improving the overall navigation experience. Best (1970) emphasized ways to enhance wayfinding quality: relocating destinations and providing effective wayfinding aids. Since destination relocation is often impractical after construction, careful consideration of wayfinding aids during the schematic design process becomes essential. Architects and interior designers are vital in translating programming and concept development into spatial designs that facilitate efficient navigation. Interior design significantly impacts occupants' well-being

and wellness within the built environment. Simplifying and optimizing route design is preferred to reduce information overload during navigation (Butler et al., 1993).

Exploring navigation heuristics and considering the role of interior design elements can greatly enhance the wayfinding experience within indoor spaces. Al-Sharaa et al., (2022a) addressed that the American Society of Interior Design (ASID) would consider the interior design as a core to facilitate the functional process for enhancing living quality and giving the influence. Interior designers, architects, and other professionals involved in the design process should be aware of these factors to create a more user-friendly and efficient built environment.

Lynch's Five Elements

Kevin Lynch (1960) studied how people navigate and make decisions in urban environments by examining their internal mental construct, known as a cognitive map. He argued that people use five environmental factors to construct their cognitive map: paths, edges, districts, nodes, and landmarks. With Kevin Lynch's five principles regarding elements of the built environment, the selected articles have theoretical sources for adapting the five principles to indoor environments. In wayfinding, the factors of self, people, and the environment affect the wayfinding process (Jamshidi et al., 2020).

Table 2 Kevin Lynch's Five Elements of Wayfinding Principles

PATHS	Paths have described the path as a route, or channel somebody travels along.
EDGES (BOUDARIES)	The linear attributes, Edges, are not considered when the observer explores space. They are barriers between two stages: shores, railroad cuts, and walls.

Table 2 Continued

DISTRICTS	Districts are medium to large city sections that the observer mentally enters inside sections, and somehow, they have common and identifying characteristics. This factor can be recognized from the inside and exterior when it is possible to see from the outside.
NODES (INTERSECTIONS)	Nodes are decision points that represent strategic spots in a city when an observer enters. They may be primarily junctions, places of a break in transportation, a crossing or convergence of paths, or moments of shift from one structure to another.
LANDMARKS	Landmarks are physical objects, buildings, signs, stores, mountains, and environmental characteristics that provide certain points.

Path

A linear path in a city or environment connects different places, including streets, sidewalks, bike paths, and other transportation routes. They allow people to move through an area and connect to different places (Lynch, 1960). With the signs of the way, the routes would take people to move from one place to another (Arthur & Passini, 1992). The authors emphasized the importance of designing clear, intuitive, and easy-to-follow paths, which can affect the wayfinding experience by building a mental map of the environment and reducing confusion for people. When Lynch's definition of a path is applied to indoor environments, it could be used as a circulation that people occasionally or potentially move along to reach destinations (Jamshidi et al., 2020). People prefer indoor paths because they minimize energy expenditure, have the longest line of sight, and are wide with sufficient brightness (Jamshidi et al., 2020; Vilar et al., 2013).

Edge

In outdoor environments, the concept of edges refers to boundaries between two areas, which differs from the linear characteristics of paths (Lynch, 1960). These boundaries can

guide people's movements and help them navigate their environment. The concept of edges can also be important in indoor environments, where well-designed edges can help people read spaces and areas (Arthur & Passini, 1992). According to a study by Jamshidi et al. (2020), local geometric properties of edges can be used as cues in spatial learning, and non-geometric cues, such as wall color, can compete with local geometric cues to be encoded as the signal for a target.

Districts

Districts on the city scale are urban elements of large areas conceived in two dimensions (Gale et al., 1985). In particular, Arthur and Passini (1992) treated neighborhoods as areas with distinct characters, identities, and purposes because physical boundaries can define them. The boundaries of districts can be defined by the environment and the types of activities or purposes, and clear signage can help people navigate within a city or building (Arthur & Passini, 1992; Alansari, 2022).

Nodes

Nodes refer to locations or intersections in the physical environment that guide people's movements and help them navigate (Lynch, 1960). In Wayfinding: People, Signs, and Architecture (1992), the authors argued for the importance of well-designed nodes that could serve as landmarks to help people understand the relationships between spaces and areas easily. During wayfinding, people decide at decision points in buildings or spaces, and the complexity of environmental cues affects decision-making time (Brunye et al., 2018). The two types of intersections, T-type and F-type, have different preferences for corridor width, and both intersection types prefer bright corridors (Jamshidi et al., 2020).

To understand the wayfinding behavior from pedestrians, the node-to-node connection on floor plan or map should be considered for navigation purposes (Mandel & Salah, 2022). The author addressed that analyzing the frequency and directness of node-to-node connections can provide insights into user wayfinding behavior in a public library, further the institutions.

Landmarks

Landmarks play a crucial role in wayfinding, according to Lynch's five principles. They are recognizable physical objects or features in the external environment that communicate with their surroundings and are closely related to the memory of the way or space in terms of wayfinding strategies (Yesiltepe et al., 2021). Key architectural elements in a building should be designed to help people understand the spatial organization of a building (Dogu & Erkip, 2000). In wayfinding, the environmental aspects of space affect wayfinding, and landmarks are one of the most important features to understand or remember the place. Wayfinding can be described as people finding their way between places or landmarks, as people with or without landmarks can cause a common error in wayfinding (Jellinger, 2000).

Table 3 Lynch's Five Principles in Interior Environments.

Corridor and circulation	Arthur and Passini (1992) discussed the importance of designing clear, intuitive, and easy paths to follow because it can affect wayfinding experience.
Walls and partitions	Edges are boundaries between two areas (Lynch K, 1960). Well-designed edges in a physical way provide a clear understanding of orientation.
Room and space	When bringing the concept of districts from Lynch's five principles, it could be defined as rooms for purposes or regions with different privacy levels (Alansari, 2022).

Table 3 Continued

Intersection	Nodes are decision points that represent objects such as cars and houses. Also, the places are described as 'nodes' and are associated with each other through activity links (O'Neill, 1991; Ahmadpoor & Smith, 2020).
Architectural and interior features	Landmark communicates with its surroundings and is closely associated with remembering the way or space regarding wayfinding strategies (Yesiltepe et al., 2021).

Environmental Factors

Designing an effective wayfinding system is critical for helping individuals navigate complex indoor environments (N. Vanhaeren et al., 2020). However, the success of a wayfinding system depends on various factors, including the building's specific characteristics and its users. To create an efficient wayfinding design, clear and consistent environmental factors, spatial elements, and cues should aid navigation (Kaplan & Kaplan, 1982).

Moreover, designing the environment to be legible, with a clear hierarchy of spaces and routes, is crucial (Dogu & Erkip, 2000). The significance of wayfinding systems in outdoor and indoor environments is that they can connect people from different cultures and countries through a unified language that enables them to guide, experience, and navigate through space (Gibson, 2009). Especially, providing newcomers with a map or other wayfinding information before they begin to navigate could improve their performance (B. Darrell et al., 1993).

Spatial Configuration

The design of spatial configurations in complex environments significantly affects the quality of wayfinding and behavioral performance. Creating spatial quality with a simplified layout with clear space arrangements is critical to facilitating effective wayfinding. Al-Sharaa et

al. (2022) suggested that hospital design's functional aspect, namely wayfinding, contributes particularly to spatial quality.

The topography and design of indoor spaces are critical factors in determining wayfinding success, underlining the significance of streamlining building layouts in complex settings (Butler et al., 1993; Jamshidi et al., 2020). Configuring stores, corridors, and levels is essential for successful navigation in shopping malls (Dogu & Erkip, 2000). Baskaya and Özcan (2004) also argue in favor of simplifying the spatial layout to reduce cognitive load and errors.

Regarding pedestrian route choice behavior, Ti et al. (2023) found that simplifying recommended route shapes boosts their selection by pedestrians. This outcome proposed that designing maps with a controlled layout complexity can impact pedestrian route choice behavior. Furthermore, Youssef and Youssef (2022) demonstrated that corridor configuration, the number of branches, nodes, segments, and building layout shape have a notable impact on spatial cognition. The study determined that cul-de-sac corridors are more effective at promoting spatial cognition than looped corridors. Additionally, cognitive ability is inversely proportional to the curvature of circulation spaces, number of nodes, and number of branches. The importance of visibility in promoting spatial cognition was also emphasized.

Hölscher and colleagues (2009) emphasized the significance of creating circulation systems in intricate multi-level buildings that facilitate multi-level wayfinding strategies and connect all floors vertically and horizontally to prevent navigation deficits.

In summary, designers should prioritize simplifying indoor environments for increased wayfinding success and decreased cognitive load on users. Special attention should be paid to

corridor configuration and the number of nodes, branches, and segments in the building layout to promote spatial cognition (Youssef & Youssef, 2022).

Environmental factors – Visual cues

Lighting

Exploring navigation heuristics for an enhanced wayfinding experience involves acknowledging the vital role of lighting in guiding people through complex building facilities. The previous studies emphasized the need to review lighting conditions throughout the day and ambient lighting in all areas to understand the direction and intensity of light for approaching way-finders. Lighting effectiveness is crucial for indoor and outdoor spaces, with well-designed lighting systems aiding wayfinding in indoor environments by highlighting important areas (Baskaya et al., 2004). Social factors, such as lighting, have been found to play a crucial role in effective wayfinding, emphasizing the importance of considering the social aspects of the environment in optimal wayfinding experiences (Yassin et al., 2021). Additionally, lighting was highlighted as a significant factor impacting the well-being of patients and staff in healthcare facilities (Huisman et al., 2012).

Considering navigation heuristics and the impact of lighting on wayfinding experiences, designers can create environments beneficial for effective wayfinding design and the well-being of occupants and visitors. Addressing the negative impact of indoor wayfinding on users' physiological and psychological health in large public environments, such as hospitals and airports, due to inadequate lighting performance is essential (Ghamari & Sharifi, 2021).

Spatial objects

The relationship between spatial objects and spaces is a key factor influencing users' wayfinding behavior. The placement of objects, such as furniture and artwork, is closely related to enhancing the overall spatial experience for pedestrians. Successful wayfinding strategies were grounded in environmental cues, emphasizing the significance of rethinking objects' roles and relationships during design (Mustikawati et al., 2018). The configuration of objects within indoor spaces should be thoughtfully defined, considering the object relation mechanism in the wayfinding process. By strategically organizing and presenting spatial objects, designers could significantly enhance navigation ease and efficiency for occupants and visitors (Firjatullah et al., 2017).

Signage

Signage's critical role in complex environments was underscored, emphasizing visibility and clarity as crucial factors for successful wayfinding. Creating intuitive and consistent signage systems to help users navigate complex buildings would be crucial (Kuliga et al., 2019). Providing clear and visible signage in appropriate locations, ensuring legibility and distance visibility, was emphasized (Butler et al., 1993). The signage system should be user-friendly, easily recognized, and understood by users, using concise language and symbols to improve effectiveness (Iftikhar et al., 2020).

Landmarks

Landmarks are acknowledged as essential visual cues or reference points aiding individuals in navigating complex environments. The functional role of landmarks lies in their ability to serve as memory did aid in route finding (Denis et al., 2014). These landmarks, which

may include large sculptures, fountains, or distinctive store facades, significantly impact accuracy and ease of navigation (Dogu & Erkip, 2000). However, their effectiveness depends on visibility, uniqueness, and memorability (Baskaya et al., 2004). Designers are encouraged to create environments rich in visual landmarks to support effective wayfinding (Denis et al., 2014).

CHAPTER 3. METHODS

Overview

The research aimed to observe what environmental information people use to find their way within the given interior spaces. The study tried to identify the factors influencing people to stop, think and decide their way to six destinations. Thus, multiple methods, behavior tracking, self-checklists, and interview, qualitative design were adopted for the study.

Behavior tracking was conducted to understand how students decide to reach their destinations because the methodology was an effective tool to understand human behavior in environments and helped to develop user experiences. Then, the researcher needed to record the participant's behavior to identify the wayfinding strategies of public buildings on campus for students, such as artificial lighting, furniture, signage, and landmarks.

There was a self-checklist that was given to the participants for the study. Also, the self-checklists for the participants consisted of a scale from least to most so that the participant could mark the environmental cues that influenced them in finding the destination. The researcher note made to follow the routes behind the participants. Then, after the tasks, the participants interviewed the researcher because the interview was part of behavioral tracking.

Behavior Tracking

A Behavior Tracking (Individual-centered Mapping) of the participants, the questionnaire, and the narratives adopted for the study. The present study followed the five steps for conducting individual-centered mapping. The observation technique could record a

subject's movements and activities in an informed environment. The behavior tracking method applies indistinct observation, and the researcher must address several major ethical issues: informed consent, privacy, and confidentiality (Gifford, 2016). Behavior tracking could be a useful tool for studying and understanding human behavior in different environments and could inform the design of these environments to improve the overall user experience.

Behavior tracking involved five steps to conduct person-centered mapping. First, the researcher drew and selected the six route tasks to observe after visiting the sites. Visual elements in the building were dominant rather than the other senses, smell, tactile and auditory. Thus, the categories of behavioral observation were related to them; lighting, natural light, furniture, interior features, and signage to understand what visual factors were useful or interrupted during wayfinding.

Prior to the observation tasks with the participants, the researcher completed a pilot study with one or two individuals to mitigate anticipated challenges during the tasks. The entire task took 45 minutes to 1 hour, including breaks if participants wish to take them during the tasks. After the six tasks, the researcher interviewed the participants for 15 to 30 minutes to ask about their experiences. The researcher made an audio recording during the interview.

Self-Checklist

Providing the checklists for participants were based on the application of visual cues in the built environment. The checklists for participants provided the scale of the given visual cues to consider the effects on them. Lighting was placed along the corridor/circulation, while different types of furniture designated spaces for specific purposes, such as study areas or rest areas. Furniture layout and interior features, such as colored walls, glass walls, and wall-placed

decorations, were selected as visual factors for participants, as these different variations could act as landmarks to help them determine their location. The largely centered stairs, which divided the study, meeting, and rest areas, were also used as landmarks.

Additionally, the building had various types of signs, including room signs, directory signs, information signs, and evacuation plans, which were collected from the official school website to create the self-checklists. The researcher provided additional pictures and examples of each factor to reduce confusion among participants before starting the observation. The participants then marked the scales of the factors while observing the six routes provided by the researcher and noted whether they affected them. Depending on the scale of each factor, the study could determine the preferences or importance of the factors (environmental cues of the building), as the scale ranged from less to most.

The participants may share additional ideas about the factors from the self-checklists because they may feel different while observing. The information could be used to improve the design of interior spaces and create more intuitive and effective wayfinding systems.

Researcher Note Forms

The researcher's note forms were used to record while the participants were doing their tasks, such as behavior or pedestrian flows. Each participant provided different behaviors and decisions through their experiences. So, the researcher drew and recorded the lines and took notes during the observation. Specifically, what visual cues caught their eyes? Were they signs or evacuation plans?

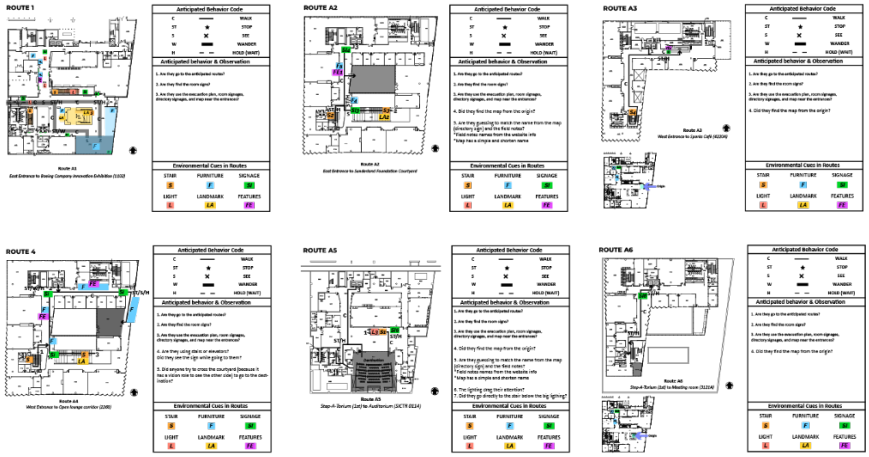


Figure 4 Researcher Note Forms

Or where they stopped or walked along routes? Based on the research questions, the researcher took notes to understand the relationships between visual cues and behaviors. It contained the analyzed spatial and visual characteristics to clarify the observation record.

Interview

After observation, participants were interviewed to understand what environmental cues of the building helped or hindered their wayfinding. They were interviewed about whether they completed all the routes. Based on the annotations in the floor plans, the interview used the self-checklists with five factors to recover the least helpful and most helpful elements. The study observed how they found their way into the given floor plans to understand the importance of interior design systems in public buildings.

Interview Questions

1. What features do you search for first to find your way?
2. What was the most helpful way to find your way?
3. What was the least helpful to find your way?

4. Do wayfinding systems (room signage, hanging signage, and map) in locations help you to figure out the next steps?
5. Can you explain your emotional reaction to the wayfinding activities?
6. Are you satisfied with the wayfinding systems in the building?
7. Are you familiar with this building?

Study Setting

The building for the observation of the study was a higher education building that houses five different scales of classrooms, an auditorium, and thirteen meeting and study rooms that provide reservation services to encourage collaboration among students, diverse maker spaces to support art and technology, and commercial space, cafe, and boutique. Based on the intentions of architects and designers on the building, it was oriented to connect outdoor and indoor environments simultaneously; it consisted of interactive spaces, creation spaces, co-working spaces, administration, and special projects of spaces. The building comprised five floors, including the lower level, and it served myriad assistance to students, faculty, staff, and visitors. The study examined the wayfinding systems in the new building to support students, faculty, and visitors to perform well. The wayfinding system in the built environment showed a minimal way rather than the other complex environments have. The designers of the given building wanted to make visitors travel inside with the centered-landmark stairs by hiding the elevators from them.

1. The building had a noticeable feature, the landmark stairs in the center of the building.

2. Another landmark feature could be found next to the landmark stairs, with a large scale of lighting above the stairs to the ground floor.
3. Each floor supplied several types of seating at the corridor intersection and next to the classrooms and conference rooms.
4. Each floor had room number signage with an easy-understanding naming system for users.

Figure 5 Five floor plans of case building. Source: Archdaily. (KieranTimberlake, 2021).

5. The building had commercial space, a student-run retail boutique, and a café on the first and fourth floors where people looked around and gathered in space.
6. Collaborative workspaces for students were provided on each floor, supporting, and encouraging students' entrepreneurship.

Wayfinding Tasks

The newest public building on campus was chosen for the study because it had six purposes regarding place functions: interaction, hacking and making, co-working, administration, special projects, and building support. The building supported the various activities that students needed to do, and the space designed for their needs. As a multi-purpose building for people, it included all students, school staff, and visitors. The six routes for the study building had different origins and destinations. The destinations spanned five levels, some of which could be seen on both floors simultaneously. All routes had sensory design elements, visual, sound, and haptic factors. These aspects were key factors to going in the right direction. The destinations had the role of collaborative workspaces or rooms for students to gather, communicate, study, and work. Each route had different characteristics, and the tasks could be helped to understand how participants find them without environmental/visual cues.

Data Collection Procedure

IRB Approval

Participants for the study were college students, so the researcher considered how to meet them and the ethical principles for the participants. Before starting the methodologies, the study was approved by the Institutional Review Board (IRB) at Iowa State University in February 2023.

Recruitment

Volunteer university students who visited the buildings via the registration portal or QR code recruited participants for the study. The recruited students, who may have previously experienced the building environments in their classes and meetings, may be acceptable for the

study as the research sought to observe wayfinding behavior in indoor environments. The recruited students had different ages, genders, backgrounds, and cultures in their countries or cities. The wayfinding skills of individuals were not considered or evaluated; the study did aim to observe and understand people's decision-making process and what environmental cues were used to help them move forward. The observation time for completing six routes would be one to one and a half hours. However, depending on participants' walking speeds, decisions, and prior experience, it might take less than an hour. After completing the trials, the post-task interview would be completed in thirty minutes per person. The interview questions would only record the subject's audio. The participants must have experience reading maps of the building, and the purpose of the study was to observe how they move so that the subjects were required to arrive at the origin. The study description was given to the subjects, and the individuals performed the task to maintain their rights as human subjects.

Data Analysis Procedure

Observation Protocol

Before beginning the methods with the participants, the researcher gave a brief introduction to the study and a description of the tasks. The researcher informed the participants that the tasks did not evaluate their wayfinding skills. Participants were given the paper to check the scale of the filed notes specified by the researcher and were informed what the researcher would do if they followed them. Participants had the given information about the origin and destination to complete the tasks. However, they could ask questions if they had difficulty finding the destination or wanted to get hints. They could ask the researcher for a

break if they needed to rest. After completing the six tasks, the researcher took them to the reserved room to interview them privately.

By collecting the results from the participants, the study analyzed the environmental/visual cues in the indoor space that were significant in deciding and thinking about the next move to the destinations. Since the design elements of the building were the main factors that people use to find their way, finding the environmental cues that would work adequately would be important.

Adapting Kevin Lynch's Five Principles in Routes

The study's routes were created to identify how spatial wayfinding designs work in the interior building environment, by adapting spatial elements from Lynch. Corridors represented Lynch's path concept in indoor environments because of their linear characteristics, allowing people to navigate along them. Edges were represented as walls and partitions because they divided spaces, while districts referred to rooms and spaces with specific functions.

Overlapping space functions could make distinguishing the boundaries between walls and rooms challenging, but dividing the building's rooms by function could create clearer districts, such as workspaces, classrooms, study rooms, and meeting rooms. Nodes were decision points or reference lines that occupants use to navigate, and the factor could appear in wayfinding design systems, such as signage and landmarks. Improving the node concept to help users find their way could involve using recognizable elements.

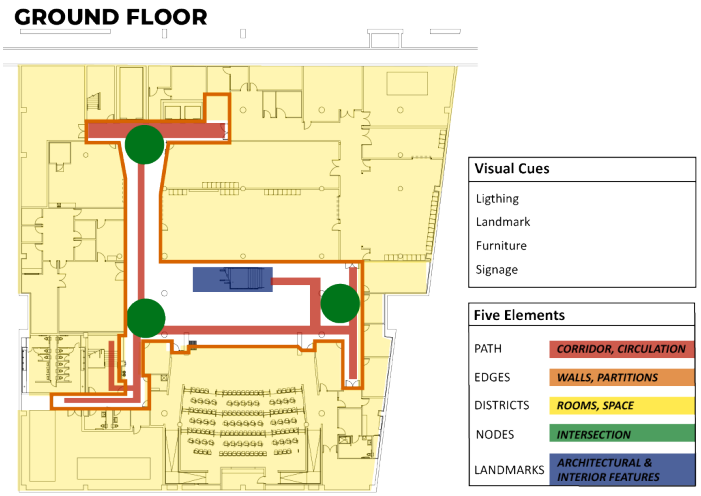


Figure 6 Analysis of Physical Factors in Indoor Environment - Ground Floor

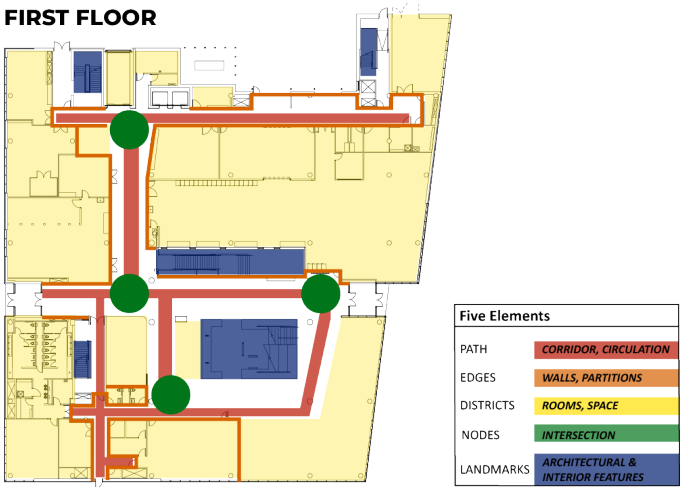


Figure 7 Analysis of Physical Factors in Indoor Environment - First Floor

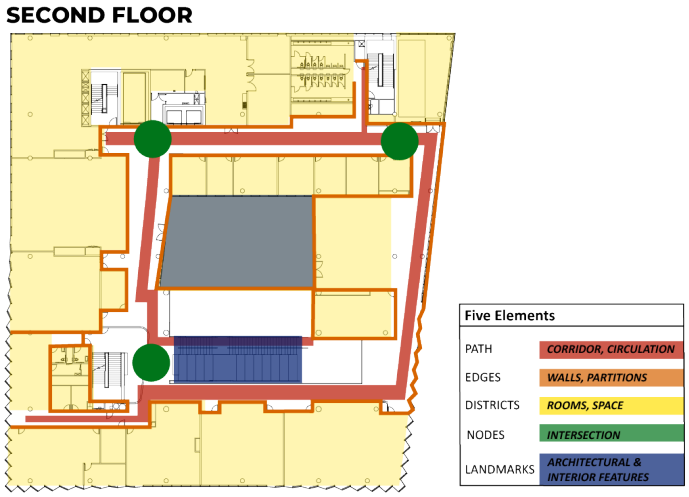


Figure 8 Analysis of Physical Factors in Indoor Environment - Second Floor

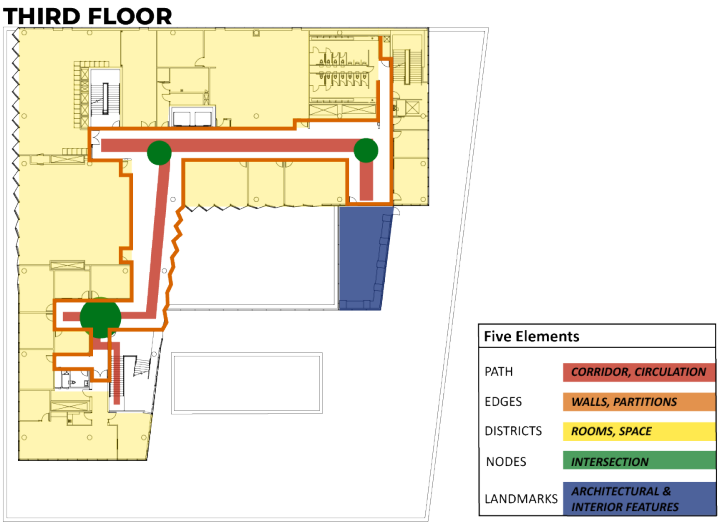


Figure 9 Analysis of Physical Factors in Indoor Environment - Third Floor

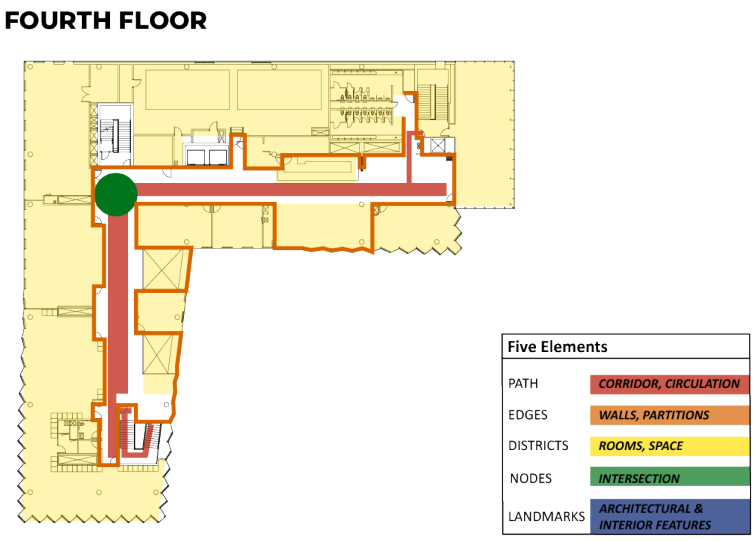


Figure 10 Analysis of Physical Factors in Indoor Environment – Fourth Floor

Visual Cues in the Study

Environmental factors could affect indoor wayfinding:

1. Lighting: Linear, circular, downward, and pendant lighting.

2. Landmarks: Interior features such as colored walls, glass walls, different furniture arr angements, and architectural features such as stairs.

3. Furniture: Work desks and chairs, high tables and chairs, lounge tables and chairs, st orage bins, benches, outdoor furniture.

4. Signs: Directory signs, room signs, information signs, and hanging signs.

The design of the interior environment could significantly affect wayfinding performance with certain design features, such as clear signage and good lighting (Ensafi et al., 2020). Based on the existing building environment, the study was extended to list the environmental cues that may affect people as they find their destinations: Artificial lighting,

furniture, furniture arrangement, interior features, and signage. The built environments did not have the different types of spatial objects except for furniture that showed each space' characters to visitors such as decorative objects or flooring.

Route Overview

Each route had different characters based on the route choices along with the heuristics (Table 1) so that the routes had possible paths. From the experiment and results from Butler et al (1993), the best paths were short, used an elevator, and did not go outdoors. There are multiple optional paths to reach a single destination, each route is expected to have two to three options. By providing six different routes, the experiment aimed to offer participants a comprehensive understanding of diverse decision-making heuristics. The paths were anticipated to check participants' behavior and observations.

Figure 11 Route 1 Overview

Route 1: Origin - East Entrance, Destination - Open exhibition area

The provided route had the path for the destination required to see or pass the centered landmark stairs. Behind space from the architectural features in the route, sometimes furniture was to provide a seating area for the public, and other days, they placed movable artworks. Since the landmark was in the center of the building, the study expected to observe the participants' paths. There are wayfinding systems in the given routes: directory map signs, artificial lighting, landmarks, and room signs. In this route, the size and number of artificial lights attracted attention as much as the landmark in the center of the building. Thus, the participants could catch the landmark lighting first.

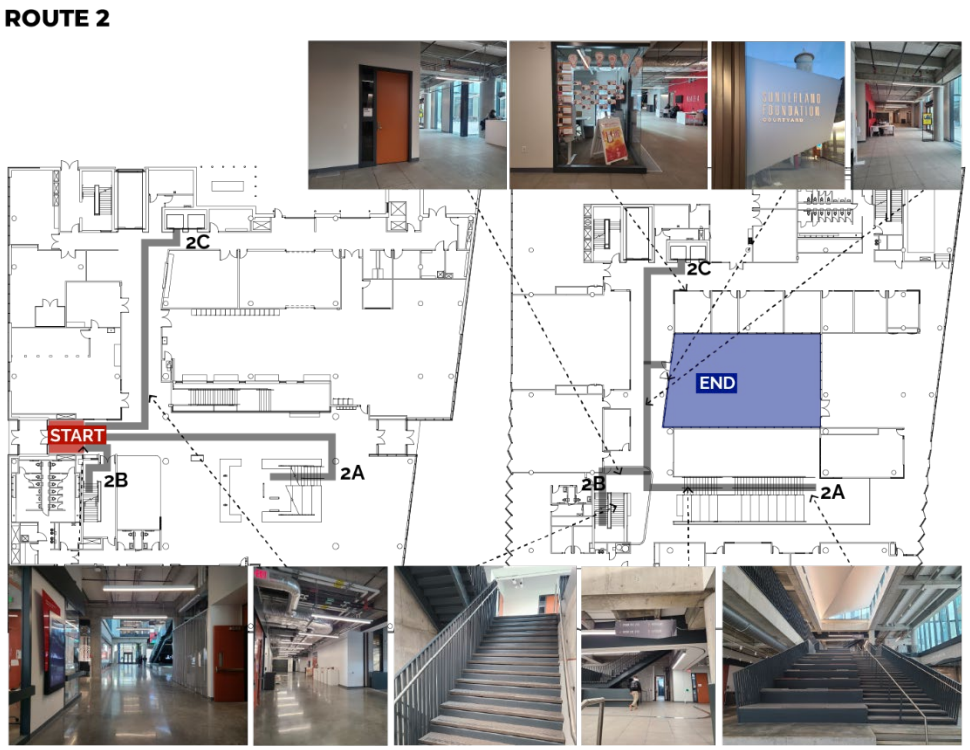


Figure 12 Route 2 Overview

Route 2: Origin – East Entrance, Destination – The outdoor courtyard

This route could get participants thinking about which stairs and equipment provided the shortest path. The route had the landmark, the centered landmark stairs, located in the center of the building and was visually open and easy to recognize. Route 2 had several visual cues: architectural features (centered landmark stairs), interior features (glass wall and colored wall), room signage, directory signage, and furniture. When the participant took the landmark to reach the destination, he/she could see the glass wall of the courtyard, and then he/she could discover the outdoor furniture. The furniture placement in this route could give an idea of what the space was for.

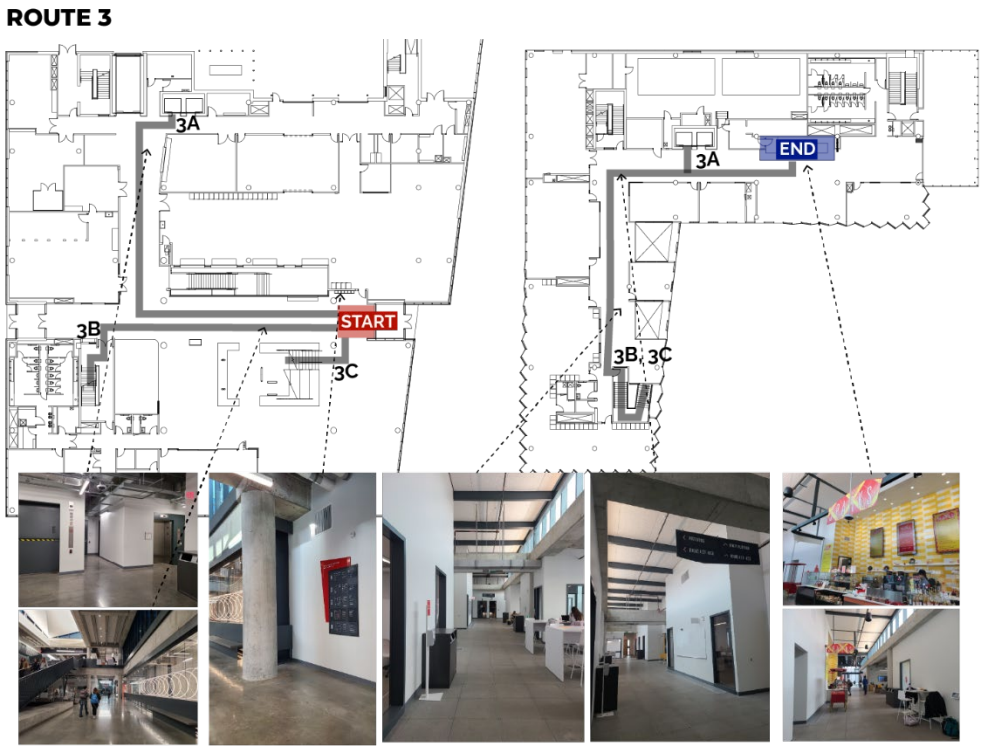


Figure 13 Route 3 Overview

Route 3: Origin - West Entrance, Destination - Cafe

The route was from the first floor to the fourth floor of the building, and people could use stairs or an elevator. To find the elevator, the subject could explore the interior with given visual attributes in the route. People using the elevator from the origin might experience visual cues such as map signage near the entrance, artificial lighting (landmarks), centered landmark stairs, furniture, and room signs. The visual cues along the way could catch the participant's attention and guide them. Then, the destination had a large and recognizable sign with its name.

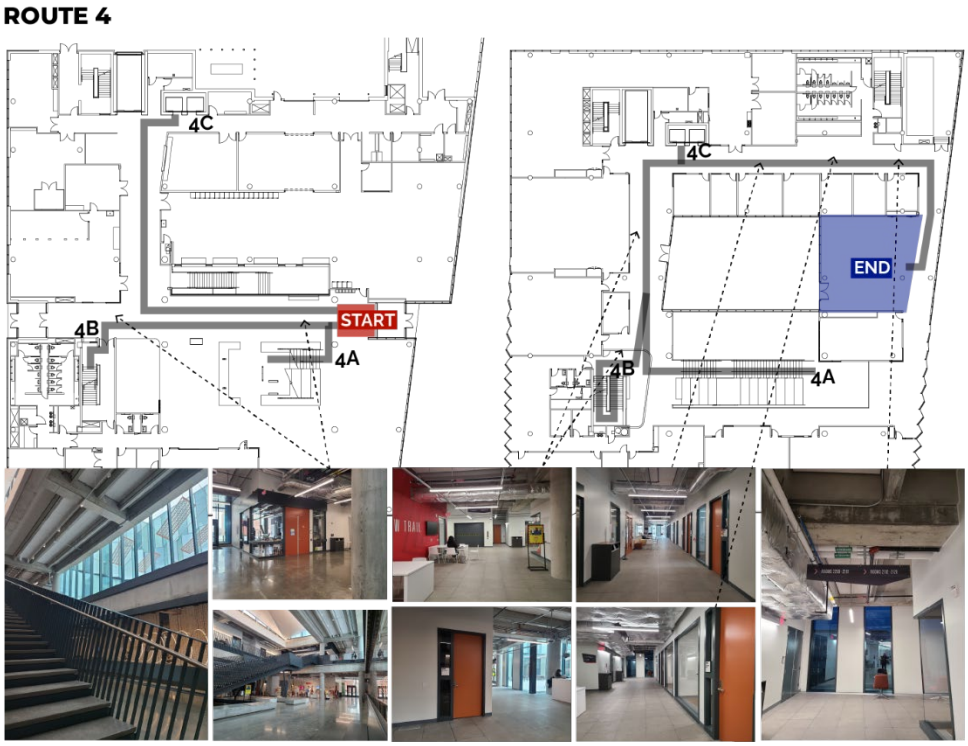


Figure 14 Route 4 Overview

Route 4: Origin – West Entrance, Destination – Open lounge space

Route 4 had the longest path among the different routes, allowing the distribution of the idea of Edge in an interior environment way. The one route out of three possible paths on

the floor plan was shown to pass the outdoor courtyard landmark. Participants could take three different paths to the destination. If people took the path expected by the researcher, they would see the room signs along the corridor and directory signs hanging from the ceiling.

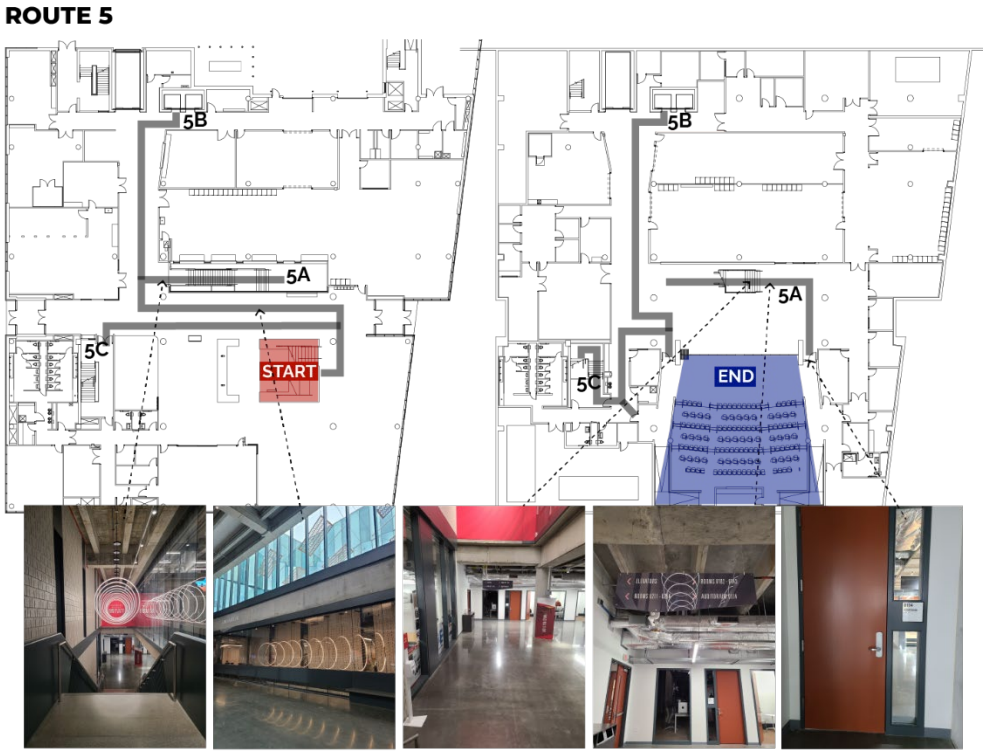


Figure 15 Route 5 Overview

Route 5: Origin - Centered landmark stairs, Destination - Auditorium

The route covered two floors, the basement, and the first floor. There were three ways to get from the starting point to the destination: the stairs near the east entrance, the stairs with lights in the middle of the building, and an elevator. This could be the shortest of the different routes from the same route level. Since the route went from the first to the ground floor, you might see landmark artificial lighting. There was a wayfinding sign when people used the stairs below the landmark artificial lighting; however, the brightness might block the clear

view because of the reflection. The directory and room signs would be easily seen when standing at the bottom of the stairs.

Figure 16 Route 6 Overview

Route 6*:* Origin - Centered landmark stairs, Destination – Meeting room

The route was from the first floor to the third floor. Participants were expected to use the stairs near the east entrance and the elevators. If they took the elevator, the directional sign above their view might attract their attention to guide them to their destinations. Using the stairs near the east entrance to reach the destination might take a short time. The signs along the route might be easy to follow and recognize at a glance; however, finding the destination at the intersection near the route should be considered to the end. Although there was room signage, discovering it might take a while.

Route Choice Heuristics in Six Routes

Six routes for the study were created based on the heuristics for route choice (Tong and Bode, 2022) to understand the given environmental cues and possible decisions of the participants. The routes had several different routes in one task. The study focused on how participants present the given visual cues and their decisions in the directions by setting up the origin and destination so that different heuristics were applied within the route. For example, route 1A and 1B diverge from the node and are influenced by slightly different visual cues, and the research wanted to correlate which visual cue influenced the decision.

Route Choices

Types	Heuristics	Route 1		Route 2			Route 3			Route 4			Route 5			Route 6		
		1A	1B	2A	2B	2C	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	6C
one-reason-heuristic	the least-decision-load heuristic		X	*1			*1			X			X			X		
	the least-angle heuristic		X	X			X						X			X		
	the shortest distance heuristic	X			X*2			X				X*4	X			X		
	the quickest path heuristic	X			X*2		X*3					X*4	X			X		
	the least costly path heuristic																	
others	★the action continuation heuristic		X	X								X		X			X	
	the initial segment heuristic		X	X			X					X	X			X		
	the central point heuristic		X	X					X	X			X			X		
	the hill-climbing heuristic																	
	the fine-to-coarse planning heuristic	X					X	X			X		X	X	X		X	X

1. The number of decision points is the same
2. Using the stair next to the East entrance will lead to the destination, but people may take the center stair
3. After getting off the elevator
4. Can cross the courtyard to the destination, but may take the path

★ The routes in the heuristic have taken longer than the other options in common.

Figure 17 Route Choice Heuristics in Six Routes

CHAPTER 4. RESULTS

Site Walk-Through

Before conducting the methodology with the participants, the researcher conducted the site walk-through to physically survey the designated routes and to get familiar with the design elements and reduce errors in the results. The routes given to the researcher resulted in expected and unexpected findings and differences, which are described below.

Route 1: Origin - East Entrance, Destination - Open exhibition area

According to the first pilot study, the *Centered landmark stairs* blocked the view of the destination due to its size. As a result, participants might be confronted with two different decision points (nodes), such as doors next to the entrance or a column next to the boutique, to orient themselves. Then, the room number was shown on the floor plan, but the actual room required information about the room signage. As a result, participants might feel uncertain about reaching their destination because they are outside the room.

Route 2: Origin - East Entrance, Destination – The outdoor courtyard

The courtyard had no room number on the floor plan or directory information, but the room sign with its name appeared when reaching the adjacent destination. Without the room number, participants needed to pay attention to visual features of the space, such as lighting fixtures.

Route 3: Origin - West Entrance, Destination - Cafe

The destination was an open room that can be found directly from the staircases or the elevators. With or without the role of signage, the furniture set at the boundaries of the destination might lead the participant to it.

Route 4: Origin - West Entrance, Destination - Open lounge space

The signage was hanging from the ceiling; however, the room signage along the existing rooms could be inferred by the target room number.

Route 5: Origin - the centered landmark stairs, Destination - Auditorium

The multiple and recognizable artificial lighting as visual cues made the wayfinding process to the destination.

Route 6: Origin - the centered landmark stairs, Destination - Conference Room

The room signs on the route helped finding the destination at the intersection near the end of the route.

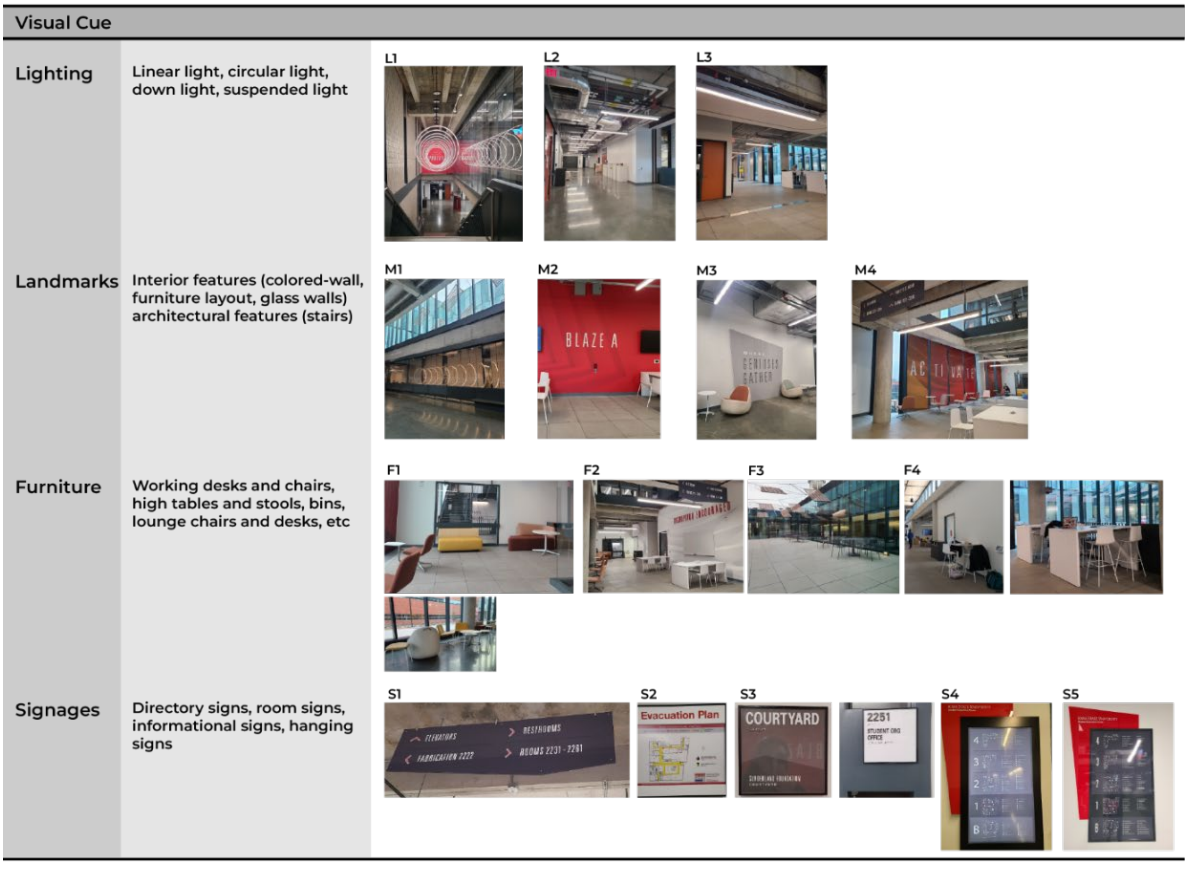


Figure 18 Visual Cues in Indoor Environments

Visual cues during walk-throughs

Natural Light and Artificial Light

The researcher visited the building multiple times to observe any differences in the natural and artificial lighting of each route. The first investigation was after 4 p.m. on a cloudy day. Although the building received amounts of natural light, it did not change the observation quality of the building. The artificial lights on the routes worked properly to see and find the targets, regardless of the impact of the natural light. Then, the second investigation was at 11 a.m. on a snowy day. The building received much natural light, but the brightness level of the artificial light was similar and enough to see inside. The day provided a great view of the outdoor space, the courtyard, where people could see the outdoor furniture. The courtyard has a glass door and panels, so there were no difficulties recognizing the space during the day. The courtyard furniture, with a clear view from the inside, were also recognizable. However, the hanging signage were affected by the amount of natural light due to the glare from the window.

L**andmarks**

Landmarks in the built environment showed different types and scales. The first floor of this building had two noticeable cues to guide travels. The circular and large-scale lighting captured the attention to observe them, and the central stairs with the seating area along them had a key role in leading people to move upstairs or stay in the surroundings. The rest of the floors had colored walls with furniture that provided a sense of zone for studying and seating.

Furniture

Furniture, tables, and chairs were placed in the destination of route 1 and were occasionally repositioned. The furniture in the open exhibition space (route 1) made people understand seating or studying area that could be challenging as an exhibition area. However, the setting did not change because the destination name on both directories and the website did not revise. With the difference, the study may have that the function of furniture clusters provides the concept of the place to participants.

Signages

Signs in the building for the experiment were placed and performed well to guide pedestrians, except for when the lighting brightness was strong. The brightness of artificial and natural lighting interrupted the observation of signs with information on the current and afterward location. From the first pilot study, the sign naming for locations had a few different names when comparing the maps on the first floor. However, the room number from maps and signs had the same numbering, which could help participants.

Observation of Wayfinding Behaviors

While observing each participant, the researcher tried to keep a distance. While doing the tasks for the participants, they talked to themselves and the researcher, such as, "Where am I?" "Did I miss something?" or? "I think I am lost." In the figures below, the participants' negative reactions during the tasks would be represented as lines to show their footprints. In figure 16 ~ 21, the lines were darker when many participants chose to go to the destination; otherwise, the lighter lines showed individual choices. When participants wanted help finding their destinations, the researcher provided verbal directions to observe the nearest clues from

their positions about how to reach the destinations. Using this method, the study addressed RQs 1 and 2 regarding the navigation heuristics and the wayfinding design elements contributing to the decision to proceed.

Researcher Note Forms

Researcher field note forms (figure 4) recorded which touchpoints participants used to find their destination. Aligned with the given diagram, the researcher marked the expected behavior of the participants. For example, ST/H or ST at intersections, C where long corridors were prominent, and W where the researcher thought the participant might get lost or go the possible routes to find the destinations. The study could also compare participants' route choices to see which routes were dominant and which were inferior. Based on that, it could draw associations with the visual cues given to those routes. On each route, it could see if the cues they got or the actions they took made the journey to the destination easier or harder.

Behavior Observations – Route Choice Analysis

The six of two-level maps showed where participants traveled on the routes in the route choice analysis tables. When the lines in the left maps became darker, it meant that the participants took the same path to reach the destination. For example, most participants took the same path when the lines cumulate, like route 4 or 5, without a different line. Then, the floor plans on the right-side meant observing the participants' behavior and marking them as circles. The researcher abbreviated the point name on the plans to mark the behavior code for analyzing of participants’ behavior. Additionally, it was based on the Lynch’ five elements by analyzing the built environment. For example, the ST/H was the same as with the node of Lynch, which could be an indoor access intersecion. Specifically, the ST/H meant that the

researcher expected the participant to stop at the point to decide where to go because the decision points suggested two more options. C corresponded to the corridor or path, so the participants walked along it. The ST/W point meant that participants might stop and wander where they are now.

Route 1

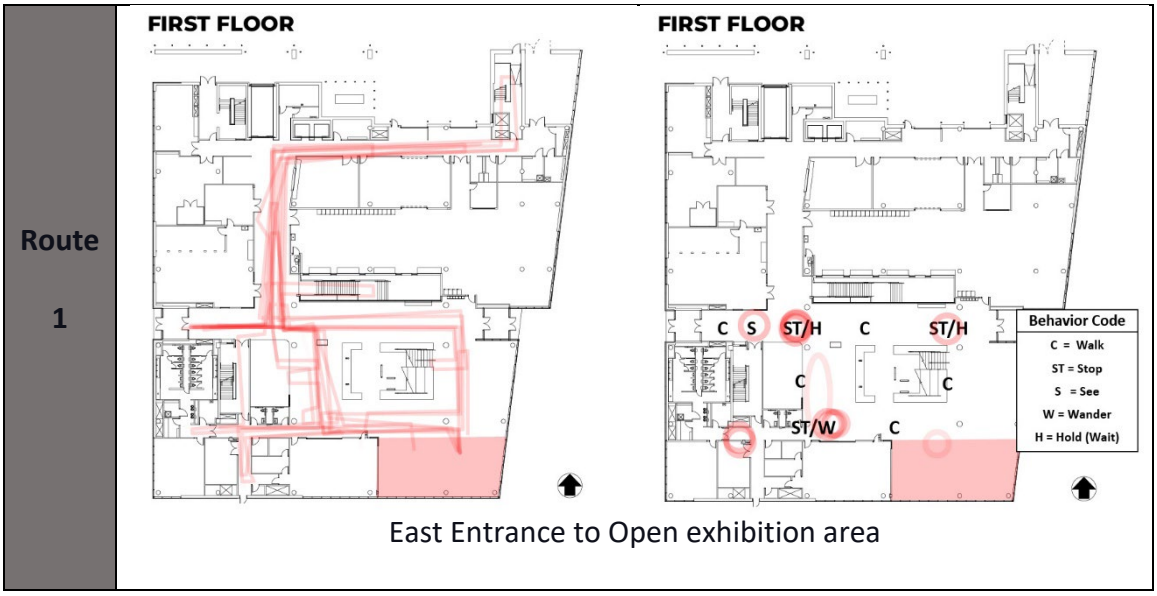


Figure 19 Behavior Observations in Route 1

Route 1, the initial task for participants, involved navigating a single floor from start to finish. Despite expecting it to be completed relatively quickly, it was the most perplexing for most participants. Despite having ample visual cues, there needed to be a crucial cue to locate the open area. Participants typically started by consulting the directory sign at the beginning point to identify the destination's name provided on the researcher's field note paper. This initial step led to a need for clarification as participants struggled to match names between the directory sign and the self-checklists, which specified "Exhibition Area" without a room number.

Consider the scenario where participants found it challenging to locate the destination by relying solely on the name, especially since the exhibition area seemed like an open space in the building. Many inadvertently went in the wrong direction, attempting to find the room sign. Realizing the room number was crucial, participants paused at the ST/H point, took a continuous path from there, and ultimately ended up on the upper side of the building. Upon returning to the starting point, they recognized the need for clarification as the room number was higher than anticipated. Subsequently, they navigated behind landmarks and centered stairs while searching for room signs. Even after finding a room sign next to the destination, they continued looking for another, assuming the destination should also have a corresponding room sign.

In the accompanying figure 16, the pedestrian lines were directed towards the west area, leading some participants astray. However, a few participants easily found the destination because the name suggested an open room, given that it was the exhibition area. Only one participant discovered the information sign inside the destination before being informed by the researcher. Post-completion of Route 1, participants expressed confusion, with comments such as "I thought the space was the room," "They should have a room sign," and "Why did they put furniture in the exhibition area?" Notably, two participants felt consistently lost during the task, resorting to seeking assistance from a store employee. Another participant asked passing students for directions, highlighting the need for external assistance. Staff members also faced challenges in accurately navigating the route, emphasizing the importance of familiarity with the surroundings.

Route 2

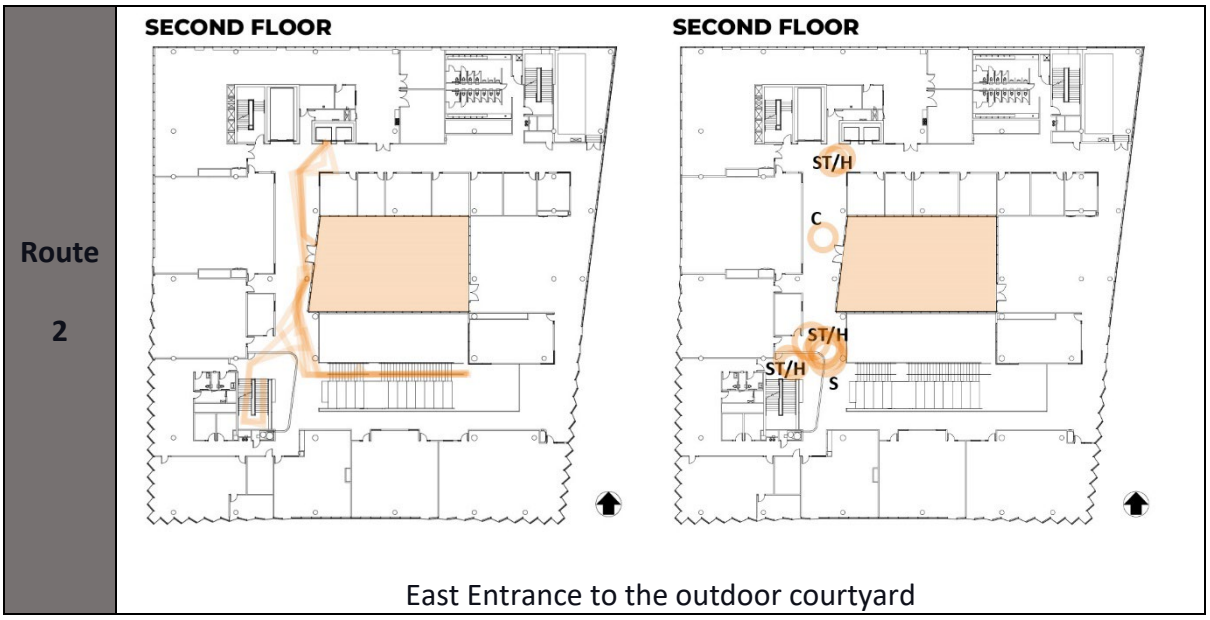


Figure 20 Behavior Observations in Route 2

Route 2 commenced on the first floor, leading participants to the destination on the second floor. Unlike Route 1, this route involved navigating different levels, with options such as stairs, elevators, and a central staircase. Among the 12 participants, 5 opted for the central stairs, another 5 chose the elevator, and the remaining 2 utilized the side stairs near the starting point. The varied approaches emphasized the diverse navigation strategies employed by participants. Many participants encountered challenges in finding the destination, particularly those who relied on directional signs from the starting point.

Some, seeking clarification about the alignment between directory signs and the self-checklists, initially opted for the central stairs. The central staircase's size and the adjacent illumination effectively diverted participants' attention, hindering their ability to survey the surroundings. Points labeled as ST/H served as common stopping points for all participants,

providing a shared reference or prompting them to contemplate the destination through glass walls before reaching the designated point. The destination's visibility served as a crucial clue for all potential routes. Those using the central staircase tended to assume it might be the endpoint, particularly observed from the first-floor area. This perceptual challenge underscored the importance of clear visual cues to guide participants accurately through the different levels of the route.

Route 3

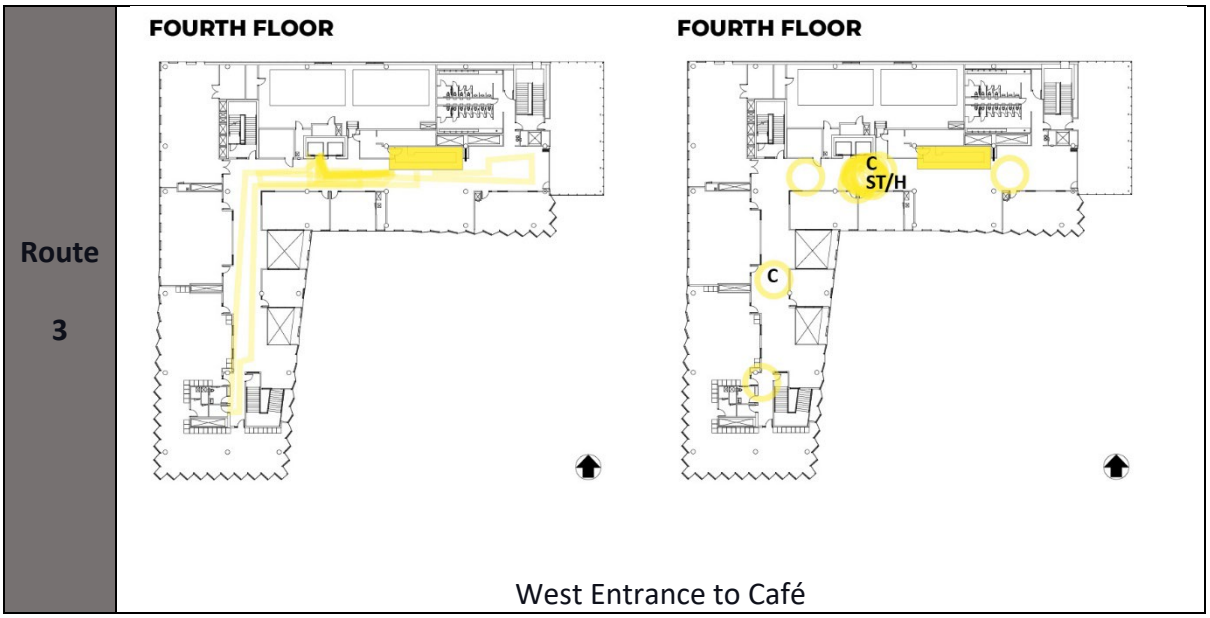


Figure 21 Behavior Observation in Route 3

Route 3 led participants to a destination on the fourth floor of the building, prompting many to choose elevators despite starting at the west entrance near the landmark-centered stairs. In these instances, participants aimed to identify the quickest heuristic to reach their destination. Upon exiting the elevator, some were initially drawn to the sounds and smells of the cafe, prioritizing sensory stimuli over visual cues in their decision-making. Conversely,

others surveyed both sides after leaving, attempting to determine the best direction. Participants who focused on their surroundings sought to comprehend the space experientially, relying on their observations before discerning the visual elements leading to the destination.

Conversely, those who committed to the centered stairs maintained an upward gaze, uncovering side stairs leading to the upper floors. Upon reaching the fourth floor's south point, these participants scrutinized room signs and hanging directory signs to navigate toward the intended destination. This varied approach highlighted the diverse strategies employed by participants, with some prioritizing sensory input while others leaned on visual observations. The choice between elevators and stairs reflected individual preferences in navigating the route effectively.

Route 4

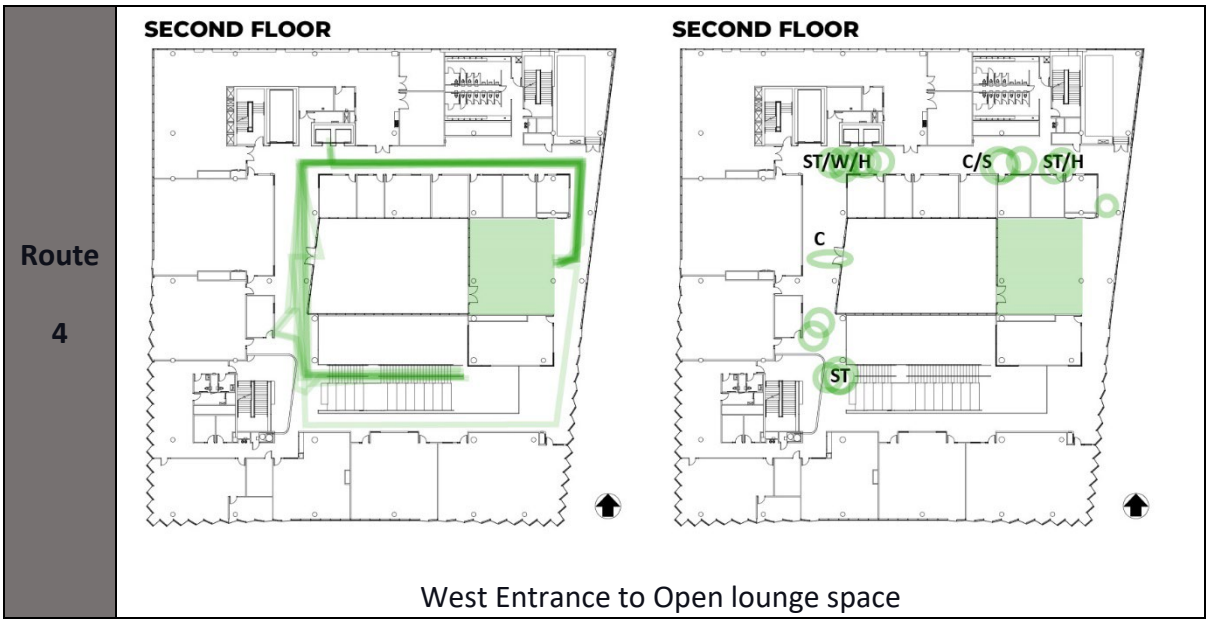


Figure 22 Behavior Observation in Route 4

Route 4 featured two prominent landmarks: the centered stairs and the courtyard. Both provided an open atmosphere with natural light and unobstructed views through clear glass walls. Most participants chose the centered stairs from the starting point while simultaneously taking in the view of the courtyard. The first landmark, the centered stairs, captivated their attention, guiding them to walk past it to reach the destination floor. Subsequently, as the second landmark, the courtyard influenced participants to consider passing through or observing it as they navigated the path.

While most participants grasped the concept of reaching the destination by crossing the courtyard, a few attempted to do so but encountered a locked door during the task. With one exception, the remaining participants continued the path from the landmark to the upper corridor, where visual cues, such as room signs, likely guided them. The efficacy of the wayfinding design in Route 4 was notably impacted by participants' choices, particularly regarding the numbering sequences of the room signs. The attached heights of the room sign next to the doors proved instrumental in participants easily recognizing them.

Additionally, visual cues such as floor plan signs and landmarks were critical in guiding participants from the route's outset to its conclusion. Some participants seek advice on directory signs, checking and reading room numbers before ascending to the second floor to reach the final destination. The complex interaction amongst landmarks, room signs, and wayfinding elements highlighted the subtle intricacies of how participants navigated through Route 4.

Route 5

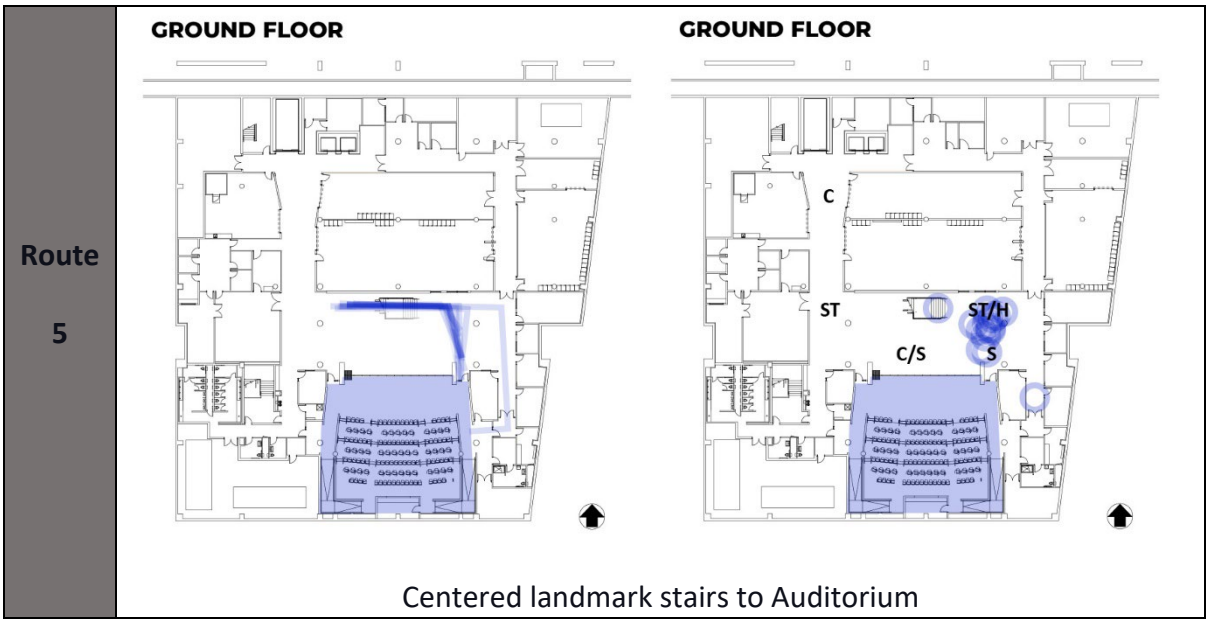


Figure 23 Behavior Observation in Route 5

Route 5 contained various visual elements, prominently featuring centered stairs, glass walls as landmarks, and a large screen and directional signage. With the starting point at the centered stairs, participants had the autonomy to distinguish which visual cues would be most helpful. The stairs leading to the lower floor were visible from the origin, allowing participants to survey their surroundings. Despite the presence of alternative stairs and elevators, the researcher anticipated participants choosing the nearby and recognizable stairs, given their association with landmarks like the centered stairs.

Participants deduced the location of the destination, identified as room 0114, drawing upon their understanding of room numbers gained from the preceding four routes. The clear view offered by the centered stairs through glass walls motivated participants to descend.

However, the anticipated impact of the size and number of lights above the stairs was less significant than expected as participants progressed.

Upon descending the stairs, half of the participants remained unaffected by hanging directory signs despite having them at eye level on the stairs. The lack of color contrast and insufficient brightness of the directional signs rendered them nearly invisible for wayfinding. Nevertheless, without consulting the directional signs, participants paused, surveyed their environment, and successfully discovered the destination. The strategic placement of the destination room sign within their field of view facilitated this intuitive discovery

Route 6

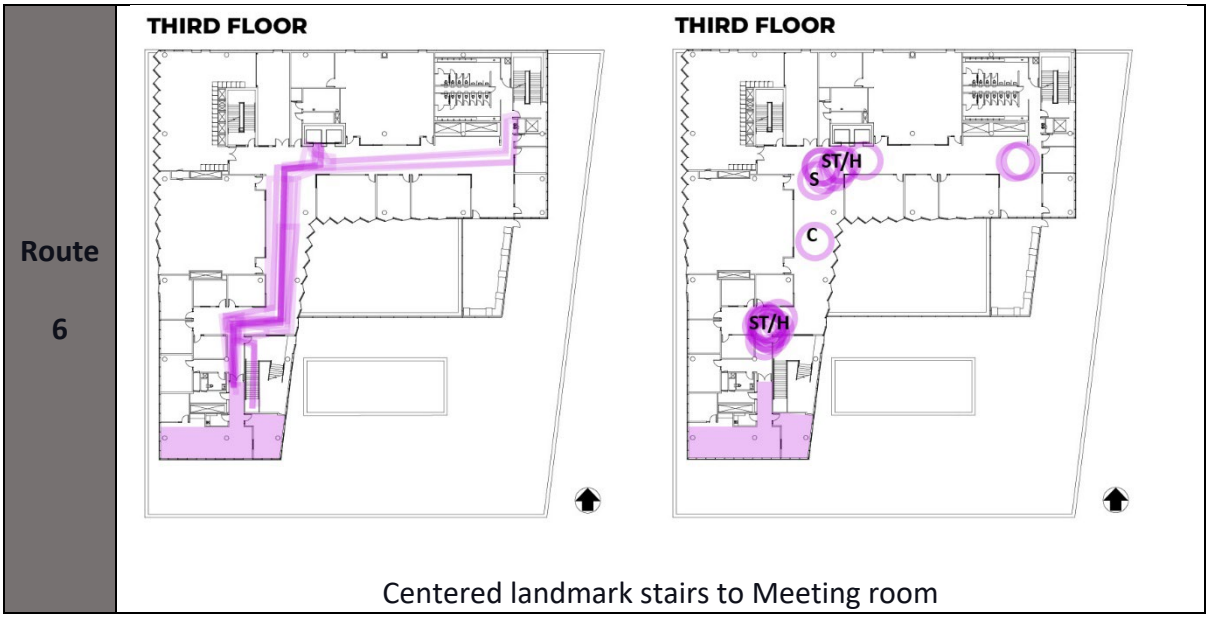


Figure 24 Behavior Observation in Route 6

Route 6 featured diverse wayfinding systems, containing different types of signs and interior features to guide participants through the space. Positioned at the centered stairs, participants could evaluate the advantages of their chosen routes. Some opted to traverse from

the center to the side stairs, while others chose to use the elevators right from the starting point. When utilizing two distinct staircases, the large central staircase, and the side staircase, participants relied on room and directory signs as the primary visual cues guiding them to their destination.

In the illustration on the right (Figure 24), the ST/H at the bottom featured a directory sign on the wall alongside room signs, providing visible cues to help participants orient themselves. However, participants suggested that additional support, such as arrows, could enhance the clarity of the information conveyed by these cues. Some participants discovered the destination by scanning both sides, while others explored the hallway to locate it.

In cases where elevators were used, participants identified hanging directory signs visible from the ST/H point in the right figure. Additionally, they used the evacuation plan posted next to the elevator for additional guidance. Armed with this information, they descended the corridor and actively sought out the destination, demonstrating the adaptability of participants in leveraging different wayfinding elements to navigate Route 6.

Participant Interview

The number of participants in the study was twelve, eight women and four men, and the average age was 29.4 years. Five were familiar with the building environment; they had regular classes and meetings there, and two students said they only visited and stayed on the specific floor and specific seating areas for purposes. Lastly, the rest said they had few visits or had never experienced it.

First Features Helps Find Their Ways

Over half of the participants reported that wayfinding signs helped navigate the built environment. The signs included room signs displaying numbers and names, directory maps located near entrances, evacuation plans near elevators, and directory signs hanging from the ceiling in the given environments. Regarding room signs, participants found that the numbering provided helpful cues for navigation. However, some participants encountered difficulty when the name on the room sign needed to match the information on the directory sign located on the first floor. Participants also noted that they attempted to locate and read the room signs to determine their location or floor level. In the case of the floor plans displayed on the directory signs, five participants found them easy to recognize and were able to determine their location, room number, or name. Two participants reported that they found the evacuation plans effective because they knew how to read them.

Wayfinding Experience

Over half of the participants reported feeling confused, frustrated, and lost while attempting the wayfinding activities in the given routes. Although the wayfinding systems in the routes did aid them in finding their way, participants expressed the desire for more effective systems to be implemented. Among the participants who provided feedback on their satisfaction with the wayfinding systems in the building, responses were moderate, with many indicating that the numbering and room signs were helpful. However, they also indicated room signs for improvement in the system.

Additionally, few participants expressed positive reactions to the built environment. One participant reported enjoying traveling to the new building and said, "I like to experience the environment because I am very bad at wayfinding." Another stated that it was "good" despite experiencing difficulties navigating space. The participant considered the experience could have been clearer, but it did not mean that it was a bad experience for the participant. Several participants said that “I would like to take elevators; I think it’s easy” while the observation tasks. Otherwise, some participants said that “I know there is an elevator, but I want to walk along with this stair.” During the tasks, the preferences were observed when doing between route 3 to 5 by participants.

Most and Least Helpful Features

Based on interviews with twelve participants, signs were the most helpful factor for wayfinding in the building. Seven out of twelve participants reported that room signs, particularly those displaying the room numbers, were useful. The directory signs on the first floor were also beneficial, as they provided a comprehensive overview of the floor plan, including evacuation plans. One participant cited the lighting on the first floor, which served as a landmark, as helpful for navigation. Another participant attributed their success in wayfinding to their memory, coupled with the use of signs. Conversely, four participants found the furniture to be the least helpful in their navigation, citing its similar appearance and placement as a factor. They noted that even if the furniture were placed in the hallway, it would not significantly impact wayfinding unless placed in the middle of the corridor. Additionally, five participants reported that artificial lighting did not significantly affect their navigation, as the brightness was even, and they did not have to pay attention to it.

Perception of Visual Cues in Five Scales

Visual Cues	Lighting		Landmarks		Furniture		Signages	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Route 1	2	1.35	1.33	0.65	1.25	0.87	3.08	1.73
Route 2	2.17	1.53	3.5	1.57	2.67	1.56	3.92	1.38
Route 3	2.58	1.62	3.58	1.68	2.5	1.93	4	1.54
Route 4	2.25	1.42	2.42	1.62	2.25	1.42	4.75	0.87
Route 5	2.5	1.45	3.17	1.64	2.17	1.80	4.42	1.08
Route 6	2.25	1.36	2.17	1.40	1.75	1.36	4.17	1.03

Figure 25 Self-Checklists in Scales

Participants rated how various factors within the building environment affected their wayfinding experience to find their way alone. The degree to which participants were affected varied, with some factors having a more significant impact on certain individuals. For instance, 11 out of 12 participants marked signs in Route 4 as the most impactful factor when finding their way. While one participant was not affected by signs as they could find their destination without relying on them. Similarly, 11 out of 12 participants rated furniture in Route 1 as not impactful on their ability to reach their destination. However, two participants addressed the furniture as a significant obstacle to determining that they found the destination because placing the multiple pieces of furniture in the destination interrupted to give an idea of the name of the destination, the open exhibition area. Regarding the overall results from the self-checklists, the average sign rating was higher than other visual cues. Even in Route 1, where the mean rating for signs was the lowest, it was still above the overall mean, indicating that the

signage system was effective for pedestrian wayfinding. Conversely, the mean lighting and furniture ratings were lower than those for the other cues.

Summary

Behavior Observation

The study involved participants completing six different routes in a building, with researchers observing their wayfinding strategies. Route 1 was found to be the most confusing, despite having enough visual cues. Route 2 involved different levels and required clarification for some participants on how to find the destination. Route 3 required taking elevators to reach the destination, and participants focused on sound and smell while observing the space. Route 4 had two landmarks that grabbed participants' attention to make them check and observe the area, and the spatial layout and the performance of the visual cues worked well. Route 5 had largely centered stairs and glass walls as landmarks, but the hanging directory signs had poor visibility on the floor because of its color combination and the light reflection. Route 6 had various wayfinding systems, with room and directory signs as the main cues. Overall, the study found that participants heavily relied on signage as a wayfinding system, but improvements could be made in visibility and clarity.

Lighting

The lighting systems in the building functioned effectively and utilized daylight to its fullest potential. Except for controlling the backlight from the window, the artificial and natural lighting systems performed applicably. The investigated building design aimed to connect the interior and exterior spaces seamlessly. Additionally, it features linear and circular downlights, with the lighting above the stairs leading to the ground floor as a prominent landmark due to its

scale and number of lights. Few participants reported that the lighting feature as the purpose of landmark drew their attention to the surrounding environment. Throughout the building, the monotonous linear pendant lighting installation performed the adequate brightness to facilitate enough visibility regarding wayfinding. The study sought to investigate whether the lighting could function as a wayfinding system in indoor environments, but the participants did not perceive it as such. Most participants did not experience any interference with their navigation and found that the lighting had minimal impact on their ability to navigate the building.

Landmarks

The building's landmarks created a sense of purpose and direction for participants. One of the most recognizable landmarks was the courtyard, which participants used as a reference point to identify their destination. While slight variations existed between the directory maps and the self-checklists, participants could easily locate the courtyard. The building's most prominent feature drew people towards it, and many participants used the stairs to navigate different areas of the building. In contrast, the interior design elements received less attention from participants as landmarks. While they served as visual cues, they were less significant than the architectural elements, such as staircases, courtyards, and large-scale lighting, in helping participants navigate the building.

Furniture

The furniture did not significantly impact participants' perception of wayfinding within the building. As a visual cue, participants found it challenging to use the furniture to navigate to

their intended destinations, as much of it appeared similar. A few participants suggested that furniture placement in the middle of hallways might be helpful for wayfinding purposes.

Signs

The building in the study featured an easily understandable wayfinding system. Participants could recognize room numbers and names when searching for specific locations, as they were clearly labeled and situated next to the corresponding doors. At intersections where participants needed to make decisions, signage was present to guide them toward their destination. However, some participants noted that the visibility and height of these hanging signs could have been improved, especially in terms of brightness and color contrast. The directory signs, which displayed the building's floor plans, were located near both entrances, making them accessible to many participants seeking orientation. There were some discrepancies between the self-checklists and signs and unexpected points on the map, which made it challenging to match the destination with the appropriate name. Furthermore, since the study relied on information on the university's website, some real names on the map signs differed from what participants expected.

CHAPTER 5. DISCUSSION

This study explored how people use cognitive heuristics when traveling from one location to another within a mixed-use academic building. Through the site analysis and observations of wayfinding behaviors, the study also identified how people prioritize environmental cues and spatial elements to make decisions for their wayfinding. This section presents the synthesized results of wayfinding behaviors in this study to visually capture the prioritized information that the participants used for their wayfinding decision-making. Then, the second part proposed the revised framework of decision-making processes for wayfinding in interior environments, focusing on goal- and experience-oriented navigations. Finally, the revised visual cues and spatial elements are explored to support better navigation experiences with design implications. As wayfinding can be goal- and experience-oriented, this study proposed design strategies to improve effective wayfinding or enjoyable wandering experiences. These considerations can be integrated into the interior design process from the early stage to support building occupants' positive emotions, safety, and well-being.

Synthesized Results – A Visual Representation of Preferential Information

Cognitive or navigation heuristics are utilized for simple decision-making or problem-solving while finding the destination within the buildings. Heuristics only sometimes lead pedestrians to their desired paths because guiding them toward their destination depends on individual differences, goals, visual information, and spatial elements. To find the destination, pedestrians may choose simple and easy-understanding information by their needs. Therefore, heuristics would bring trials and errors regarding individual memory and experience.

Route Analysis

During observation tasks, some participants prioritized reaching their destination quickly, actively seeking signages or directories to save time. Confusion occurred when the provided cues did not align with their expectations, and participants blamed themselves or expressed frustration. Conversely, others with limited building experience embraced the opportunity to explore, accepting occasional disorientation as part of the journey. Despite encountering challenges, such as room signs or closed areas not leading them to their destination, some participants persisted in exploring.

When participants sought efficiency, they diligently tried to find visual cues. The decision-making process for route choice must consider the interior wayfinding preferences, similar to wayfinding design strategies. The research identified two predominant wayfinding experiences among participants through behavior tracking, self-checklists, and interviews: 1) Goal-oriented and 2) Experience-oriented navigation. Goal-oriented users seek information about destinations, whereas experience-oriented users spend more time exploring the surroundings. The following overview of the route analysis includes the researcher's observation of these different approaches to wayfinding. Based on this analysis, navigation heuristic principles for interior environments are discussed in Chapter: Navigation Heuristic Principles for Interiors.

In Route 1A (Figure 26), participants applied planning heuristics, aiming for the shortest and fastest route. However, despite their knowledge that the destination should be open, various conditions in the built environment led some participants to inadvertently travel to the other side. In Route 1B, strong visual cues, primarily landmarks (centered stairs) and landmark

lighting, guided pedestrians effectively, even if the path required a detour. The central area with these strong landmarks remained unaffected by the decision-making process due to the consistent application of wayfinding design strategies.

Route 2 (Figure 27) demonstrated that hanging signs at the ST/H point were more effective than other routes. Conversely, in Route 4 (Figure 29), a dimly connected sign to glass walls and doors posed challenges in finding the destination without visual cues. However, room signs in Route 4 proved effective in guiding participants continuously. Routes 2 and 4 provided an easy path for exploration, leading some participants to choose these routes without frequent reference to signages.

In Route 5 (Figure 30), landmark lighting drew attention but sometimes diverted participants from finding their destination as they focused on other elements. Route 6 (Figure 31) showcased that furniture and interior features expanded participants' perspectives along the corridor. Many chose the centered stairs due to their familiarity, while those opting for elevators enjoyed diverse views provided by zigzag-shaped windows and different types of furniture.

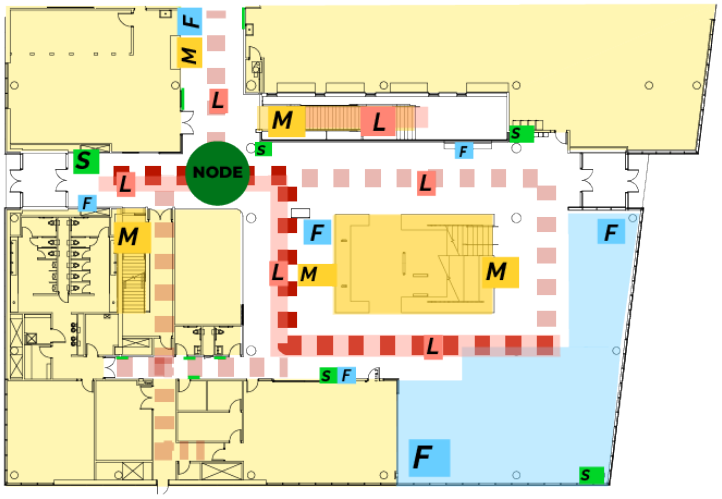
Revised Visual Cues and Adapted Five Elements for Interiors

This chapter discussed how the revised visual cues and adapted five elements for interiors could contribute to the quality of the wayfinding experience by considering the navigation heuristics. The visual cues to assist the wayfinding performance in the built environment could work with the interior spatial design strategies for the way-finders (occupants and visitors).

ROUTE 1

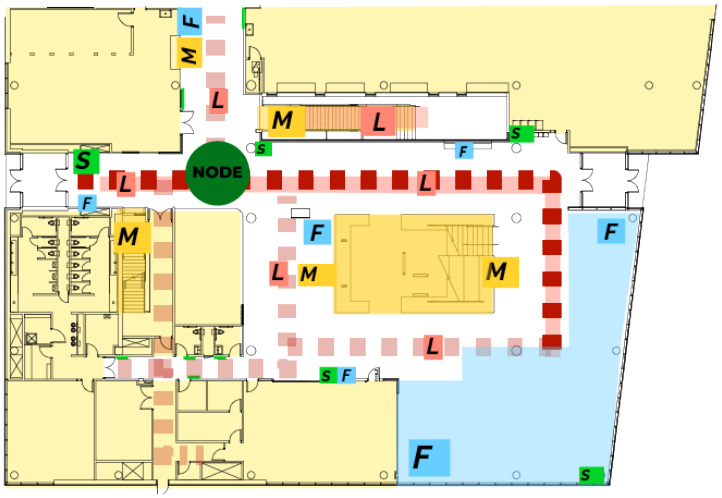
Heuristics

the shortest distance
the quickest path
the fine-to-coarse planning



ROUTE 1A

the least-decision-load
the least-angle
the action continuation
the initial segment
the central point



ROUTE 1B

Physical Elements

- Corridor, Circulation
- Walls & Partitions
- Rooms & Spaces
- Intersection
- Architectural & Interior Features

Environmental cues

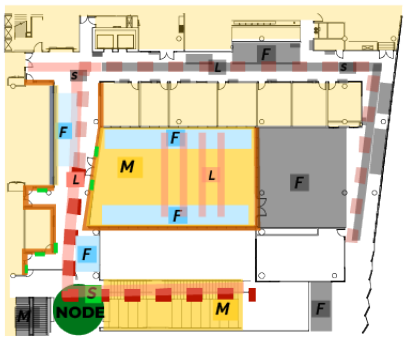
L	Lighting
M	Landmarks
F	Furniture
S	Signs

Figure 26 Route 1 Analysis

ROUTE 2

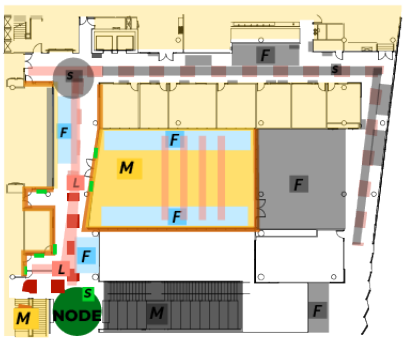
Heuristics

the least-decision-load
the least-angle
the action continuation
the initial segment
the central point



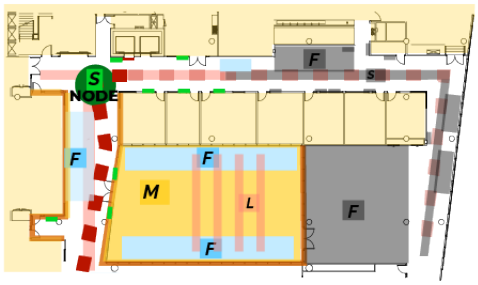
ROUTE 2A

the least-decision-load
the shortest distance
the quickest path



ROUTE 2B

the least-decision-load



ROUTE 2C

Physical Elements

- Corridor, Circulation
- Walls & Partitions
- Rooms & Spaces
- Intersection
- Architectural & Interior Features

Environmental cues

L	Lighting
M	Landmarks
F	Furniture
S	Signs

Figure 27 Route 2 Analysis

ROUTE 3

Heuristics

the least-decision-load
the least-angle
the quickest path
the initial segment
the fine-to-coarse planning

ROUTE 3A

the least-decision-load
the shortest distance
the fine-to-coarse planning

ROUTE 3B

the least-decision-load
the central point

ROUTE 3C

Physical Elements

- Corridor, Circulation
- Walls & Partitions
- Rooms & Spaces
- Intersection
- Architectural & Interior Features

Environmental cues

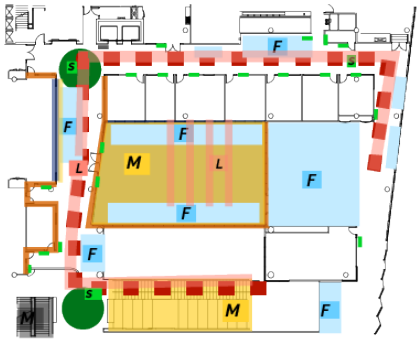
L	Lighting
M	Landmarks
F	Furniture
S	Signs

Figure 28 Route 3 Analysis

ROUTE 4

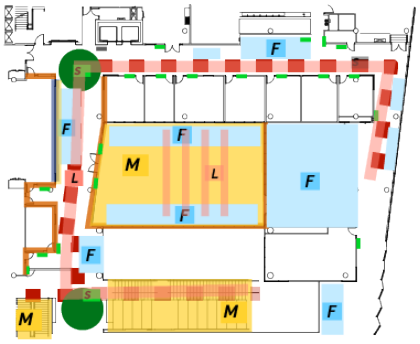
Heuristics

the least-decision-load
the central point



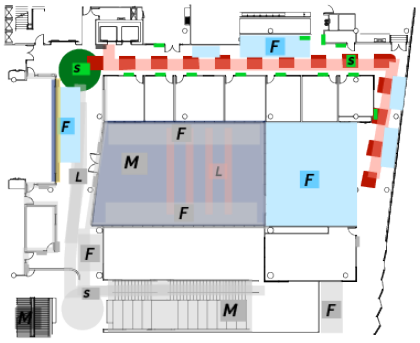
ROUTE 4A

the fine-to-coarse planning



ROUTE 4B

the shortest distance
the quickest path
the action continuation
the initial segment



ROUTE 4C

Physical Elements

- Corridor, Circulation
- Walls & Partitions
- Rooms & Spaces
- Intersection
- Architectural & Interior Features

Environmental cues

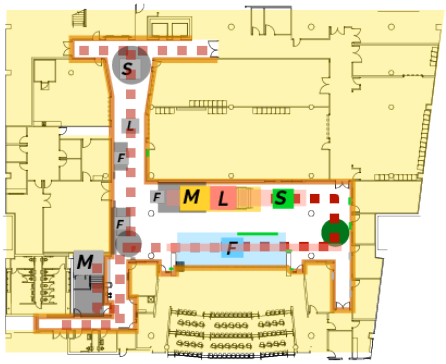
L	Lighting
M	Landmarks
F	Furniture
S	Signs

Figure 29 Route 4 Analysis

ROUTE 5

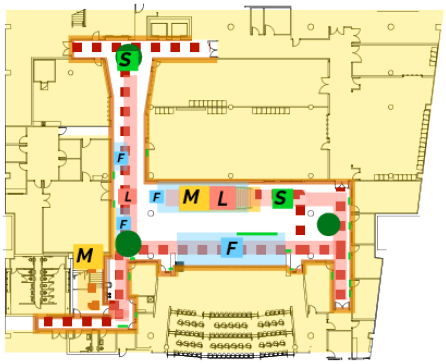
Heuristics

the least-decision-load
the least-angle
the quickest path
the initial segment
the fine-to-coarse planning



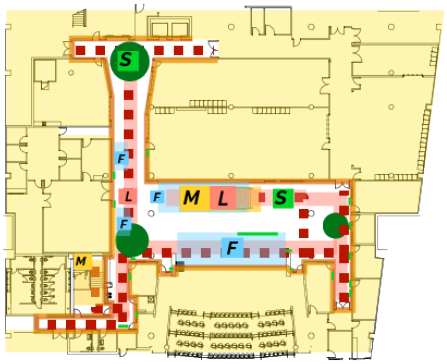
ROUTE 5A

the least-decision-load
the shortest distance
the fine-to-coarse planning



ROUTE 5B

the least-decision-load
the central point



ROUTE 5C

Physical Elements

- Corridor, Circulation
- Walls & Partitions
- Rooms & Spaces
- Intersection
- Architectural & Interior Features

Environmental cues

L	Lighting
M	Landmarks
F	Furniture
S	Signs

Figure 30 Route 5 Analysis

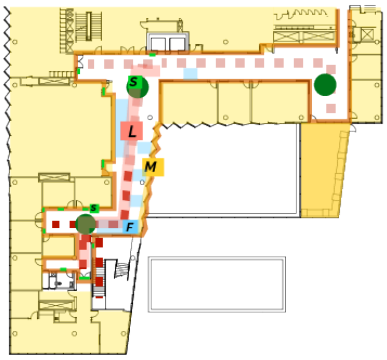
ROUTE 6

Heuristics

the least-decision-load
the least-angle
the shortest distance
the quickest path
the initial segment
the central point

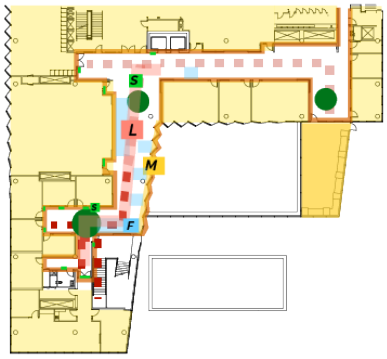
the action continuation
the fine-to-coarse planning

ROUTE 6A



ROUTE 6B

the fine-to-coarse planning



ROUTE 6C

Physical Elements

- Corridor, Circulation
- Walls & Partitions
- Rooms & Spaces
- Intersection
- Architectural & Interior Features

Environmental cues

L	Lighting
M	Landmarks
F	Furniture
S	Signs

Figure 31 Route 6 Analysis

Suggested insights for visual cues could aid in solving wayfinding problems, such as lighting reflection, changeable landmark location, and the lack of a dynamic way for visual cues to guide pedestrians in developing spatial identity and functionality. Additionally, it discussed the adaptation of five spatial elements for interiors that could be designed in the early design stage to support the revised visual cues' roles. The adapted five elements could serve the various navigation behaviors for goal-oriented and experiential approaches.

Pathfinding

The study on pathfinding in this research context involves presenting a navigation system, offering clear visibility and direction to facilitate goal-oriented and experience-oriented navigation heuristics. Initially rooted in aiding wayfinding through lighting, the revised visual cues signify a transformation in how lighting is conceptualized and employed to guide pedestrians effectively. The shift in focus emerged from the need to address pedestrians' diverse needs and preferences and enhance overall navigation experiences.

The background for creating these cues lies in exploring how lighting impacts pedestrians during wayfinding. The study revealed the importance of balancing lighting continuity for visibility during the day while avoiding overwhelming or distracting brightness. The revised cues were developed to cater to the dual needs of providing clear visibility and enhancing the overall experience for pedestrians. Diverse placement and style choices for lighting were integrated, allowing variations catering to experience-oriented users' preferences. Interior designers are encouraged to explore different lighting types, such as LED strips, tracks, and accent lights, to create a dynamic atmosphere.

The effects of these revised visual cues are varied. Pedestrians may have the opportunity to encounter a variety of lighting styles, adding an aesthetic dimension to their journey. The cues enable designers to play with different lighting elements, enhancing the overall ambiance of the space. Additionally, the revised cues contribute to a sense of direction, with the lighting serving as a functional and aesthetically pleasing guide for pedestrians. By renaming the lighting based on its function of providing a sense of direction, the cues become an integral part of the environmental design, influencing how individuals perceive and interact with their surroundings.

In a related context, lighting has been identified as a crucial element in shaping spatial experiences and providing direction and orientation. Its consistent brightness, intensity, and visibility aid wayfinding, encouraging people to walk on the path and reach their destination. Lighting installations in study routes attract visitors and guide them through space. Vilar et al. (2013) highlight the importance of lighting in enhancing wayfinding by drawing attention to specific areas and artworks.

The field of interior lighting design has evolved to offer a wide array of fixtures and technological advancements. Lighting solutions can be customized to suit different shapes, lighting levels, and focal points, providing designers with tools to emphasize elements or help people navigate. Linear lighting, for example, offers flexibility in directing light precisely where needed. Track lighting and LED strips are versatile to meet unique space requirements and preferences and are available in various styles, sizes, and finishes.

Design anchor

As visual cues, landmarks in the built environment were reevaluated in recent observations, considering them as planned architectural and interior features. Various features of different shapes, sizes, and dimensions have been placed in specific locations, such as corridors, seating areas, open spaces, or intersections, to improve memorability and functionality for pedestrians during wayfinding. The study found that fixed forms of landmarks, as opposed to movable objects, were more effective in guiding people and defining the space repeatedly throughout the floors.

The updated concept of landmarks serves as a design anchor, shaping strategies that capture the functionality and identity of space, resulting in better recall. Spatial information is better retained when linked to fixed cues, like full windows, colored walls, standing structures, and centered stairs or lighting, rather than movable sculptures. The research emphasized the importance of optimizing space utilization for wayfinding and enhancing the effectiveness of non-stationary design anchors.

During the schematic design stage of interior design and architecture, the study recommended including design anchors to provide a unique identity and aid in wayfinding. Rather than solely emphasizing objects, the focus should be on spatial design strategies that improve navigability and memorability. For instance, the courtyard in Route 2 utilized open visibility to connect the interior and exterior, establishing itself as a landmark alongside centered stairs. Movable environmental cues could be strategically placed or combined with other cues, such as lighting or objects, to enhance their visibility and effectiveness.

In conclusion, using design anchors as a spatial design strategy for wayfinding could enhance the overall user experience and facilitate navigation. Designers could create more navigable and memorable spaces by including unique and distinctive spatial design elements. The study underscored the importance of enhancing design anchors and suggested that designers consider these elements during the schematic design phase of interior design or architecture.

Spatial objects

According to Mustikawati et al. (2018), furniture is considered a crucial component of spatial elements that shape path design environments. Spatial objects, including informational signs, human-scale landmarks, and wall-mounted interior features, are also identified as aids in wayfinding, contributing to the remembrance of space. However, participant feedback on these spatial objects and furniture indicated their insignificance as cues for finding destinations. Despite this, interior designers must continue to acknowledge their roles in spaces and areas as they provide a sense of identification to pedestrians.

The creation of revised visual cues addresses this challenge. These cues redefine the role of spatial objects and furniture to influence wayfinding effectively. Designers can utilize strategies such as material contrast or size differences to make objects and spaces stand out, encouraging exploration of the area. Environmental forms, such as scenic images and buildings, are also highlighted as contributors to orientation and wayfinding (Abu-Obeid, 1998).

The background for creating these revised cues stems from the understanding that objects in interior environments serve diverse roles, including occupational, placement, display, and stylistic functions. These objects help define a space's function by establishing a visual hierarchy that guides individuals using the room or place. For example, seating arrangements,

televisions, or wall-mounted screens create gathering areas for socializing or advertising. Objects also contribute to aesthetics by introducing visual interest, texture, and color, enhancing the overall appeal of a space. They can strategically draw spatial attention or add depth and dimension to specific areas, such as the end of a corridor or a crowded wall.

Furthermore, objects provide practical convenience in indoor spaces, with elements like furniture, blinds, rugs, or lighting fixtures regulating temperature and light levels. Ultimately, objects contribute to the style of indoor environments, expressing characteristics and identity. The revised visual cues aim to integrate these functions cohesively, creating a functional and aesthetically pleasing space that aligns with the needs and desires of its occupants (Mustikawati et al., 2018).

HERE

In a study conducted by Hölscher et al. (2009), the role of signage in effective wayfinding systems was underscored. Participants heavily relied on room and directional signs, often accompanied by floor plans, during observation tasks to navigate through spaces. Despite their simple design, these signs utilized color, contrast, and fonts to convey concise information within designated sizes. However, issues arose concerning the placement of signs, as the given environment did not consider factors like backlighting and light reflections. Directional signs, placed at considerable heights at decision points, often went unnoticed by participants. The diverse nature of signage, whether attached to walls, placed on the floor, or suspended from ceilings, posed visibility challenges for pedestrians moving through these spaces.

The creation of revised visual cues responds to these challenges by considering the utilization of three surfaces—walls, floors, and ceilings—allowing interior designers to adapt

sign systems that complement the spatial aspects of the environment. For instance, kinetic interiors that change position or form based on occupants' behaviors or specific times of the day could provide dynamic wayfinding guides and strong visual interest.

Clear signage recognition became essential at turning or decision points in corridors, where people seek spatial information to proceed. Effective signage aided wayfinding, enhancing path and corridor functionality and visual appeal (Hölscher et al., 2009). For example, projecting navigation mapping onto walls or floors with directional arrows or partial maps could provide real-time wayfinding instructions that adapt to pedestrians' positions and destinations.

Visual cues, encompassing lighting, spatial objects, environmental forms, and signage placement, were crucial in effective wayfinding in the broader context (Gärling et al., 1986; Butler et al., 1993). This study advocates expanding the role of signs beyond mere cues, transforming them into spatial guidance elements that navigate indoor spaces according to individuals' preferences and needs. For instance, variations in textures and materials could complement interiors by adding a tactile and visually appealing dimension to wayfinding.

In these insights, "HERE" emerges as a potential reimagining of traditional signage in interior design, emphasizing the importance of these elements in providing guidance, wayfinding assistance, and navigation cues within interior spaces. The term "HERE" compacts a broader range of solutions beyond conventional signs, containing various design features and techniques to direct people through complex environments while seamlessly integrating with the interior design aesthetic.

The effects of these revised visual cues are evident in their ability to address visibility challenges, enhance wayfinding experiences, and contribute to the functionality and visual appeal of paths and corridors. By transforming signage into dynamic, adaptable spatial guidance elements, the cues go beyond traditional roles, providing real-time instructions and adding aesthetic value to indoor spaces. The "HERE" concept represents a paradigm shift in interior design, acknowledging the multifaceted nature of visual cues in facilitating navigation and creating cohesive, user-friendly environments.

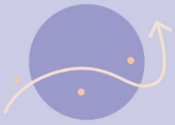
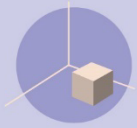
PATHFINDING 	**Consistent and Adaptable Lighting:** Ensure consistent brightness, intensity, and lighting visibility throughout the space to guide wayfinding. Use technology to provide adaptable lighting solutions, such as track lighting or LED strips, to direct light where needed. **Balance Natural and Artificial Lighting:** Consider the interplay between natural and artificial lighting. Adjust artificial lighting to maintain visibility, especially when competing with natural light sources. **Strategic Sign Placement:** Ensure that directory signs do not obstruct the visibility of lighting fixtures. Adjust sign placement to maximize clarity while preserving the aesthetics of the space. **Spatial Experience Enhancement:** Recognize that lighting not only aids wayfinding but also shapes the spatial experience. Embrace lighting as a tool for enhancing the environment's overall ambiance and aesthetic appeal.
DESIGN ANCHOR 	**Spatial Identity and Memorability:** Design anchors should provide a unique identity to locations. Ensure that design anchors are memorable and easily recognizable for users to orient themselves effectively. **Strategic Placement:** Consider the placement of design anchors to guide user positioning. Designers should think about the consistent placement of these anchors to improve wayfinding. **Schematic Design Integration:** Incorporate design anchors during the schematic design stage of interior design and architecture to ensure effective wayfinding utilization.
SPATIAL OBJECTS 	**Role of Spatial Objects:** Recognize that spatial objects, including furniture, signs, landmarks, and interior features, play different roles in wayfinding, aesthetics, function, and style. **Color Contrast and Size Difference:** Use color contrast and size differences to make objects stand out and encourage exploration. This aids in spatial identification and memorability. **Aesthetic Enhancement:** Understand that objects serve functional roles and enhance the space's aesthetics. Incorporate objects that add visual interest, texture, color, and depth to the environment.
HERE 	**Signage Placement:** Consider the placement of signs carefully to ensure visibility, especially at turning points or decision points in corridors. **Dynamic Signage:** Explore the use of dynamic signage systems that adapt to the positions and preferences of pedestrians. This can improve real-time wayfinding instructions. **Expanding the Role of Signs:** Transform traditional signs into spatial guidance elements. Incorporate textures, materials, and visual elements that enhance the wayfinding experience. **Kinetic Interiors:** Explore the concept of kinetic interiors that change based on occupant behavior or specific times of the day to provide dynamic wayfinding guidance.

Figure 32 Revised Visual Cues Guidelines

Adapted Five Elements

Spatial design and the arrangement of visual cues could facilitate both goal-oriented and experience-oriented navigation in the early design stages. Designers can integrate navigation heuristics into their design process by combining path design strategies with considerations for identity and function, ensuring clear sight lines for corridors, and incorporating distinctive landmarks.

Goal-oriented navigation involves creating a clear and efficient path for individuals to reach their destination quickly. In addition to goal-oriented navigation, designers should also focus on experience-oriented navigation by considering the spatial configuration to enhance the legibility of the space. This involves guiding pedestrians and creating a sense of progress towards their destination. To enrich the wayfinding experience, designers can integrate mixed-use elements like seating areas, retail spaces, and gathering spaces, providing an engaging environment for individuals to enjoy as they navigate the space.

The study emphasizes the importance of visual cues in helping pedestrians navigate interior spaces. However, it emphasizes the need to tailor these cues to the indoor environment to enhance functionality. Spatial design for wayfinding should be carefully considered and developed to minimize confusion and deliver concise information to users.

When defining spatial elements in a mixed-use academic building, it is crucial to acknowledge different areas' diverse functions and identities. This is especially relevant when combining visual cues for wayfinding. Such buildings serve various purposes, including teaching, learning, research, social interactions, and administrative functions. Referring to Lynch's

Principles in Interior Environments, the spatial elements encompass rooms and spaces dedicated to studying, meeting, making, gathering, and opening. Corridors and intersections connect these spaces and guide individuals through the building.

To effectively define spatial elements in a mixed-use academic building, designers should consider intersections, corridors, walls, rooms and spaces, and architectural or interior features. This comprehensive approach ensures that the design caters to both goal-oriented and experience-oriented navigation, offering a seamless and enjoyable wayfinding experience within the diverse functionalities of the building.

Table 4 Spatial Elements in Interiors

Corridor	Corridors are long, narrow passageways that connect various rooms, spaces, and intersections within the building. They facilitate movement and circulation throughout the structure.
Walls	Walls in an academic building define the boundaries of rooms and spaces. They can be structural or non-structural and may include doors and windows for access and natural light.
Room and space	These are functional areas within the building, each designed for a specific purpose. They include classrooms, laboratories, lecture halls, offices, libraries, restrooms, and other areas tailored to academic activities and administrative functions.
Intersection	An intersection is where two or more corridors or pathways meet. It often serves as a central point for navigation and may include signage or landmarks to aid wayfinding.

Table 4 Continued

Architectural and interior features	These elements encompass various design aspects that contribute to the building's aesthetics and functionality. They may include: **Ceilings:** The overhead surface with architectural details, lighting, and acoustic treatments. **Flooring:** The material covering the floor, which can vary by area, from carpet in offices to durable materials in high-traffic corridors. **Lighting:** Fixtures and natural light sources illuminate the interior spaces, providing visibility and ambiance. **Furniture:** Tables, chairs, desks, and other furnishings for functional and ergonomic purposes. **Architectural Details:** These encompass design elements like archways, columns, stairs, molding, and decorative finishes that enhance the building's aesthetics.

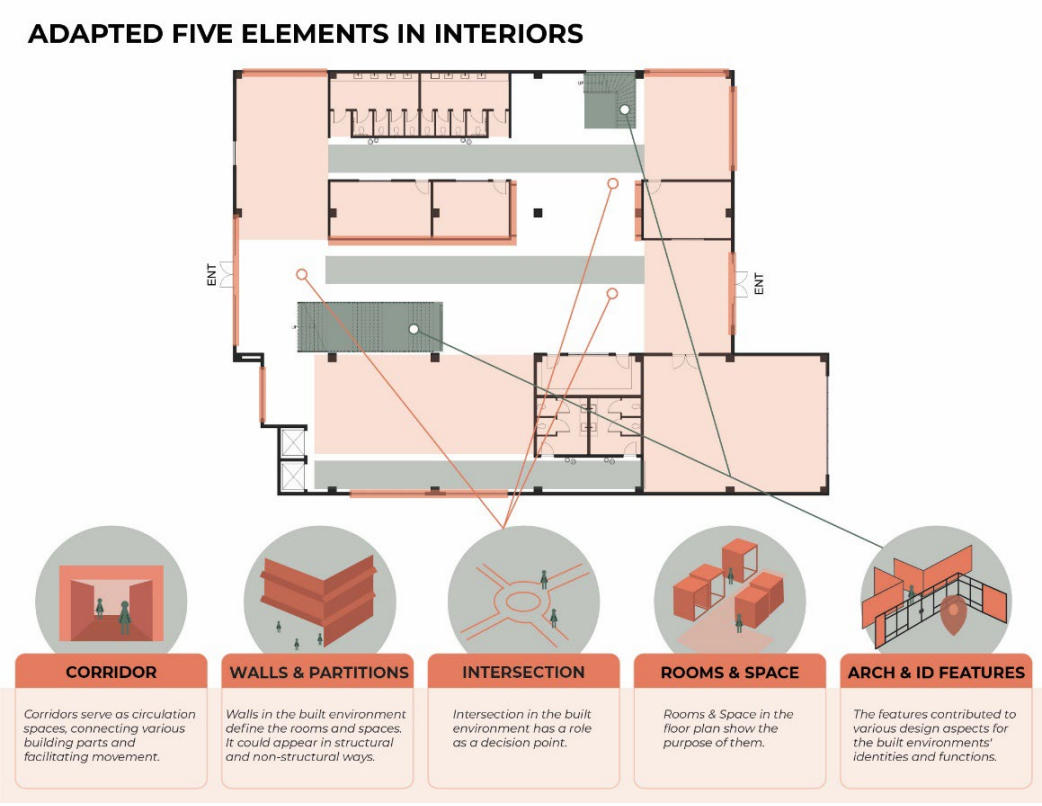


Figure 33 Adapted Five Elements in Interiors

Navigation Heuristic Principles for Interiors

Navigation heuristics are mental shortcuts that individuals use to navigate through an environment. These heuristics were influenced by the available information in the environment, including visual cues and spatial elements. Based on the framework of the principles from Tong and Bode (2022), the study brought us to understand the two types of navigation heuristics for people: goal-oriented and experience-oriented.

Goal-oriented navigation means where people focus more on finding the destination or finishing the goal than watching around to experience the built environment since people who want to solve the given tasks may feel stressed when the goal still needs to be fulfilled. In contrast, when considering the time visitors spent in the indoor environment, providing an interesting space design for them with experience-oriented navigation heuristics was significant. A visible or memorable design element could be considered for the built environment. The identified decision-making process for route choices in this study, based on Tong and Bode's (2022) framework with four stages, is shown in Figure 34.

In the perception stage of the decision-making process, the study adapted the cognitive considerations for goal- and experience-oriented users. When considering perception as the first sequence of finding the destination, pedestrians of both paths would focus on collecting information unconsciously and consciously. The goal-oriented users tend to inspect environmental cues more consciously than experience-oriented users.

In the integration stage, both users integrate the collected spatial information to develop a mental map of the environment to reach their destination efficiently or enjoyably. For goal-oriented users tend to establish their route planning to reach their destination, identify

the path or surrounding spatial information, and then minimize the cognitive load for decisions. Otherwise, the experience-oriented users may understand the space and discover the navigation flexibility.

In the decision-making mechanisms stage, individuals' path choices could rely on the spatial elements based on their purpose. For example, goal-oriented individuals might choose the shortest or most direct path to reach their destination quickly, while experience-oriented individuals might choose a path that provides a more interesting spatial experience. Also, goal-oriented individuals might want to search for easy-understanding environmental cues, while experience-oriented individuals would want to walk or travel and then identify the spatial information to experience and find the way.

In the final stage, individuals could show different heuristics based on their purpose and decisions in response to the information stage. Goal-oriented individuals might rely more heavily on visual cues such as signs and lighting, while experience-oriented individuals might use their previous knowledge of the environment to navigate and recognize landmarks and spatial elements, including objects.

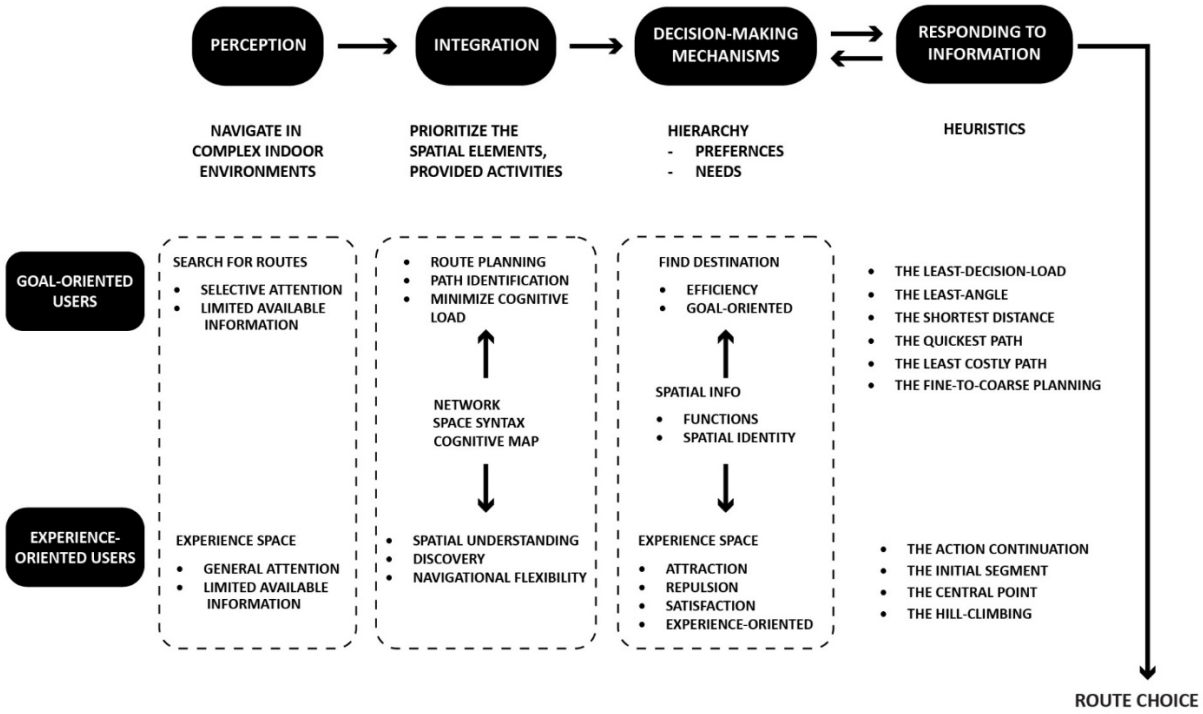


Figure 34 Decision-Making Process for Route Choice based on Tong and Bode (2022)

Table 5 Decision-Making Scenario Based on Tong and Bode (2022)

Stage	Strategy	Description
Perception	Perceive the open area by navigating in the built environments. *The structure and form of built environments affect navigation behavior.	G-O: Trying to perceive the space by their needs or goals. E-O: Choose random direction > path with clear segment or path with clutters segment. Path can be different width or length depending on the spatial elements. With limited information or knowledge, selecting a route that minimizes the risk of getting lost is important.

Table 5 Continued

Stage	Strategy	Description
Integration	Integrate the given information. (Route choice with the collected information or knowledge by pedestrians)	Prioritize the spatial elements and visual environmental cues in built environments. (Route choice with the familiarity, experience, or surroundings) 1. Access to open space with spatial elements and environmental cues (info desk, reception desk, waiting area, or seating area) 2. Goal with integrating information and goal with experiencing space can have different strategies based on the individuals have purposes or not. 3. Following the spatial elements or surrounding path area that individuals targeted to follow helps to be less risky to get lost. 4. Wandering the space for travel or experience the given environment to be familiar with it. Want to follow the noticeable in the area. Want to stay in the seating area. Want to take stairs. Want to turn around based on the landmark. Want to walk in the environment.

Table 5 Continued

Stage	Strategy	Description
Decision-making mechanism	Decide the route by the spatial, individual, environmental hierarchy by preferences and needs. *The spatial or environmental information at locations or areas that require navigators to make decisions.	1. Follow physical or spatial elements such as edge or landmark. Both can be the central or focal point to orient in the built environments or open areas. 2. With a target or purpose, they only need to decide on the direction that follow the path with spatial elements or not. 3. Individuals can choose the route that is easy to remember. Or route with familiarity in previous experience to avoid getting lost. Want to turn to the closet path. Want to orient later after this path. Want to buy something here and then go to the path. Want to sit here for a moment and choose the path. Want to see that in the center of the area.
Responding to information	Focus on individual decisions to decide the path. Route choices with knowledge or limited knowledge.	G-O: The least decision load The least angle The shortest The quickest The least costly The fine-to-coarse planning E-O: The action continuation The initial segment The central point The hill-climbing

Path selection heuristics could explain why people navigate space to meet personal goals or needs. People seeking to reach a destination quickly may choose the shortest or most familiar route, while those seeking efficiency may observe information near the destination relevant to environmental cues. Decision-making in the interior environment and following heuristics can be categorized as goal-oriented, focusing on figuring out the space to the destination, or spatial-oriented, focusing on people's experience in space.

Design Implications

Studying cognitive heuristics and wayfinding behavior in mixed-use buildings provides valuable insights for designing interior spaces that optimize the navigation experience. By analyzing participants' preferences for cognitive shortcuts and their interaction with environmental cues, this study presents significant design implications that can be integrated into the interior design process from its earliest stages. The goal is to support building occupants' emotions, safety, and well-being by enhancing their wayfinding experiences.

Navigating complex environments presents challenges that could be addressed through thoughtful path design strategies. The synthesis of findings from this study suggests valuable insights into how occupants prioritize wayfinding cues and how these preferences could inform the creation of paths that emphasize identity and functionality. By combining three guidelines for path design for goal-oriented and experience-oriented users, designers could cultivate navigation experiences seamlessly, blending spatial identity and efficient functionality.

Cognitive heuristics are important in occupants' decision-making during navigation. Designers should align path design strategies with these cognitive shortcuts to create an intuitive and efficient navigation experience. Recognize that occupants often seek simple and

easily understandable information. Thus, integrate clear suggested visual considerations at decision points to facilitate quick and confident choices.

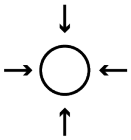
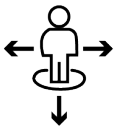
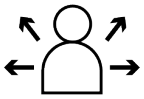
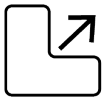
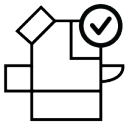
ACKNOWLEDGE GOAL- AND EXPERIENCE-ORIENTED NAVIGATION	PERCEPTION	INTEGRATION	DECISION-MAKING MECHANISMS	COGNITIVE LOAD CONSIDERATIONS	CUSTOMIZED WAYFINDING SOLUTIONS
Adapt wayfinding for goal and experience navigation. 	Design cues for conscious and subconscious information gathering by goal- and experience-oriented users. 	Aid mental mapping simplifies goal-oriented routes and fosters exploration for experience-oriented users. 	Offer diverse spaces: efficient paths for goal-oriented and immersive experiences for the experience-oriented. 	Cut cognitive load for goal-driven; promote exploration in experience-oriented users. 	Diverse heuristics: Goals drive visuals for G-O, while E-O relies on prior knowledge. 
PATH SELECTION HEURISTICS	**CATEGORIZE DECISION-MAKING**	**OPTIMIZE SPATIAL DESIGN**	**EMBRACE MIXED-USE ELEMENTS**	**VISUAL CUES IN CONTEXT**	**SPATIAL COFIGURATION AND LEGIBILITY**
Path choices match personal goals. Design for quick destination reach or immersive spatial experiences. 	Categorize interior decision-making as destination-focused (G-O) or experience-centric (spatial-oriented). 	Interior design optimization: enhance spatial layout, visual cues, and wayfinding efficiency. 	Designers integrate mixed-use areas for intuitive, engaging wayfinding, acting as user focal points. 	Essential visual cues must align with indoor space and its unique functions. 	Enhance space legibility through strategic configuration guiding pedestrians with a sense of progress toward their destination. 

Figure 35 Navigation Heuristic Principles for Interiors

Based on the findings, occupants rely on unique architectural features, design anchors, and spatial objects to aid navigation. Designers should strategically position these elements as functional cues and distinctive design statements.

Efficiency and aesthetic engagement are not mutually exclusive. Path design should balance providing direct routes for goal-oriented individuals and visually engaging pathways for those seeking experiential exploration. This duality can be achieved by designing clear sight lines, integrating interactive installations, and creating pathways harmonizing with the overall

spatial identity. Designers can transform the act of navigating into a journey of discovery, enhancing functionality and aesthetic appeal.

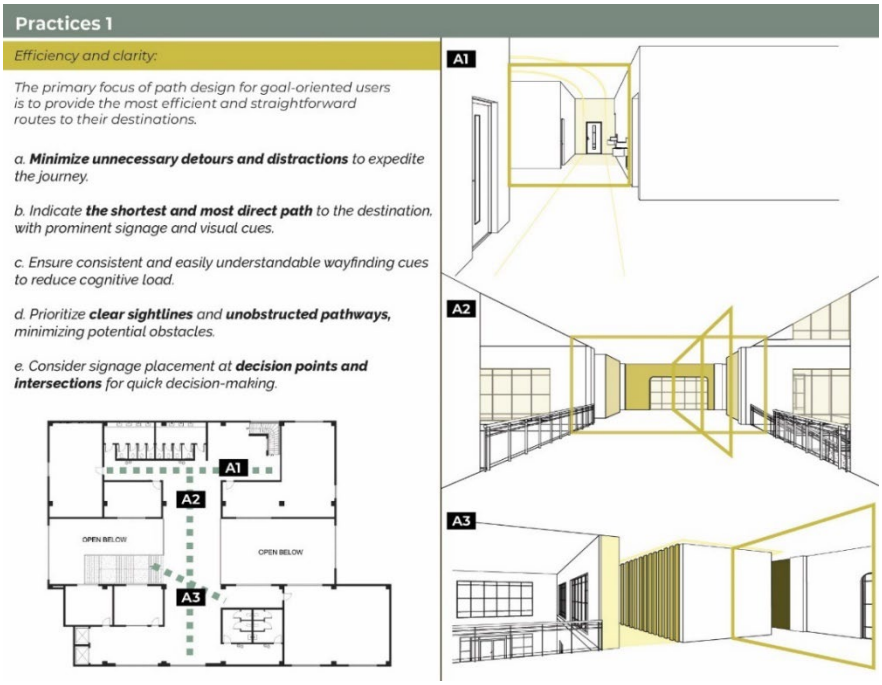


Figure 36 Practice 1

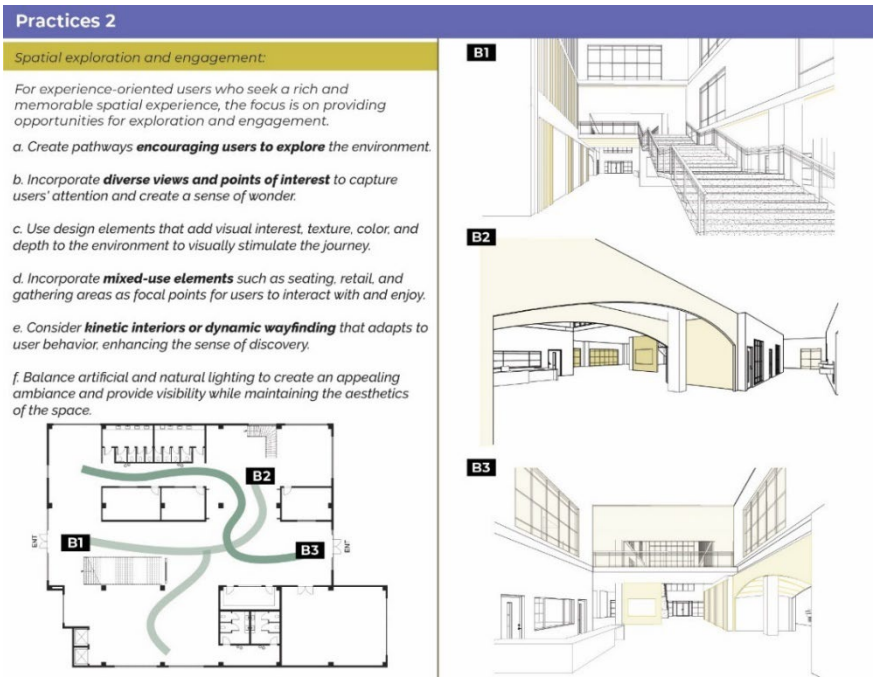


Figure 37 Practice 2

Limitations

Wayfinding is now a common topic in the area, but wayfinding in interior design areas is difficult to specify especially the wayfinding design systems. Only a few studies researched the interior design elements regarding wayfinding, although these features could assist and blend in the design process. Bringing the wayfinding design strategies into the design process did not seem like an interior designer's work because graphic design has worked in these areas for many years. However, considering effective wayfinding design in integrated design strategies is necessary to develop and decrease the problems from maximum to minor in the built environment.

The study did not consider individuals' wayfinding abilities, which is crucial for wayfinding system research. The sample size was small, with only twelve participants from different cultural backgrounds, the discussion may not be suitable for all users, particularly those with disabilities or diverse cultural backgrounds. For example, certain visual cues or design anchors may not be universally recognizable or accessible to individuals with visual impairments. In addition to the limitations mentioned earlier, it is important to note that the study's focus on goal-oriented and experience-oriented navigation may not apply to all individuals or cultures. While these heuristics are common, some individuals may use other decision-making processes to navigate complex environments.

Additionally, the study's suggestions for designing paths for goal-oriented and experience-oriented heuristics may only be effective for some users, especially those who do not fall into either category. It is essential to consider diverse user groups and their unique needs and preferences when designing wayfinding systems to ensure they are accessible and

effective for all. Furthermore, the study did not address the potential impact of technology on wayfinding, such as the use of digital maps or virtual reality. Therefore, designers must incorporate inclusive design principles and consult with diverse user groups to ensure the wayfinding system is accessible and effective for all users.

Future Studies

While the study highlights the importance of considering expanding the role of visual cues by combining them with spatial strategies, it needs to comprehensively compare and develop the simple role of cues in built environments. Future studies could systematically examine the impact of different visual cues on wayfinding performance and user experience. The study mentions that individual differences may influence the wayfinding process but does not explore this topic in depth. Future research could examine how age, gender, cultural background, and cognitive ability affect wayfinding behaviors and preferences. The study proposes two categories of heuristics, goal-oriented and experience-oriented, but other heuristics could be useful for wayfinding in complex environments. Future research could explore new heuristics and test their effectiveness in real-world settings.

Conclusions

In conclusion, the study of wayfinding in interior design originated from the researcher's firsthand experiences in complex environments. Recognizing the importance of ensuring high-quality indoor spaces for individuals engaged in various activities, including staying, gathering, or walking, became a critical perspective in interior design. Further studies led the researcher to examine the role of interior designers in enhancing the wayfinding process and improving overall user experience. While the wayfinding design system typically falls under the purview of

the graphic design department, it is imperative to acknowledge that the built environment is more than a canvas for visual aesthetics. It serves as an integral space that contributes to the well-being and safety of its occupants. Therefore, the focus of the study has been to scrutinize the quality of the wayfinding system within the realm of interior design.

Cognitive heuristics in navigation

Cognitive heuristics are crucial in navigation, representing mental shortcuts individuals use when moving through buildings. Two primary types are distinguished: goal-oriented, emphasizing reaching the destination quickly, and experience-oriented, focusing on enjoying the environment. Goal-oriented individuals rely on visual cues and opt for efficient routes, while experience-oriented ones appreciate distinctive design elements and prioritize spatial experiences. The decision-making process involves perception, integration, decision mechanisms, and a final stage, all shaped by an individual's navigation style. Paths are chosen based on personal goals, emphasizing efficiency or spatial experience.

The role of design strategies in interior wayfinding decision-making

Effective wayfinding within indoor spaces relies on visual cues and spatial elements. Lighting shapes experiences and guides paths, design anchors like centered stairs function as landmarks, and objects contribute to aesthetics and functionality. Innovative signage, conceptualized as HERE, transforms traditional signs into dynamic spatial guides. Interior designers should optimize these elements early in the design process to establish a clear and engaging pedestrian environment, considering factors such as identity, function, and mixed-use spaces.

Applying Navigation Heuristics in Design

To enhance navigation experiences in mixed-use buildings, interior designers can apply navigation heuristics by aligning design strategies with occupants' cognitive shortcuts. This involves providing clear visual cues at decision points, strategically placing unique design elements, and balancing efficiency with aesthetic engagement. The goal is to turn navigation into a journey of discovery, creating spaces that are functional and visually appealing for building occupants.

The goal is to identify opportunities for applying interior design features to enhance the overall wayfinding experience and contribute to advancing wayfinding design systems within the built environment. Through this exploration, the study seeks to bridge the gap between graphic design specialization and the broad spatial considerations essential to promoting effective wayfinding in diverse interior environments.

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APPENDIX A. IRB APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office of Research Ethics
Vice President for Research
2420 Lincoln Way, Suite 202
Ames, Iowa 50014
515 294-4566

Date: 02/03/2023

To: Eunjung Choi Jae-Hwa Lee

From: Office of Research Ethics

Title: How people navigate in interior environments: Behavior tracking of college students on campus

IRB ID: 23-036

Submission Type: Initial Submission **Exemption Date:** 02/03/2023

The project referenced above has been declared exempt from most requirements of the human subject protections regulations as described in 45 CFR 46.104 or 21 CFR 56.104 because it meets the following federal requirements for exemption:

2018 - 2 (ii): Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) when any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.
2018 - 3 (i.B): Research involving benign behavioral interventions in conjunction with the collection of information from an adult subject through verbal or written responses or audiovisual recording when the subject prospectively agrees to the intervention and information collection and any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation. - 3 (ii) If research involves deception, it is prospectively authorized by the subject.

The determination of exemption means that:

- **You do not need to submit an application for continuing review. Instead, you will receive a request for a brief status update every three years. The status update is intended to verify that the study is still ongoing.**
- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any *modifications to the research procedures* (e.g., method of data collection, nature or scope of information to be collected, nature or duration of behavioral interventions, use of deception, etc.), any change in *privacy or confidentiality protections*, modifications that result in the *inclusion of participants from vulnerable populations*, removing plans for informing participants about the study, any *change that may increase the risk or discomfort to participants, and/or* any change such

that the revised procedures do not fall into one or more of the regulatory exemption categories. The purpose of review is to determine if the project still meets the federal criteria for exemption.

- All ***changes to key personnel*** must receive prior approval.
- **Promptly inform the IRB of any addition of or change in federal funding for this study.** Approval of the protocol referenced above applies only to funding sources that are specifically identified in the corresponding IRB application.

  Detailed information about requirements for submitting modifications for exempt research can be found on our website. For modifications that require prior approval, an amendment to the most recent IRB application must be submitted in IRBManager. A determination of exemption or approval from the IRB must be granted before implementing the proposed changes.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Additionally:

- All research involving human participants must be submitted for IRB review. **Only the IRB or its designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.
- **Please inform the IRB if the Principal Investigator and/or Supervising Investigator end their role or involvement with the project** with sufficient time to allow an alternate PI/Supervising Investigator to assume oversight responsibility. Projects must have an eligible PI to remain open.
- **Immediately inform the IRB of** (1) **all serious and/or unexpected adverse experiences** involving risks to subjects or others; and (2) **any other unanticipated problems involving risks** to subjects or others.
- **Approval from other entities may also be needed**. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted**.
- Your research study may be subject to **post-approval monitoring by Iowa State University's Office of Research Ethics**. In some cases, it may also be subject to formal audit or inspection by federal agencies and study sponsors.
- Upon completion of the project, transfer of IRB oversight to another IRB, or departure of the PI and/or Supervising Investigator, please initiate a Project Closure in IRBManager to officially close the project. For information on instances when a study may be closed, please refer to the IRB Study Closure Policy.

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

APPENDIX B. TABULATED DATA

		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Mean	SD
Light	Route 1	1	2	5	1	3	1	1	2	4	2	1	1	2.00	1.35
	Route 2	1	5	2	1	5	1	1	1	3	2	1	3	2.17	1.53
	Route 3	1	5	4	5	3	1	1	1	4	2	3	1	2.58	1.62
	Route 4	1	4	2	1	1	2	4	1	4	1	3	1	2.08	1.31
	Route 5	2	5	5	3	3	1	2	1	3	1	3	1	2.50	1.45
	Route 6	2	5	4	3	1	1	3	1	3	2	1	1	2.25	1.36
Furniture	Route 1	1	1	4	1	1	1	1	1	1	1	1	1	1.25	0.87
	Route 2	4	5	5	1	4	2	2	1	1	3	3	1	2.67	1.53
	Route 3	1	5	4	5	3	1	1	1	4	2	3	1	2.58	1.62
	Route 4	1	4	2	1	1	2	4	1	4	1	3	1	2.08	1.31
	Route 5	2	5	5	3	3	1	2	1	3	1	3	1	2.50	1.45
	Route 6	2	5	4	3	1	1	3	1	3	2	1	1	2.25	1.36
Landmark (Interior Features)	Route 1	1	1	2	1	1	3	1	1	1	2	1	1	1.33	0.65
	Route 2	4	5	4	4	4	4	1	5	4	1	1	5	3.50	1.57
	Route 3	1	5	1	5	5	2	5	2	5	3	5	4	3.58	1.68
	Route 4	2	5	5	4	1	1	2	1	4	2	1	1	2.42	1.62
	Route 5	1	5	5	5	3	3	2	1	3	4	1	5	3.17	1.64
	Route 6	1	5	4	3	1	3	3	1	1	2	1	1	2.17	1.40
Signage	Route 1	1	1	3	1	1	5	5	5	3	4	3	5	3.08	1.73
	Route 2	5	5	5	3	4	5	3	4	2	1	5	5	3.92	1.38
	Route 3	5	5	5	5	1	5	4	5	4	3	5	1	4.00	1.54
	Route 4	5	5	5	5	5	5	2	5	5	5	5	5	4.75	0.87
	Route 5	5	5	5	3	5	5	3	5	5	2	5	5	4.42	1.08
	Route 6	5	4	5	5	5	4	2	5	3	4	3	5	4.17	1.03

APPENDIX C. SURVEY RESPONSES

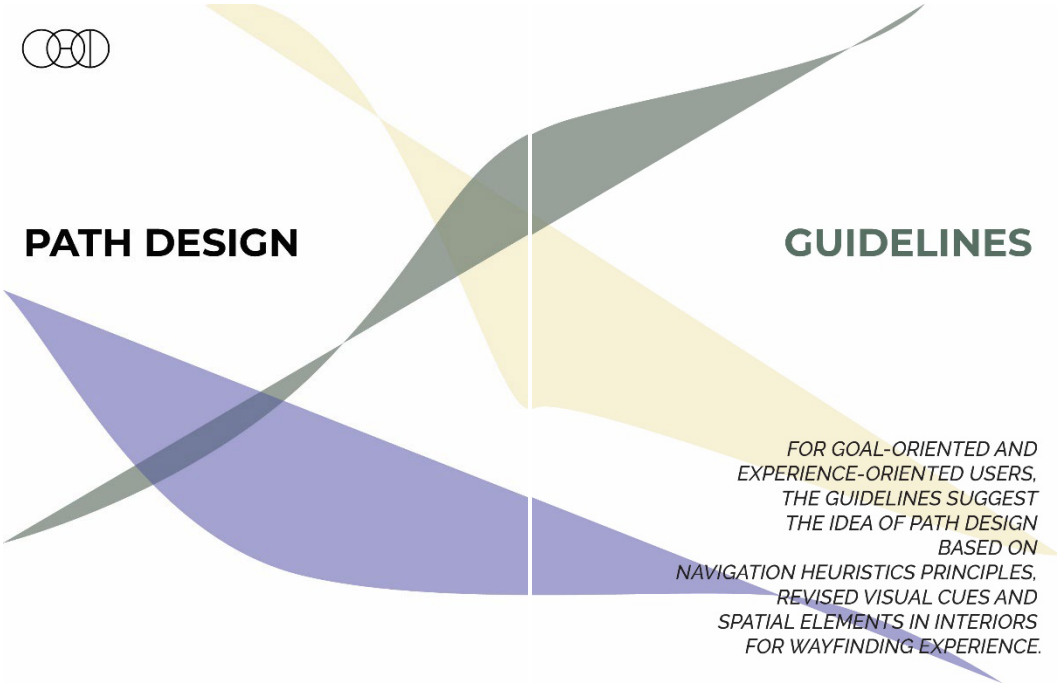
Questions	Answers
What features do you search for first finding your way?	P1: Room signage to see the name and number, directory map to see anything on the board. P2: Signs and floor plans. On my sight, signage was the first because the name (number of the destination) you gave me was the hint to see the signs. P3: Directory sign next to the entrance. Then, looking for the big signs above our sight. It was recognizable, but the font size should be bigger. P4: Floor plans because I know how to read them. P5: Signs. To get some helps P6: Directory signs next to the entrance because it showed at once. P7: Map to figure out the location and to see the floor plan. P8: Room signs that wanted to know where I am or which level. P9: In general, signs depend on my mood because I tried to find them without signs. If there's layout on the sign locations, I will look that too. P10: Signs to look. Before the map near the entrance, I knew that the room signs. I understood the numbering system is alongside of the direction. Not much over the head signage. It is a secondary sign, not eye level. They are not on the eyesight. We are not looking up while walking. Evacuation plans: they were at eye level, that helped me. P11: Guideline (plan or map) I meant signs and map. Because I am little bit bad at wayfinding, have a hint about vision, trying to find my location, destination to estimate where they are. P12: Signs and map. Because it was the easiest way to. It can control my confusion. If I was familiar, I don't have to find signage.
What was the most helpful to find your way?	P1: Map, because it helped to get an idea what should I go next, and it gave me where I am now. P2: Signage and the lighting on the first floor (Big one). The shape of lighting can help me to where I am or something. P3: Room numbers on the signs. The names are not that effective, because the number is easily understandable for me. P4: Floor plan to know where the room is. Signs for the number of the room. How to match the texted room number and the signage. P5: Signs, except for the first floor (Route 1) P6: Room signs with the numbering. Except for the environmental cues, my previous experiences such as class or personal purpose helped me. P7: Signs with room numbers. Signs next to the door were helped. I saw them check the number and name that they were matched.

	P8: Signs and evacuation plan. Figuring out the evacuation plan to know where I am, and to know where I should go. Based on the plan because the plan has the room number. To know the matching of room number and the number in evacuation plan. P9: Some routes need a sign, but some destinations did not. if I am familiar with the destination. Directional signage. Sometimes the layout (Space planning) helps. The numbering (code) represents the level that understanding immediately. Courtyard: gives some sense of its placement. P10: My memory. Prior knowledge helped me and signage as well. I know I can recognize the space, but the name. P11: Plans (evacuation plan) the room number, and label. Tried to follow the number of rooms. Tried to imagine the space of furniture. Is it going to be close, small, open, or else? P12: signage. It is accurate to save my time. Easiest way rather than lighting.
What was the least helpful to find your way?	P1: Lighting. The location was not affected, but I was satisfied with the brightness of looking around. P2: Furniture. They looked similar, it couldn't help people to find or think of a way. P3: The name of the spaces or rooms. Especially, when the room has no info of the name. I don't know the name's meaning. P4: Names of the rooms. Route 1 doesn't' help me to locate. Meeting room. Not an open space for everyone. Meeting room. P5: Evacuation plan because it didn't show what I wanted to see. P6: Artificial light because brightness is the same and it didn't affect regarding finding. I was wondering if there's differences between lighting colors. P7: Furniture. They were not outstanding. It only gave me the sense of their people and there's furniture, not about wayfinding. Also, the hanging directory signs. I didn't even notice that they were there. P8: Artificial light because the building is bright. Natural light and opening space give brightness. P9: Furniture. The corridor is empty if the furniture is placed in the middle of the corridor. It could have affected me. Sometimes you can recognize the space or room by the furniture, but the exhibition area. P10: Furniture. Lounge hallway corridor. Might be the space? Or not. Exhibition area. P11: Didn't pay attention to the lighting, wall color (interior features) because they look like the color. Minimal colors, patterns. There are floor lines of the flooring, but those things are not there. They looked similar. P12: Lighting was the least. They are in the same placement. No differences.

Do wayfinding systems in locations help you to deduce the next steps?	P1: Yes, everything helped. P2: I hope that the signs should be placed on the intersection at eye level. I saw the sign after passing (hanging from the ceiling). Some sections didn't place. P3: Yes and no. I wish to have more information on every floor. In the route A3, the café doesn't have specific sign, but the rest of floors have signs. The second floor is easy to recognize because of the courtyard. If each floor had individual landmarks, it would be more helpful. P4: No. There is no wayfinding sense until you find the signs, it has no idea. Color-wise mattered. The height was a matter. Auditorium should be located low to understand its signs. I hope there's color contrast with the environment (indoor design elements). P5: It was. They helped. P6: It helped. In general, all of them helped me to think. P7: Map or the room numbering systems helped to think I am going to there or was that an opposite side to take another way. P8: Really helped. The room signage made me find the correct or exact room. It had helped me that I was in the wrong place. I was surprised about the room. Numbering systems helped. P9: Signs helped to see, but the artificial lighting above the signs were difficult to see. P10: Yeah, I guess. Most of the time that I knew that I was going. Signage. Helped. Interior features don't help. Do not remarkable way. P11: Yeah. The experiences with the direction, by the number of the room, it grows. I could find the map. P12: Yes. For example, room starts with the number, 1120> can help me to think the level. Matching with signage and room numbers that I provided.
Can you explain your emotional reaction to the wayfinding activities?	P1: Difficult and confused. In route 1, although you gave me the info of the destination such as room number, it wasn't a room that made me confused. If I planned to meet friends at the destination, I may not find it. Otherwise, the rest of route was helped with the system. P2: So, confused. Circulation map doesn't help me a lot since I lost. Sometimes I find it, but sometimes I don't. P3: Confused. When you arrive on time for the class, the building does not have a wayfinding system. Lost and frustrating. P4: Unsatisfied (Dislike) P5: Good. P6: Exciting. Finding was fun without negative emotions. P7: Frustrating about route 1. Lost. P8: Interesting. If I found the destination in a short time, I felt accomplished, but otherwise, I felt frustrated.

	P9: I felt that if I noticed fast, I would be happy about saving time. If finding was easy, I would be happy. P10: Good because I didn't get lost. P11: First, confused, disappointed by me. After I got familiar with experiences. Tried to remember the possible destination. (I am lost) P12: Confusing. I can't sense logic. 101, 102, then, 105 was not there. It feels like a numbering system. The first route: looking for the room, but it wasn't. The signage was placed at the end of the space from my eyesight. 1102 number, I didn't catch that. Comparing all routes: 2nd was easiest. The courtyard should be there. I knew that. Auditorium was easy.
Are you satisfied with the wayfinding systems in the building?	P1: Moderate. Half was good and half was bad. Sometimes finding was easy, but there's a lack of boundaries between rooms and districts. The name on the directory confused me too. P2: Not really P3: Moderate P4: No P5: Good P6: No. Except for the room signs, there's no advantage points to find my way. Even signs are not that impressive very well. P7: No. They are not noticeable. They looked white, not distinct. P8: Not really, challenged. P9: Moderate. Room names and numbers could help but they were supposed to give me an easy name to remember. P10: No. need to be adequate but okay. Need to be improved. P11: No. it's confusing. Interesting. Makes me disappointed. Become confused and anxious. P12: No
Are you familiar with this building?	P1: Not much P2: Went here several times. P3: Yes P4: Yes P5: Kind of P6: Yes P7: Yes P8: A little bit, 3 to 4 visits. I know this building and use my experience. P9: Moderate. Not the whole building, I spent my time using the first, second, and fourth floor. P10: Clearly P11: No P12: No

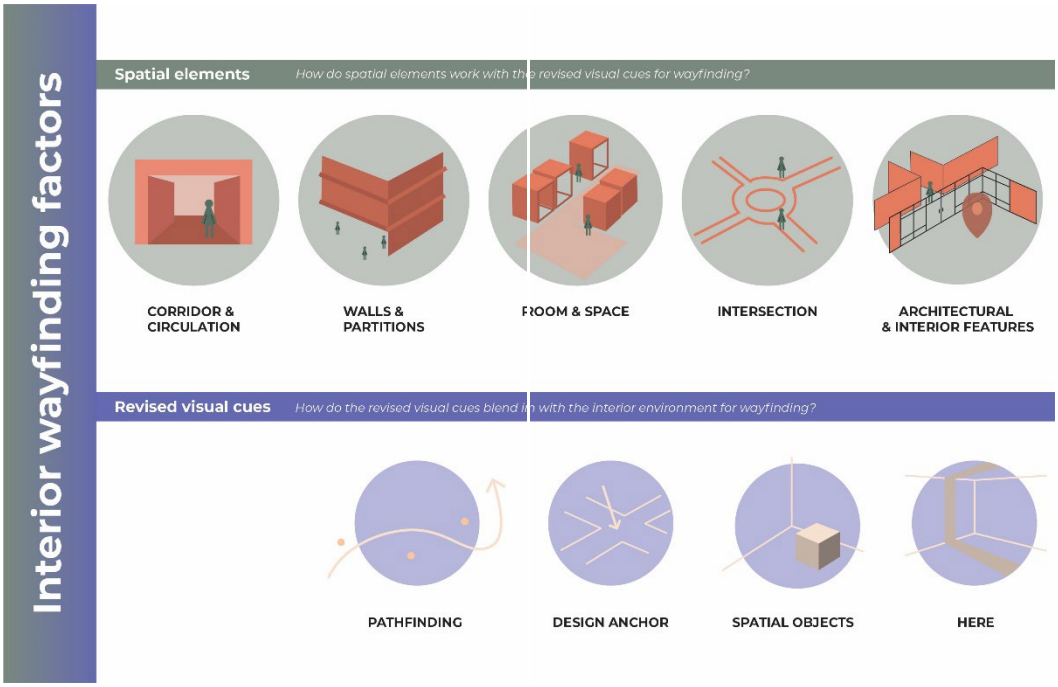
APPENDIX D. CREATIVE COMPONENTS

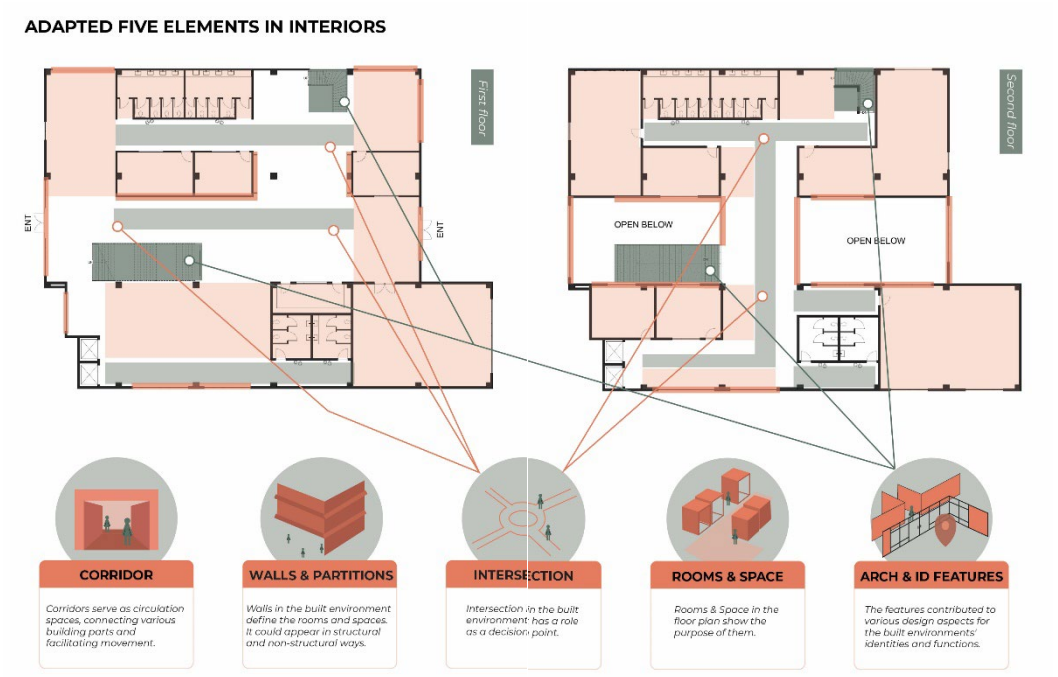


HEURISTIC PRINCIPLES FOR INTERIORS

NAVIGATION HEURISTICS GUIDELINES

ACKNOWLEDGE GOAL- AND EXPERIENCE-ORIENTED NAVIGATION	PERCEPTION	INTEGRATION	DECISION-MAKING MECHANISMS	COGNITIVE LOAD CONSIDERATIONS	CUSTOMIZED WAYFINDING SOLUTIONS
Adapt wayfinding for goal and experience navigation.	Design cues for conscious and subconscious information gathering by goal- and experience-oriented users.	Aid mental mapping simplifies goal-oriented routes and fosters exploration for experience-oriented users.	Offer diverse spaces: efficient paths for goal-oriented and immersive experiences for the experience-oriented.	Cut cognitive load for goal-driven; promote exploration in experience-oriented users.	Diverse heuristics: Goals drive visuals for G-O, while E-O relies on prior knowledge.
PATH SELECTION HEURISTICS	**CATEGORIZE DECISION-MAKING**	**OPTIMIZE SPATIAL DESIGN**	**EMBRACE MIXED-USE ELEMENTS**	**VISUAL CUES IN CONTEXT**	**SPATIAL COFIGURATION AND LEGIBILITY**
Path choices match personal goals. Design for quick destination reach or immersive spatial experiences.	Categorize interior decision-making as destination-focused (G-O) or experience-centric (spatial-oriented).	Interior design optimization: enhance spatial layout, visual cues, and wayfinding efficiency.	Designers integrate mixed-use areas for intuitive, engaging wayfinding, acting as user focal points.	Essential visual cues must align with indoor space and its unique functions.	Enhance space legibility through strategic configuration guiding pedestrians with a sense of progress toward their destination.


Interior wayfinding factors
Spatial elements
How do spatial elements work with the revised visual cues for wayfinding?
CORRIDOR & CIRCULATION
WALLS & PARTITIONS
ROOM & SPACE
INTERSECTION
ARCHITECTURAL & INTERIOR FEATURES
Revised visual cues
How do the revised visual cues blend in with the interior environment for wayfinding?
PATHFINDING
DESIGN ANCHOR
SPATIAL OBJECTS
HERE


ADAPTED FIVE ELEMENTS IN INTERIORS
First floor
Second floor
ENT
ENT
OPEN BELOW
OPEN BELOW
CORRIDOR
Corridors serve as circulation spaces, connecting various building parts and facilitating movement.
WALLS & PARTITIONS
Walls in the built environment define the rooms and spaces. It could appear in structural and non-structural ways.
INTERSECTION
Intersection in the built environment has a role as a decision point.
ROOMS & SPACE
Rooms & Space in the floor plan show the purpose of them.
ARCH & ID FEATURES
The features contributed to various design aspects for the built environments' identities and functions.

PATHFINDING

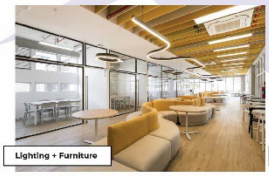
Consistent and Adaptable Lighting: Ensure consistent brightness, intensity, and lighting visibility throughout the space to guide wayfinding. Use technology to provide adaptable lighting solutions, such as track lighting or LED strips, to direct light where needed.

Balance Natural and Artificial Lighting: Consider the interplay between natural and artificial lighting. Adjust artificial lighting to maintain visibility, especially when competing with natural light sources.

Strategic Sign Placement: Ensure that directory signs do not obstruct the visibility of lighting fixtures. Adjust sign placement to maximize clarity while preserving the aesthetics of the space.

Spatial Experience Enhancement: Recognize that lighting not only aids wayfinding but also shapes the spatial experience. Embrace lighting as a tool for enhancing the environment's overall ambiance and aesthetic appeal.


Lighting + Inserted Wall


Lighting + Furniture

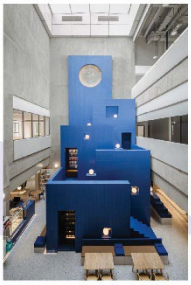

Lighting + Flooring

DESIGN ANCHOR

Spatial Identity and Memorability: Design anchors should provide a unique identity to locations. Ensure that design anchors are memorable and easily recognizable for users to orient themselves effectively.

Strategic Placement: Consider the placement of design anchors to guide user positioning. Designers should think about the consistent placement of these anchors to improve wayfinding.

Schematic Design Integration: Incorporate design anchors during the schematic design stage of interior design and architecture to ensure effective wayfinding utilization.


Arch & Interiors features


Open space with spatial objects

SPATIAL OBJECTS

Role of Spatial Objects: Recognize that spatial objects, including furniture, signs, landmarks, and interior features, play different roles in wayfinding, aesthetics, function, and style.

Color Contrast and Size Difference: Use color contrast and size differences to make objects stand out and encourage exploration. This aids in spatial identification and memorability.

Aesthetic Enhancement: Understand that objects serve functional roles and enhance the space's aesthetics. Incorporate objects that add visual interest, texture, color, and depth to the environment.


Plants + Flooring


Furniture

HERE

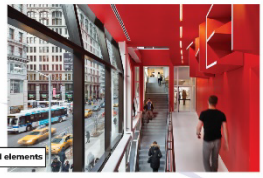
Signage Placement: Consider the placement of signs carefully to ensure visibility, especially at turning points or decision points in corridors.

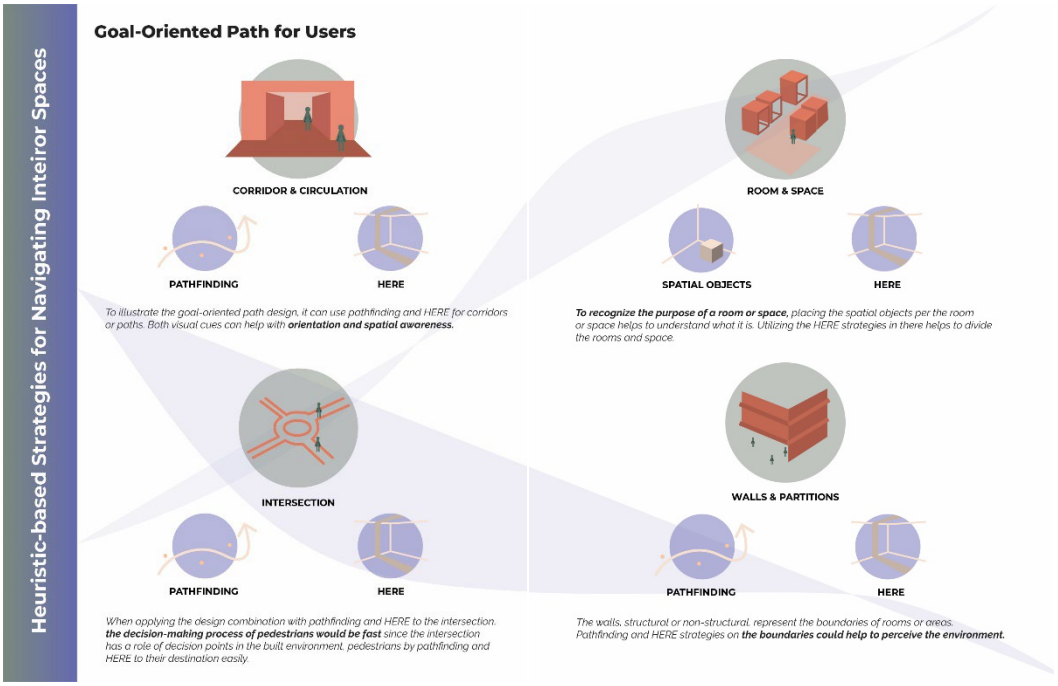
Dynamic Signage: Explore the use of dynamic signage systems that adapt to the positions and preferences of pedestrians. This can improve real-time wayfinding instructions.

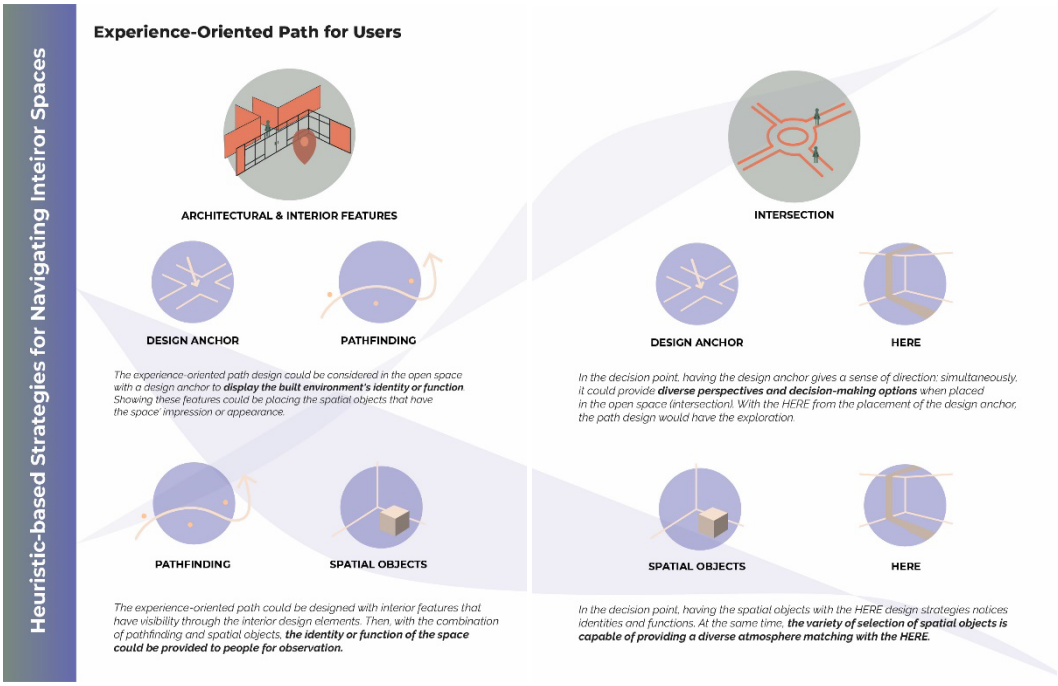
Expanding the Role of Signs: Transform traditional signs into spatial guidance elements. Incorporate textures, materials, and visual elements that enhance the wayfinding experience.

Kinetic Interiors: Explore the concept of kinetic interiors that change based on occupant behavior or specific times of the day to provide dynamic wayfinding guidance.


Material accents


Using spatial elements


Heuristic-based Strategies for Navigating Inteiror Spaces
Goal-Oriented Path for Users
CORRIDOR & CIRCULATION
PATHFINDING
HERE
To illustrate the goal-oriented path design, it can use pathfinding and HERE for corridors or paths. Both visual cues can help with orientation and spatial awareness.
ROOM & SPACE
SPATIAL OBJECTS
HERE
To recognize the purpose of a room or space, placing the spatial objects per the room or space helps to understand what it is. Utilizing the HERE strategies in there helps to divide the rooms and space.
INTERSECTION
PATHFINDING
HERE
When applying the design combination with pathfinding and HERE to the intersection, the decision-making process of pedestrians would be fast since the intersection has a role of decision points in the built environment, pedestrians by pathfinding and HERE to their destination easily.
WALLS & PARTITIONS
PATHFINDING
HERE
The walls, structurol or non-structural, represent the boundaries of rooms or areas. Pathfinding and HERE strategies on the boundaries could help to perceive the environment.


Heuristic-based Strategies for Navigating Inteiror Spaces
Experience-Oriented Path for Users
ARCHITECTURAL & INTERIOR FEATURES
DESIGN ANCHOR
PATHFINDING
The experience-oriented path design could be considered in the open space with a design anchor to display the built environment's identity or function. Showing these features could be placing the spatial objects that have the space' impression or appearance.
INTERSECTION
DESIGN ANCHOR
HERE
In the decision point, having the design anchor gives a sense of direction; simultaneously, it could provide diverse perspectives and decision-making options when placed in the open space (intersection). With the HERE from the placement of the design anchor, the path design would have the exploration.
PATHFINDING
SPATIAL OBJECTS
The experience-oriented path could be designed with interior features that have visibility through the interior design elements. Then, with the combination of pathfinding and spatial objects, the identity or function of the space could be provided to people for observation.
SPATIAL OBJECTS
HERE
In the decision point, having the spatial objects with the HERE design strategies notices identities and functions. At the same time, the variety of selection of spatial objects is capable of providing a diverse atmosphere matching with the HERE.

Practices 1

Efficiency and clarity:

The primary focus of path design for goal-oriented users is to provide the most efficient and straightforward routes to their destinations.

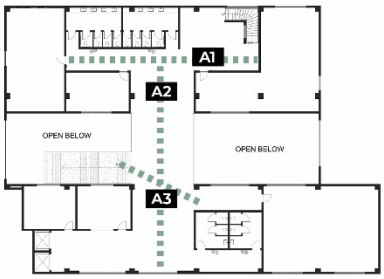
a. ***Minimize unnecessary detours and distractions*** *to expedite the journey.*

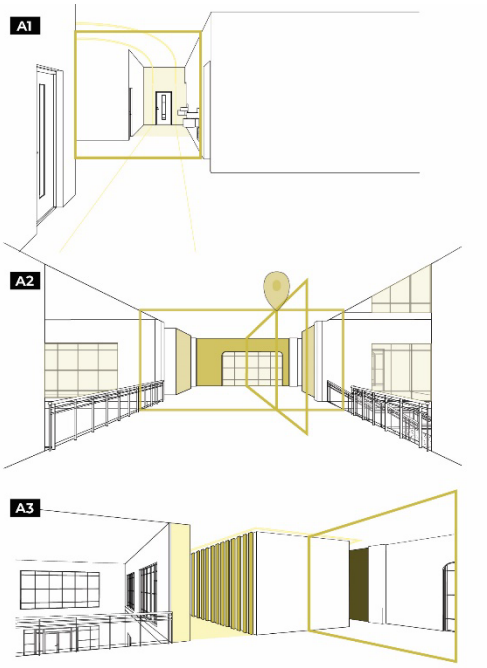
b. Indicate ***the shortest and most direct path*** *to the destination, with prominent signage and visual cues.*

c. Ensure consistent and easily understandable wayfinding cues to reduce cognitive load.

d. Prioritize ***clear sightlines*** *and* ***unobstructed pathways,*** *minimizing potential obstacles.*

e. Consider signage placement at ***decision points and intersections*** *for quick decision-making.*





Practices 2

Spatial exploration and engagement:

For experience-oriented users who seek a rich and memorable spatial experience, the focus is on providing opportunities for exploration and engagement.

a. Create pathways ***encouraging users to explore*** *the environment.*

b. Incorporate ***diverse views and points of interest*** *to capture users' attention and create a sense of wonder.*

c. Use design elements that add visual interest, texture, color, and depth to the environment to visually stimulate the journey.

d. Incorporate ***mixed-use elements*** *such as seating, retail, and gathering areas as focal points for users to interact with and enjoy.*

e. Consider ***kinetic interiors or dynamic wayfinding*** *that adapts to user behavior, enhancing the sense of discovery.*

f. Balance artificial and natural lighting to create an appealing ambiance and provide visibility while maintaining the aesthetics of the space.