The Role of Research-Based User-Centred Signage Graphic Design in Improving the Effectiveness of the Wayfinding Signage System in Academic Settings for Partially Sighted Individuals

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The candidate confirms that the work submitted is his/her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Wayfinding signage is one of the essential tools for wayfinding activities. However, the current wayfinding signage graphic design only seems to fulfil the needs of the most 'abled' population. Partially sighted individuals are left 'out of the space'. Creating a better wayfinding signage graphic design to accommodate the needs of this group of users requires a better understanding of their needs and expectations for the design. Currently, there is a lack of knowledge about how sight loss affects individuals' signage graphic design needs, making it difficult to suggest a solution to address these issues.

This research investigates the role of research-based user-centred signage graphic design in improving the effectiveness of the wayfinding signage system in academic settings for partially sighted individuals by involving partially sighted participants in the design process. A series of research activities were carried out to identify a clear picture of partially sighted individuals' needs for signage design in academic settings. An audit drew together the available design guidelines to define graphic design factors essential to signage design in academic settings. An online questionnaire investigated partially sighted individuals' experiences and opinions of current signage graphic design in academic settings. Four online co-design workshops were conducted to visualise partially sighted individuals' signage graphic design needs. A focus group was carried out to reflect on the developed design approach and the value of user-centred signage graphic design outcomes. The results show that there is a lack of comprehensive signage graphic design guidelines that reflect partially sighted individuals' pain points, experiences, preferences, and cultural conventions, which are four factors identified to be important to signage graphic design for them. It was found that giving partially sighted individuals the autonomy to directly influence the design process and outcome facilitates participants' creative contributions to design and leads to a better design outcome that reflects their design needs. This developed user-centred signage graphic design approach has shown great potential in improving the effectiveness of signage design in academic settings for partially sighted individuals. This thesis adds to our understanding of inclusive environmental graphic design, specifically signage graphic design. This thesis presents a theoretical methodology framework for co-designing wayfinding signage with partially sighted individuals, utilising the novel workshop co-design approach developed during research. This thesis offers useful insights into designing for the partially sighted and has generalizability value for designing for marginalised user groups.

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Chapter 1 Introduction

1.1 The need for effective signage design for partially sighted individuals

Wayfinding is a destination-oriented exploration that is essential to the mobility of the partially sighted (Passini and Proulx, 1988, p.228; Golledge, 1993, p.63). Wayfinding signage emerged from the need to find one's way around unfamiliar physical environments (Hunter et al., 2016b, p.4), and it is heavily influencing wayfinder's abilities for information processing, decision making, decision execution, and wayfinding closure (Arthur and Passini, 1992, p.33; Vandenberg, 2016, p.18). It has an indispensable impact on the wayfinding outcome and satisfaction (O'Grady and O'Grady, 2008, p.72; Helvacıoğlu and Olguntürk, 2011, p.410).

There are almost 2 million individuals living with sight loss in the UK. Approximately 340,000 are registered as blind or partially sighted (NHS, 2021). There are an estimated at least 2.2 billion individuals who have a near or distance vision impairment globally, of whom 1 billion have moderate or severe distance vision impairment (World Health Organization, 2020). The condition of blindness is not a binary, but a spectrum, with many partially sighted individuals being misrepresented as having no light perception at all, a disputed fact (Hersh, 2008, p.84; RNIB, 2014). Traditional products, such as magnifiers, guide dogs and white canes, only meet the needs of one user group who are experiencing substantial blindness. The majority of partially sighted individuals who have 'functional vision,' meaning what they can see, for example, peripheral vision or tunnel vision, or are able more easily to see in certain light conditions. This varies amongst the individuals' conditions (RNIB, 2014). Therefore, when wayfinding signage design in an academic setting is only designed with the standard of an adequate vision designer, millions of partially sighted people are left 'out of the space'.

"Access to education for youth with disabilities is enshrined within the UN Convention on the Rights of Persons with Disabilities as a fundamental human right (Sukhai and Mohler, 2016, xxv)." Furthermore, based on legislation, the facilities/service provider must adjust to ensure accessibility to the disabled (Disability Discrimination Act, 1995). Therefore, providing accessible and essential wayfinding information for partially sighted individuals to access academic settings should not be dismissed.

Partially sighted individuals have the same spatial-cognitive abilities as fully sighted individuals to complete a wayfinding task (Passini and Proulx, 1988, p.251; Passini et al., 1990, p.91; Golledge et al., 1996, p.242; Kitchin et al., 1997, p.225; Fortin et al., 2008, p.3001). Although a

certain environment feature is found to be more important to one group than the other, partially sighted wayfinders are found to be able to model the route without any errors, as well as retain a general understanding of the spatial attribute of the setting (Passini and Proulx, 1988, p.251). The partially sighted individual develops a spatial understanding based on an **egocentric model**[1]. This means their information mainly comes from the direct interaction with spatial layout through locomotion; and the indirect inference of spatial information that uses heuristics (Golledge, 1993, p.74). The defect of vision is inhibiting the collection of information from a long distance, which imposes a series of challenges for partially sighted wayfinders (Rousek et al., 2009, p.531). When the wayfinding signage graphic design fails to support partially sighted individuals, it leads to stress caused by disorientation (Kanakri et al., 2016, p.251) and puts the visitor at considerable risk of accidental injuries (Rousek et al., 2009, p.531). This shows the importance and opportunities to improve the effectiveness of signage graphic design for partially sighted individuals.

However, as discussed in Chapter 4, the challenge of designing effective wayfinding signage for partially sighted individuals comes from the lack of comprehensive and updated signage graphic design guidelines reflecting their needs for signage design. Previous studies has highlighted the difficulties of the partially sighted in navigating their surroundings (Rousek et al., 2009, p.531; Khattab et al., 2015, p.157; Obeidat and Rashid, 2017, p.8). However, these studies mostly focus on the cognitive aspects of partially sighted individuals' spatial competence (Passini and Proulx, 1988, p.227; Passini et al., 1990, p.91; Golledge et al., 1996, p.215; Kitchin et al., 1997, p.225; Fortin et al., 2008, p.2995), wayfinding confusion (Kitchin et al., 1998, p.34), and wayfinding performance (Passini and Proulx, 1988, p.227; Golledge, 1993, p.63; Jacobson, 1998, p.289; Ungar, 2000, p.1; Mereu and Kazman, 1996, p.10; Postma et al., 2007, p.1253; Wan et al., 2010, p.344; Šakaja, 2018, p.1). The majority of the publications provide a great understanding of how sight loss affects individual spatial-cognitive abilities but exhibit very little understanding of how to design effective signage for the partially sighted. Most publications associated with signage design can be categorised into:

- Visual literacy (e.g., Uebele, 2007; Meuser et al., 2010; Viction:ary, 2014).
- Information design books briefly discuss wayfinding signage design (e.g., O'Grady and O'Grady, 2008; Gibson, 2009).
- Books discuss general wayfinding, signage, and architecture (e.g., Arthur and Passini, 1992, v; Barker and Fraser, 2004; Calori and Vanden-Eynden, 2015).

[1] Egocentric model: encode surrounding information with the respect of self to object (Martinez-Martin et al., 2014, p.2)

- Journal paper focusing on one specific issue in wayfinding design (e.g., colour, landmark, illumination) (e.g., Helvacıoğlu and Olguntürk, 2011, p.410; Frankenstein et al., 2012, p.165).
- Accessible wayfinding signage design guidelines published by established organisations (e.g., ADA, 2010; Barker and Fraser, 2004).

The 10 common issues (Arthur and Passini, 1992, p.184) with wayfinding signage design are: 1) Ambiguity, 2) Conflict, 3) Deficiency, 4) Excess, 5) Glare, 6) Illegibility, 7) Inaccuracy, 8) Obstructions, 9) Unreliability, 10) The User themselves. Nine out of ten of these issues can be resolved or improved by understanding the user needs and context of use (Arthur and Passini, 1992, p.184; Petrie and Bevan, 2009, p.4; Bevan, 2009a, p.13). The lack of specification of the requirements (of the partially sighted) in the design makes it difficult to produce an effective wayfinding signage system.

The challenges of improving the effectiveness of signage graphic design for partially sighted individuals lie in the prediction of design needs, together with acquiring the feedback required for enhancement of the current design (Alnawaisri, 2019, p.18). The generic design process that the design consultancies follow has little input from partially sighted users. This is due to a lack of experience working with people of different capabilities, along with time and money constraints (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289).

The user-centred design approach involves users in four stages of research activities: 1) Understanding and specifying the context of use, 2) Defining the user requirements, 3) Producing design solutions, and 4) Evaluation (Bevan, 2003, p.434; Bevan, 2008, p.3; Bevan, 2009b, p.110; Petrie and Bevan, 2009, p.4). This has proven to lead to better usability, cost-effective and sustainable design solutions (Abras et al., 2004, p.12; Vermeeren et al., 2010, p.521). This could mean a more user-friendly, relaxed, and safer wayfinding experience for partially sighted individuals.

In order to identify design practices which will address partially sighted individuals' needs for wayfinding signage graphic design in academic settings, a thorough understanding of how specific design can benefit or challenge partially sighted individuals' experience with wayfinding signage is required. The user-centred design approach aligns with the design problem this thesis is proposing to solve and provides a framework to support the structure of research activities. Therefore, this thesis is a great opportunity for us to explore the potential of research-based user-centred signage graphic design in improving the effectiveness of the wayfinding signage system in the academic setting for partially sighted individuals.

Two considerations should not be overlooked before conducting the research to investigate the problems partially sighted individuals have with wayfinding signage graphic design in

academic settings. The first is to acknowledge that partially sighted individuals are a population with diverse vision conditions. They rely on wayfinding information to find their way around as much as fully sighted individuals. The lack of vision does not prevent them from needing signage in wayfinding, but effective wayfinding signage is important to their wayfinding experience. Second, there is a lack of available frameworks and tools to help partially sighted individuals directly and creatively contribute to the signage graphic design process. With all user-involved research instruments, I need to ensure accessibility in order to safeguard data quality. Identifying or developing an accessible data collection tool to conduct user-centred research is essential.

1.2 Aims and objectives

1.2.1 Research aim

The overall goal of this thesis is to investigate the challenges partially sighted individuals face with wayfinding signage graphic design and identify design practices that are needed for the effectiveness of wayfinding signage design in academic settings. **This study aims to investigate the role of research-based user-centred signage graphic design in improving the effectiveness of the wayfinding signage system in academic settings for partially sighted individuals.**

1.2.2 Research objectives

The research objectives of this study follow four stages.

Stage one: Exploring the context of the design 'problems'

a. To define the graphic design factors that matter to wayfinding signage design.
b. To identify the graphic design factors essential to signage design in academic settings.

Stage two: Defining the user requirements for design

c. To investigate partially sighted individuals' experiences and opinions on current wayfinding signage graphic design in academic settings.

Stage three: Producing design solutions

d. To prototype signage graphic design that reflects user needs with partially sighted individuals through co-design.

Stage four: Evaluation and reflection

e. To reflect on the co-designed signage graphic design outcomes with partially sighted participants.
f. To reflect on the design practice with the partially sighted participants.
g. To conclude the value of research-based user-centred signage graphic design practice in improving the effectiveness of the wayfinding signage system for partially sighted individuals in academic settings.

1.3 Research questions

Research question: Based on research, what is the best design approach to improve the effectiveness of signage graphic design for partially sighted individuals in academic settings?

As shown in *Table 1-1 Research sub-questions and corresponding* objectives, five sub-questions were developed to help answer the research question.

Table 1-1 Research sub-questions and corresponding objectives

	RESEARCH SUB-QUESTIONS	OBJECTIVES
1	What graphic design factors are essential to wayfinding signage design in academic settings?	• Objective a • Objective b
2	What are partially sighted individuals' experiences with signage graphic design in academic settings?	• Objective c
3	What are partially sighted individuals' design needs for signage graphic design in academic settings?	• Objective c • Objective d
4	How to design effective wayfinding signage graphic design for partially sighted individuals in academic settings?	• Objective d • Objective e • Objective f
5	What is the value of the developed signage graphic design practice in this thesis for improving the effectiveness of the wayfinding system in academic settings for partially sighted individuals?	• Objective e • Objective f • Objective g

1.4 Thesis structure

To fulfil the aim and meet the objectives set for this study, this thesis is divided into eight chapters, including this **introductory chapter**.

Chapter 2 presents a review of the literature. It defines the wayfinding signage graphic design, the importance of signage graphic design for partially sighted individuals, and the need to carry out the research in this thesis.

Chapter 3 discusses the background and planned research activities in this thesis. It provides a review of the research position, briefly introduces research activities, and explains how I identify and sample participants for the research. The detailed research method and procedures are introduced in the corresponding chapters.

Chapter 4 presents a design guideline review and audit. This chapter helps explore the surrounding context of signage graphic design in academic settings. It identifies graphic design factors essential to signage design in academic settings. The outcome of this chapter informs subsequent research activities.

Chapter 5 presents an online questionnaire. This chapter provides a better understanding of partially sighted individuals' experience with signage graphic design in academic settings. It identifies graphic design factors contributing to a satisfactory wayfinding experience for them in academic settings.

Chapter 6-1 and **Chapter 6-2** present four co-design workshops to help partially sighted individuals visualise their ideal signage graphic design. **Chapter 6-1** details the theoretical foundation and the development of the co-design workshop tools and activities in order to achieve the research goal without compromising accessibility in data collection. **Chapter 6-2** documents the implementation of the developed co-design workshops, a collection of signage graphic design prototypes that embodied partially sighted individuals' needs for signage design in academic settings were produced by the end of the chapter.

Chapter 7 presents an online focus group to reflect on the value of the research-based user-centred signage graphic design in increasing the effectiveness of the wayfinding system in academic settings. This chapter discusses the value of the design approach developed in this thesis and the value of the signage graphic design outcome produced by this design approach.

Chapter 8 concludes and discusses the research activities I have conducted and the major findings from this study. The contribution, limitations and recommendation for future research are also addressed in this chapter.

Chapter 2 Contextual Background

2.1 Introduction

The creation of wayfinding signage has emerged from the most basic human need for finding one's way around unfamiliar physical surroundings. The advancement of the wayfinding design discipline has been with a view to improving the 'visibility' of the physical environment for its users. However, this seems to have failed for the partially sighted. Several studies have identified daily challenges which are experienced and, therefore, to ensure the basic needs of the partially sighted are reflected in wayfinding signage graphic design, it is important to understand the context of the design 'problem'. In order to do this, relevant literature was reviewed to provide a better understanding of the importance of signage graphic design in wayfinding systems and the potential of improving the effectiveness of signage graphic design for the partially sighted.

This literature review will start by establishing an understanding of wayfinding, wayfinding design, and the significance of signage graphic design in the wayfinding system. How user needs have informed the advancement of this discipline will be discussed.

This review then moves on to discuss the capacity of partially sighted individuals to use wayfinding signage, together, with the types of challenges and user needs from the wayfinding system. The review will later address the reason I chose academic settings as a starting point in order to be able to understand partially sighted individuals' signage graphic design needs and the potential research approach that can bring effectiveness to signage design. The importance of this study is concluded at the end of the chapter.

2.2 Wayfinding signage design

2.2.1 The origin of wayfinding design

2.2.1.1 Emerged from the needs

The wayfinding system emerged from the need to find one's way around unfamiliar physical environments. Throughout civilisation, human beings have established and developed ways to guide one or the other through the physical environment (Gibson, 2009, p.13). Traditional wayfinding relied on the nature cues, such as the sun, stars in the sky and landmarks like

mountains and rivers, which over time were supplemented by man-made navigation devices (Hunter et al., 2016b, p.8).

Figure 2-1 One of the earliest man-made wayfinding cue - a clay map produced in the late Babylonian (The British Museum, 2022)

Throughout history, people have gravitated toward vibrant public spaces. As cities became more complicated and more people became literate, the need for effective information to help people find their way around the city increased. Over time, the presence of signs in written and verbal messages became essential to people who live and work in the city (Gibson, 2009, p.13). Eventually, cities and towns grew bigger and merged into metropolises. Social activities across the city became the norm. The need for more effective wayfinding information to assist people moving between streets, buildings, and structures has emerged.

2.2.1.2 The specialisation of wayfinding design

The demand for effective wayfinding information has driven the specialisation of wayfinding design. People will always need to know where they are, how to reach their destination and how to enter and exit a space. Specialised environmental graphic designers are responsible for enhancing the space experiences by finding order in complex physical structures (Arthur and Passini, 1992, p.52). As the city modernises in the 1960s, the needs of the signs are no longer just limited to offering the correct directions. Signposts were also expected to look

aesthetically good in the direction process. Artists were getting involved in making wayfinding signs more aesthetically pleasing.

Meanwhile, the Bauhaus movement (1910s-1930s) greatly impacted design education. The Bauhaus movement advocates the importance of reuniting fine art and functional craft (The Art Story Foundation, 2021). Wayfinding design was first included in the design curriculum alongside typography, colour and layout.

In the 1970s, the *Society for Environment Graphic Design* was founded (Calori and Vanden-Eynden, 2015, p.4). Designers started to study the practice of guided navigation (Gibson, 2009, p.13). The acknowledgement of human-centred architecture design shaped the 1980s gradual specialisation of Environmental Graphic Design (EGD). This specialisation cultivated environmental graphic design into a more defined and sophisticated subject. The understanding of the wayfinding practice and human wayfinding behaviour significantly improved during this time.

2.2.1.3 Rapid development

The demand for specified wayfinding needs pushed the development of wayfinding design. As a result of the rapid economic development, physical spaces in the city are becoming increasingly complicated as specified functional needs arise. Stakeholders realised that public spaces such as shopping malls, airports, transportation terminals and educational settings need to offer the visitor a pleasant well-oriented journey to facilitate the return visit (Gibson, 2009, p.16; Calori and Vanden-Eynden, 2015, viii).

Figure 2-2 Wayfinding sign in Prague airport (Airport World, 2022)

As a result of globalisation, public spaces such as the airport must develop a new wayfinding strategy to accommodate visitors of differing nationalities. Airports developed much of the first innovated signage and symbols to provide a safe and effective wayfinding solution. Because of the universal comprehensibility of the symbols system, symbols were also immediately widely used in wayfinding systems to provide assistance to direction indication in community settings such as hospitals which accommodates an increasingly diverse population (Rousek and Hallbeck, 2011, p.771; Boersema and Adams, 2017, p.304). Gradually, people rely on and expect the wayfinding design to provide accurate information for their needs.

2.2.2 The discipline of wayfinding design

Wayfinding design has emerged from the basic user needs of finding one's way in complicated physical spaces. Therefore, in order to better understand the discipline of wayfinding design, it is essential to understand the activity of wayfinding.

2.2.2.1 Types of wayfinding tasks

Based on the purpose of the travel, there are three basic groups of wayfinding tasks: commute, exploration and quest (Allen, 1999, p.554). This classification is determined by one's familiarity with the destination and the functionality of the travel. The **commute** involves travelling between locations that were previously visited. The **exploration** involves travelling

with no specific destination in mind. The **quest** involves travelling towards a particular destination known through any information format. As the number of one's contacts with the immediate environment increases, the understanding and familiarity with the surroundings build up, and the spatial representation starts to shape over time (Golledge, 1993, p.71; Allen, 1999, p.554; Steyvers and Kooijman, 2009, p.223). Regardless of the type of wayfinding tasks, it always follows a similar cognitive wayfinding process.

2.2.2.2 The cognitive process of wayfinding

Wayfinding is continuous spatial problem solving under uncertainty, and the goal of wayfinding is to make a journey and reach a destination (Arthur and Passini, 1992, p.27; Hunter et al., 2016b, p.4). Based on the literature, accomplishing these goals requires problem-solving behaviours and cognitive resources in several steps (Arthur and Passini, 1992, p.27; Vandenberg, 2016, p.18). Scholars have proposed different models for the cognitive process of wayfinding; nevertheless, similar ideas are identified across these studies, as shown in *Figure 2-3 The cognitive process of wayfinding.*

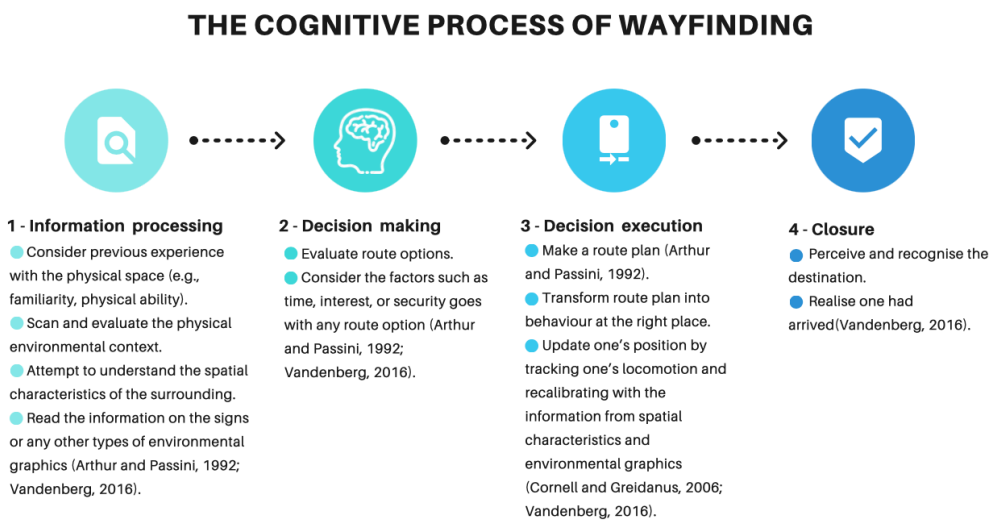

Figure 2-3 The cognitive process of wayfinding

The original wayfinding cognitive process model was proposed by Arthur and Passini (1992). This model initially breaks down the cognitive process of wayfinding into *information processing, decision making,* and *decision execution* (Arthur and Passini, 1992, p.26). However, as the goal of wayfinding is to make a journey to reach a destination, it does not make sense to end the process at the step of decision execution. *Decision execution* was later reinforced by Cornell and Greidanus (2006). The wayfinding decision execution does not stop at making a

wayfinding plan based on the result of route option evaluation. It requires continuously updating one's position by tracking one's movement and recalibrating with the information from physical surroundings and wayfinding cues (Cornell and Greidanus, 2006, p.230). The stage of *Closure* was last added by Vandenberg (2016). This stage marks the completion of a wayfinding task. Because each step of the wayfinding is a process subject to uncertainty and unpredicted factors that might require additional information processing, decision making, and decision execution to reach the destination (Vandenberg, 2016, p.18). Therefore, the step of closure is momentous to mark the end of a wayfinding journey. Hence, closure is considered part of the cognitive process of wayfinding in this thesis.

2.2.2.3 The definition of wayfinding

Wayfinding was originally considered **the comprehensive understanding of the exterior environment held by individuals, and it is the product of the memory of the previous experience and the instant sensation** (Lynch, 1960, p.5). The term *"Way-finding"* was first introduced by architect Kevin Lynch (1960) in the book *The Image of the City. "Way-finding devices"* were used to describe maps, street numbers and route signs, which support *"way-finding."* The wayfinding process is linked to the *"image,"* the generalised mental picture of one's immediate physical surroundings. In an urban setting, this mental picture is shaped by the distinction of the urban environment characteristics, such as colour, shape, motion, and light, and the individual sensory, such as sound, touch and smell.

Wayfinding was then defined as **the process of reaching a destination that involves spatial problem-solving** (Arthur and Passini, 1992, p.27). Arthur and Passini (1992), in their book *Wayfinding: People, Signs and Architecture,* argue that wayfinding is a more complicated human cognitive activity than remembering the space, which initially indicated the importance of *"spatial problem-solving"* in wayfinding. This problem-solving process involves information processing, spatial decision making and decision execution (Arthur and Passini, 1992, p.26), which all require the wayfinders' mental effort to actively engage with the physical surroundings to complete a wayfinding journey.

These two definitions provided the initial understanding of the word *"wayfinding".* However, as a human activity, wayfinding, in parallel with the mental effort, the physical movement of making the journey and reaching the destination is also essential to wayfinding (Golledge, 1993, p.81; Hunter et al., 2016a, vii; Vandenberg, 2016, p.23; Kanakri et al., 2016, p.255). Moreover, as discussed earlier in *2.2.2.2 The cognitive process of wayfinding,* the cognitive process of wayfinding involves information processing, spatial decision making, decision execution and closure. Wayfinding is more than simply remembering or knowing the way from

place A to place B; but the total sensory experience of the journey from place A to place B. The latest definition for wayfinding can be concluded **as the continuous dynamic communication** (Cornell and Greidanus, 2006, p.230) **between wayfinder and their immediate physical surroundings that involves both physical movement** (Montello, 2010, p.257; Garip, 2011, p.1771) **and mental effort** (Arthur and Passini, 1992, p.27)**.**

With the growing popularity of virtual environments, the term *"Wayfinding"* expanded the meaning from the previous construct. *"Wayfinding"* is also used to refer to the cognitive process of navigating from place A to place B through a virtual journey (O'Grady and O'Grady, 2008, p.72). This construct diversifies where the wayfinding journey could take place; however, this deviated from the interests of this thesis. **This thesis defines wayfinding as the action of travelling between places involving physical movement and mental effort in contact with the physical environment.**

2.2.2.4 The difference between navigation

The terms *"wayfinding"* and *"navigation"* are often used interchangeably due to the semantically overlap. It seems just a subtle difference between these two terms, however, this difference is significant to the purpose of wayfinding design. Therefore, the difference between these two terms needs to be discussed.

The debate between these two terms manifests as the subordination relationship between wayfinding and navigation. Montello (2010) suggests that navigation is the destination-oriented physical movement through a spatial setting, and wayfinding is the destination-directed planning part of the navigation (Montello, 2010, p.257). Karimi (2015) argues that wayfinding involves identifying the route and making the travel plan, whereas navigation as part of the wayfinding involves travelling and receiving updated guidance on the journey (Karimi, 2015, viii).

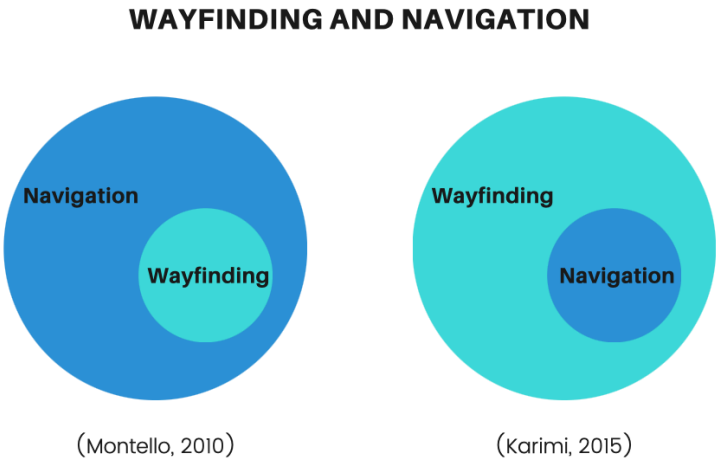

Figure 2-4 Different ideas of the relationship between wayfinding and navigation

Both scholars acknowledge the equal importance of mental effort and physical movement. However, the latter corresponds to the definition of wayfinding in this thesis, which acknowledges the mental effort (*information processing, spatial decision making and decision execution*) (Arthur and Passini, 1992, p.27) of wayfinding. Identifying the route between spaces and making plans to travel require information processing and spatial decision making, whereas travelling corresponds to updated guidance involving decision execution and physical movement.

Moreover, the term “navigation” is often used to emphasise the destination-oriented physical movement with a wayfinding plan in mind. In the context of daily usage of this term, navigation is more often used as one following a route provided by intelligent navigation machines or organisms (Montello, 2010, p.257). Therefore, in this thesis, wayfinding is considered what involves the mental effort of information processing, spatial decision making and decision execution. Navigation plays the part of the physical movement, which reflects the mental efforts and decision execution.

2.2.2.5 Components of wayfinding information and wayfinding design

Components wayfinding information

Differ from navigation, wayfinding is the action that requires both spatial problem solving and physical movements. Spatial problem solving involves information processing, spatial decision making and decision execution (Arthur and Passini, 1992, p.27; Vandenberg, 2016, p.18). Navigation plays a part in executing the wayfinding plan and bringing in new wayfinding

information to facilitate the wayfinding (Karimi, 2015, viii). Therefore, wayfinders need to be able to understand both **physical environmental context** and **graphic environmental information** to begin the cognitive and behavioural process of the wayfinding (Arthur and Passini, 1992, p.33; Vandenberg, 2016, p.18).

The **architectural (information)** provides the basic cues, such as entrances, exits, pathways and vertical accesses. The architecture communicates the circulation system of the built environment, which sets the context for wayfinding problem solving and establishes the complexity, visibility, and accessibility of the space (Gibson, 2009, p.16; Vandenberg, 2016, p.20).

The **graphic information (system)** provides legible and readable information about the facilities and the events. Graphic information is most commonly in the form of signage graphic design and maps, thereby reinforcing and explaining the circulation in detail. However, it cannot effectively substitute the missing architectural information (Arthur and Passini, 1992, p.56).

A wayfinder cannot construct a wayfinding plan before engaging with the setting. The decision making requires information from both **architectural information** and **environmental graphic information** which explain the architectural information (Arthur and Passini, 1992, p.56).

Components of wayfinding design

The components of wayfinding design are informed by components of wayfinding information required to construct a wayfinding plan. Therefore, the wayfinding decision making requires information from **architectural information** and **environmental graphic information** which explains the architectural information. Three components are considered essential to any wayfinding journey, **environmental characteristics** (landmark, physical structures) (Weisman, 1981, p.202; O'Grady and O'Grady, 2008, p.72), **environmental graphic design** (O'Grady and O'Grady, 2008, p.72; Helvacıoğlu and Olguntürk, 2011, p.410), in addition to the **individual**'s **intelligence** to decode and encode the information from the physical environment (Gärling et al., 1983, p.183; Golledge et al., 1995, p.154; Kanakri et al., 2016, p.255).

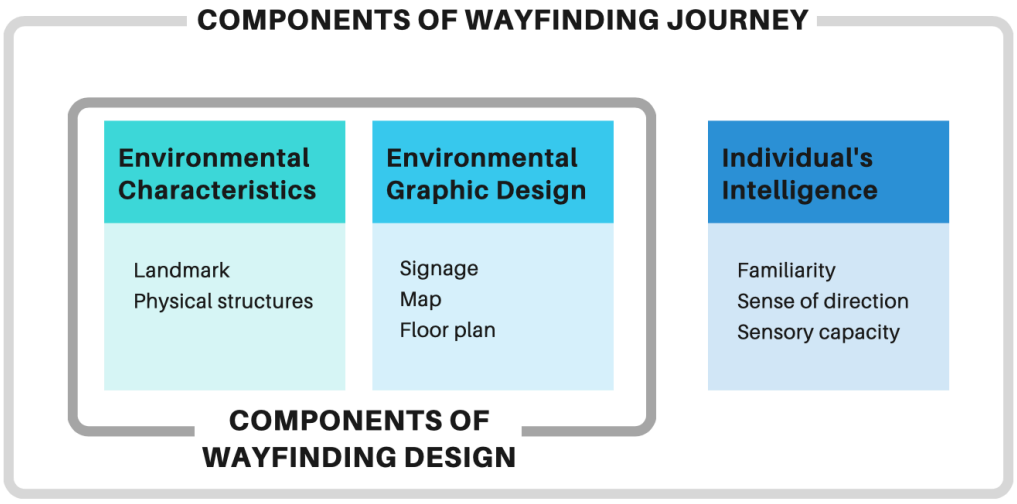

Figure 2-5 Components of wayfinding design

Due to the fact that intelligence and perception level vary from individual to individual, wayfinding design integrates both the **physical environment design** and the **environmental graphic design** (Weisman, 1981, p.202; O'Grady and O'Grady, 2008, p.72; Helvacıoğlu and Olguntürk, 2011, p.410; Li and Klippel, 2012, p.35). The physical environment design composes both the complexity of the physical configurational layout and the visibility of the configurational structures. Environmental graphic design provides cues and information needed to complete a wayfinding task (Arthur and Passini, 1992, p.55). Ambiguous information adds uncertainty to decision execution. When a wayfinder fails to comprehend a space successfully, disorientation happens, with the result that the wayfinder is lost in the physical space (Arthur and Passini, 1992, p.23; Cornell and Greidanus, 2006, p.230; Vandenberg, 2016, p.19). Therefore, wayfinding design has a fundamental emotional and practical significance to wayfinder (Lynch, 1960, p.4).

2.2.2.6 The importance of wayfinding design

Based on the literature, wayfinding design is critical to wayfinders in two ways. To provide prompt effective wayfinding information to ensure mental wellbeing during the wayfinding journey.

Functional importance: Wayfinding requires consistent interaction with the spatial environmental characteristics (Garip, 2011, p.1771) and environmental graphic design from the immediate surroundings to maintain the sense of direction and locomotion movement (Montello, 2010, p.257; Garip, 2011, p.1771). The available information cues directly identify

the legibility of the physical environment. At the same time, the planning of the informational cues is highly confined by the physical environment (Ittelson, 1960, p.212; O'Grady and O'Grady, 2008, p.72; Montello, 2010, p.274; Garip, 2011, p.1771). The physical environment layers the basic configuration, such as height, size, shape, colour or lighting. At the same time, information cues play a key role in being able to discern the physical environment to support wayfinding decision making.

Emotional importance: poor wayfinding design can have negative affect on the emotions during the wayfinding task. When a wayfinder is experiencing disorientation in the task, symptoms such as stress, increasing blood pressure, desperation, and tiredness are likely to occur (Lawton, 1996, p.137; Calori and Vanden-Eynden, 2015, p.2; Kanakri et al., 2016, p.251).

2.2.2.7 The impact of wayfinding difficulties

Being able to navigate from place to place is essential to daily human life. The absence of confidence in wayfinding can have unfavourable consequences on mobility and well-being (Gibson, 2009, p.14; Hunter et al., 2016b, p.4). Establishing this confidence relies on the wayfinding design to fulfil its both functional and emotional importance. There are four major consequences resulting from wayfinding difficulty.

a) **The frustration and stresses:** Failure to find one's way around in a physical space often result in frustration and stress. However, because emotional distress is deemed to be less harmful than physical harm, failure to acknowledge the importance is seen in service providers (Arthur and Passini, 1992, p.7).
b) **Functional inefficiency:** People wander purposelessly and eventually become lost. When the wayfinding system is poorly designed, it increases the time one needs to complete a wayfinding task and induces frustration and stress (Arthur and Passini, 1992, p.8).
c) **Accessibility:** Research has shown that wayfinding difficulties are amplified for the disabled population. The wayfinding project should focus on physical barriers and psychological barriers. The physical barriers are well-identified in literature, translated into design guidelines and supported by legislation. People with sensory disabilities such as visual impairment are less supported in the current wayfinding system design (Arthur and Passini, 1992, p.9; Hunter et al., 2016b, p.11).
d) **Safety:** People who enter a building also need to know how to exit it. Sometimes they need to do this in a time efficient way. Emergency evacuation is a crucial problem as the physical setting grows larger and more complex. It raises an extra challenge for disabled (Arthur and Passini, 1992, p.10).

2.2.3 The significance of signage graphic design in wayfinding design

2.2.3.1 Flexibility in wayfinding information communication

As the influences of the physical environment are permanent, signage graphic design is a flexible environmental graphic tool to bring order to a complicated physical environment, thereby enhancing legibility of spatial configuration. Compared to verbal instruction or digital media, signage graphic design has a significant advantage in facilitating wayfinding satisfaction by providing consistent information support about the direction, orientation, location and regulation thus reducing the effort to memorise the information (Gibson, 2009, p.46; Barclay and Scott, 2012, p.37; Kanakri et al., 2016, p.255). Moreover, signage graphic design facilitates the fulfilment of the functional and emotional importance of the wayfinding design (Passini and Proulx, 1988, p.251; Barker and Fraser, 2004, p.21; Gibson, 2009, p.46; Calori and Vanden-Eynden, 2015, p.2).

2.2.3.2 Fulfilment of the essential information needs

Most wayfinding difficulties occur during the cognitive step of the information processing (Arthur and Passini, 1992, p.33; Vandenberg, 2016, p.19). The environmental graphic information reflects the characteristics of the physical surroundings, and it provides relevant information to help the user make and execute decisions along any given route. The availability and legibility of the environmental graphic information have a directly impact on the result of the wayfinding outcome.

As one of the most predominant environmental graphic information, wayfinding signages graphic design directly associated with the wayfinding task are the key to reaching the wayfinding closure (Passini and Proulx, 1988, p.227; Arthur and Passini, 1992, p.50; O'Grady and O'Grady, 2008, p.72; Rousek and Hallbeck, 2011, p.771; Vilar et al., 2014, p.511; Kanakri et al., 2016, p.255). Signages are able to provide the three basic information (Arthur and Passini, 1992, p.45; Calori and Vanden-Eynden, 2015, p.11) that wayfinders need to be able to travel around an unfamiliar setting:

a) **Orientation and general information** about the setting: this information facilitates decision-making, and it provides information about the setting, where the user is and where the destination is.
b) **Directional information** to the destination: this information facilitates decision-executing, it directs user to the destination.
c) **Identification of destination**: this information concludes and facilitates the decision-making/executing process; it provides assurance and closure to the user.

Through these types of information, signage enhances the clarity and the legibility of the spatial structure, visually unifying the physical environment (Calori and Vanden-Eynden, 2015, p.6; Alta Planning + Design, 2019, p.21), enhancing the wayfinder's mental wellbeing and safety (Arthur and Passini, 1992, p10) thus creating a pleasant wayfinding experience (O'Grady and O'Grady, 2008, p.72; ATKINS, 2014, p.54).

2.2.3.3 Versatile graphic tools

Four types of graphic tools are commonly used for visual communication in the environmental graphic design, as shown in *Figure 2-6 Types of environmental graphic visual tools.*

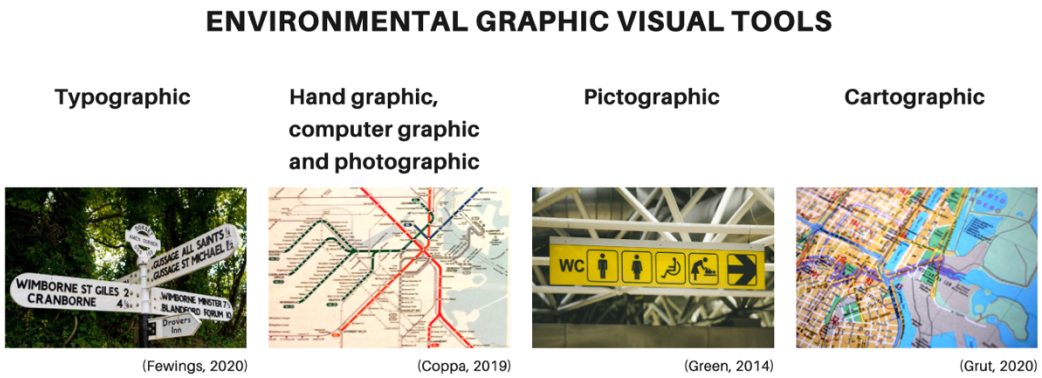

Figure 2-6 Types of environmental graphic visual tools

a) **Typographic**: typography is the most used communication on a sign. It assumes the user is literate and can read. Therefore, it is best to combine pictographic with typographic messages (Arthur and Passini, 1992, p.142).
b) **Hand graphic, computer graphic and photographic**: drawings created by hand or computer can be useful to illustrate reality in a simple form, which helps the user to understand their surroundings. Photography follows the same functionality as hand drawing and computer-generated graphics, and they portray reality (Arthur and Passini, 1992, p.142).
c) **Pictographic**: glyphs, symbols, and pictographs (often used as synonyms) are used in signs that, through the combination of colour and shape, provide a level of meaning which elevates the simple meaning of the symbol itself. Symbols take an abstract form but strive for realism (Arthur and Passini, 1992, p.142). A small number of symbol signs could break down the barrier between language and literacy, which can be present without the presence of clarification (Boersema and Adams, 2017, p.304).

d) **Cartographic**: Maps are commonly used in environmental communication. However, many people have trouble using maps.

As computer graphics and cartographic are often used independently, whereas signage graphic design incorporates both typographic and pictographic. In addition, by combining the usage of other design components like colour and shapes, signage graphic design is able to offer constant and clear visual cues along the route to assist wayfinders in processing information and making decisions with less mental effort (Arthur and Passini, 1992, p.142; O'Grady and O'Grady, 2008, p.72; Kanakri et al., 2016, p.255).

2.2.3.4 Signage graphic design categorisation

As discussed in the previous section *(2.2.3 The significance of signage graphic design in wayfinding* design*)*, signage design is crucial to wayfinding and needs to be both flexible and versatile. In order to understand the potential signage graphic design in improving the effectiveness of the wayfinding system, it is important to understand the types of signages available to be utilised.

The categorisation of wayfinding signage is often identified in two different contexts in the literature. The first context of categorisation groups wayfinding signages according to the information it provides (Arthur and Passini, 1992, p.150; Barker and Fraser, 2004, p.22; Gibson, 2009, p.46; Calori and Vanden-Eynden, 2015, p.91 ; RGD, 2019, p.75). The sign-information-based categorisation includes ***Information Sign, Directional Sign, Location Sign,*** and ***Regulatory Sign***.

The second context of categorisation groups wayfinding signages based on where the signage is placed in a wayfinding system (Calori and Vanden-Eynden, 2015, p.91; Alta Planning + Design, 2019, p.36). The sign-placement-based categorisation **includes *Decision Sign, Turn Sign***, and ***Confirmation Sign***.

The only difference between these two categorisations is signage being named differently due to the difference in context. These two categorisations are not mutually exclusive. For example, signage with an arrow is considered a directional sign in the sign-information-based categorisation because of its characteristics. It can also be considered a decision sign or turn sign because of its placement in a wayfinding system.

As shown in *Figure 2-7 Signage information and categorisation*, the sign-information-based categorisation has the advantage of coherence and corresponds to the three types of basic information signage provide that discussed in *2.2.3.2 Fulfilment of the essential information needs*. Moreover, each group of signage in this categorisation possesses its unique signage

layout, and this would be beneficial to future signage graphic design and development. Therefore, this thesis will adopt the sign-information-based categorisation model in future research and discussion.

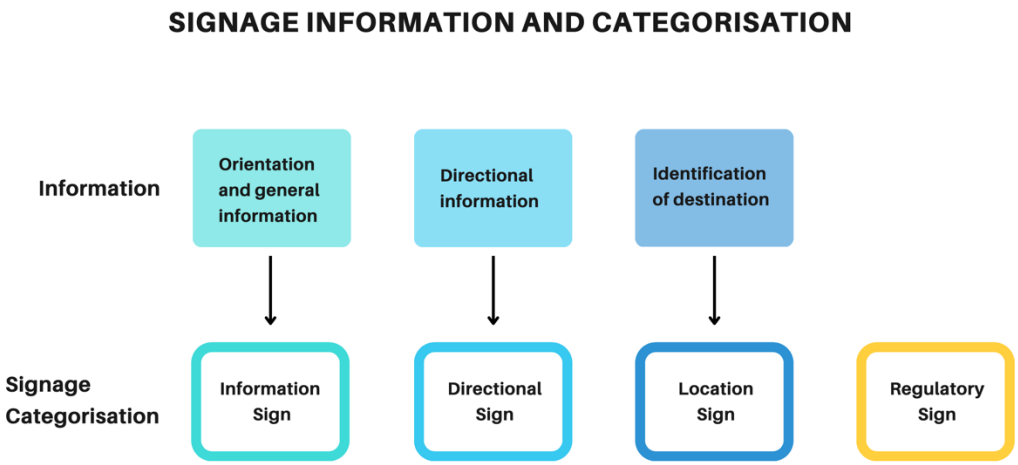

Figure 2-7 Signage information and categorisation

2.2.3.5 Signage categorisation based on signage information

Figure 2-8 Examples of information signs (Yuan, 2018, p.26)

Information Sign: or orientation sign, offers wayfinders a comprehensive view of the spatial environment in the form of a map, plans and directories (Arthur and Passini, 1992, p.143; Gibson, 2009, p.46). Information signs usually take the form of large freestanding units or wall-mounted, readily visible to wayfinder (Arthur and Passini, 1992, p.143; Barker and Fraser, 2004, p.22). In this thesis, signages with comprehensive information about surroundings, in some interior cases, the multi-level information is considered information signs.

Figure 2-9 Examples of directional signs (Yuan, 2018, p.28)

Directional Sign: is the most recognised sign by wayfinders because it always helps them navigate a way to the destination (Arthur and Passini, 1992, p.143; Calori and Vanden-Eynden, 2015, p.91). It provides prompt cues to help the wayfinder keep moving through the space (Gibson, 2009, p.46). It contributes to the circulatory system of a wayfinding programme. The typical directional sign has the layout of a simple message accompanied by an arrow to direct

the wayfinder (Calori and Vanden-Eynden, 2015, p.91). Commonly, a single directional sign carries several destination messages in one cluster of signs; arrows are often used to differentiate the directions (Barker and Fraser, 2004, p.22). In this thesis, signages with arrows that indicate the direction to locations are considered directional signs.

Figure 2-10 Examples of location signs (Yuan, 2018, p.31)

Location Sign: confirms the wayfinder's arrival at a destination (Calori and Vanden-Eynden, 2015, p.91). It signifies the closure to the wayfinder by indicating the arrival (Vandenberg, 2016, p.19) and gives the first impression of a destination (Gibson, 2009, p.46). Location signs communicate the identity of the location with the typography message or actual logo. It also suggests a certain image of the destination once the location has been reached. Location sign appears at individual destinations to indicate a location, a service, or a room (Barker and Fraser, 2004, p.22; Calori and Vanden-Eynden, 2015, p.91). Location signs are installed at the beginning and the end of the path to indicate the entrance or exit to the primary and secondary destination. It always appears without the arrow and may contain one or several levels of information (Gibson, 2009, p.46; Calori and Vanden-Eynden, 2015, p.91). This thesis considers a location sign as one single message to indicate the identity of a location or some pair with a small arrow to indicate the entrance of the location.

Regulatory sign: is regulated by legislation or organisation such as The International Organization of Standardization (ISO) or Royal National Institute of Blind People (RNIB). This group of signs usually included safety signs (i.e., fire signs, emergency exits), warning signs and prohibition signs. It is suggested to be more beneficial to follow the local regulation than to

make one's own (Barker and Fraser, 2004, p.22; Gibson, 2009, p.54). Therefore, this thesis will only address the issue considering the prior three groups of signs mentioned above.

2.2.3.6 Wayfinding difficulties and the goal of signage graphic design

Wayfinding difficulties surface when it is a struggle to navigate in a physical environment. Wayfinding difficulties could vary both from the individual and the situation encountered (Frankenstein et al., 2012, p.165; Sanford, 2016, p.83). Often these difficulties result from the disconnection between the physical environment and the information designed to provide clarity. The physical environment provides the most basic wayfinding cues, such as entrances, exits, paths and vertical accesses. Graphic information reinforces the circulation in more detail and assists the wayfinder to build a mental image of the surroundings (Arthur and Passini, 1992, p.51). However, wayfinding users often encounter two major difficulties with the information:

a) The information may not be legible due to obstruction, bad placement, too small, blurred, or tactilely hard to be noticed.
b) The information may not be readable or understood, even when it can be recognised.

Therefore, the **availability**, **legibility**, and **readability** of the wayfinding information determine whether wayfinders are able to understand the spatial environment and the outcome of the wayfinding (Barthel, 1995, p.65; Lawton, 1996, p.137; Bradley and Dunlop, 2005, p.402; Stewart et al., 2008, p.333; Garip, 2011, p.1770; Quinones et al., 2011, p.1647; Chandler and Worsfold, 2013, p.926; Galea et al., 2017, p.908; Giudice et al., 2018, p.260; Šakaja, 2018, p.18). As wayfinding is continuous spatial problem solving that involves mental efforts and physical movement. This means the goal of wayfinding signage graphic design is to consistently assist wayfinders in identifying locations and reaching the destination by providing legible and readable wayfinding information.

2.3 Wayfinding signage graphic design and partially sighted individuals

Being able to find one’s way from place to place is essential to daily human life. The absence of confidence in wayfinding can have unfavourable consequences on personal mobility and well-being (Gibson, 2009, p.14; Hunter et al., 2016b, p.4). Signage graphic design is significant in fulfilling both the functional and emotional importance of wayfinding design by providing information to wayfinders to help them to understand the physical environment and plan their wayfinding journey. Therefore, based on what was discussed in *2.2.3.6 Wayfinding difficulties*

and the goal of signage graphic design, the availability, legibility, and readability of wayfinding signage design determine the effectiveness of the wayfinding system in public spaces.

However, it has been identified by studies that the major wayfinding problem in public spaces is that the signage system cannot offer effective wayfinding instructions to wayfinders who needs to get around the setting (Wilson et al., 1997, p.213; Hölscher et al., 2006, p.284; Rousek et al., 2009, p.531; Polger and Stempler, 2014, p.89; Symonds, 2017, p.60), studies have shown this issue is significant to partially sighted wayfinders (Rousek et al., 2009, p.531; Khattab et al., 2015, p.157; Obeidat and Rashid, 2017, p.8). This could raise a series of challenges for partially sighted to access public spaces and engage in social activities. Potential issues related to signage design, such as the size of the signs, illumination, placement and obstructive decorative issues, are pointed out by very few studies (Rousek et al., 2009, p.531). There is a lack of understanding of the influence of sight loss experience on wayfinders' signage graphic design needs. To identify a potential solution to increase the effectiveness of signage system for them, it is important to understand the characteristics of this user group. Therefore, the following sections of the literature review will discuss the partially sighted individuals' capacity to use wayfinding signage and the potential of signage graphic design to improve the effectiveness of the wayfinding system for them.

2.3.1 Sight loss and wayfinding spatial competence

Sight loss affects people of all ages and circumstances. The number of people with sight loss in the UK has been drastically increasing. Every day approximately 250 people (one per six minutes) start to lose their sight. It is estimated that there are approximately two million partially sighted people in the UK, and it is expected to double to four million by 2050 (RNIB, 2016; RNIB, 2017). Traditional products, such as magnifiers, guide dogs, and white canes, only meet the needs of one user group who is experiencing substantial blindness. The majority of partially sighted individuals have *"functional vision,"* (which refers to what a person can see) for example, they might have peripheral vision or tunnel vision or are only able to see in certain light conditions; this varies amongst individuals' conditions (RNIB, 2014). Therefore, when wayfinding signage design in public spaces is designed with the standard of an adequate vision designer, millions of people are left 'out of the space'.

Several scholars debated whether blind individuals acquire wayfinding spatial-cognitive competence. The early answer provided by Fletcher (1980) assumed that either the congenitally blind individual does not acquire the ability of spatial thought at all; or that the blind individual possesses the same ability as fully sighted to process and understand spatial

concepts. Any differences can be explained by intervening variables such as access to information, experience, or stress (Fletcher, 1980, p.385).

The later studies provided more in-depth evidence of the sight loss individual's wayfinding competence. Passini and Proulx (1988) compared the spatial representing[2] outcome of 15 congenitally blind and 15 controlled sighted subjects in an experiment. Subjects were asked to remodel a route they had learned. Although a certain environment feature is more important to one group than the other, a third of congenitally blind can model the route without any errors and retain a general understanding of the spatial attribute of the setting. This proves that a partially sighted individual acquires spatial-cognitive ability and is more than capable of learning and modelling the physical environment. Passini et al. (1990) carried out another experiment to test the spatial-cognitive competence of partially sighted individuals in performing wayfinding tasks. The experiment took place in an artificial labyrinth setting with 90 subjects divided into five groups with different sight conditions, including congenitally blind, adventitiously blind, subjects with weak visual residue, blindfolded fully sighted, and fully sighted subjects as the control group. The test assigns subjects eight basic wayfinding tasks, such as learning, inversion a route and pointing tasks in the labyrinth setting. Although it takes longer for the congenitally blind subjects to complete the task, they surprisingly performed better than blindfolded subjects, adventitiously blind subjects and residual vision subjects. This proves that visual impairment does not take away individuals' ability to perform wayfinding tasks.

Golledge et al. (1996) reinforce previous studies (Passini and Proulx, 1988, p.227; Passini et al., 1990, p.91), who suggest that congenital blind's spatial abilities such as exploration and obstacle avoidance, turning angles and understanding the configurational environment are yet to be compromised. Kitchin et al. (1997) concluded the previous studies and added the third theory, which asserts that congenitally blind individuals can understand and mentally manipulate spatial concepts, but their information is based upon auditory and haptic cues. This level of knowledge and comprehension might be inferior to what is based on the vision.

There was still uncertainty about how sight loss affects individuals' learning, storing, and processing of spatial information. Fortin et al. (2008) reinforce the earlier findings and give a reasonable answer to the question that has been argued for decades. The research found that when subjects perform a complex route learning task, significant advantages in navigation

[2] Spatial representing: is a research tool that helps researcher to understand the individual understanding of the external physical environment (Fletcher, 1980, p.381).

skills and learning outcomes were found in the blind group compared to the blindfolded, fully sighted group. Additionally, a significant increase in the hippocampus volume was found in blind individuals, regardless of the time the individual acquires the blindness. Fortin et al. (2008) argue that comparing sighted individuals using vision, the congenitally blind individuals use an idiothetic strategy to help to shape the environmental representation.

These findings (Passini and Proulx, 1988, p.247; Passini et al., 1990, p.114; Golledge et al., 1996, p.242; Kitchin et al., 1997, p.225; Fortin et al., 2008, p.3001) push back the speculation of the deficiency theory have been made to reject congenitally blind individuals' wayfinding competence. It gives wayfinding scholars a fresh perspective and understanding of the spatial-cognitive ability of blind populations. However, the condition of blindness is more than binary but a spectrum. Moreover, what was discovered confirmed the wayfinding competence of the sight loss individual but is still far from explaining the wayfinding needs of the partially sighted wayfinders.

2.3.2 Impact of sight loss on wayfinding performance

Based on the time of the blindness developed, sight loss individuals can be classified as **congenitally blind** (born with the blind condition), **early blind** (acquire blindness before seven) and **adventitiously blind** (acquire blindness later in life) (Rieser et al., 1980, p.185; Kitchin et al., 1997, p.225; Struiksma et al., 2009, p.145; Wan et al., 2010, p.347; Chebat et al., 2015, p.1; Maidenbaum et al., 2016, p.1; McDonald and Rodrigues, 2016, p.1).

Although sight loss might seem to cause a major inconvenience in blind individuals' daily life, Wan et al. (2010) found that blind individuals have developed different strategies to compensate for their defect of vision according to the time they acquire the blindness. This is also reflected in the sight loss individual's wayfinding behaviours (i.e., early blind individuals have enhanced auditory skills to help them navigate). Apart from the advantage of route learning mentioned earlier, congenitally blind was also found to have superiority when performing with haptic spatial configurational information (Postma et al., 2007, p.1262; Šakaja, 2018, p.18) and auditory tasks (Mereu and Kazman, 1996, p.14; Wan et al., 2010, p.344).

Like congenitally blind, adventitiously blind is acknowledged by acquiring different spatial cognitive knowledge rather than underdeveloped (Jacobson, 1998, p.303). Ungar (2000) experimented to explore blind individual's experience and their mental representation of physical space. The observation indicated a high similarity between adventitiously blind and fully sighted when subjects performed a range of wayfinding tasks. The experiment results show that when wayfinding tasks require subjects to memorise the spatial configuration,

congenitally blind, early blind and adventitiously blind have shown a significant advantage in completing the tasks over the fully sighted. Simultaneously, congenitally blind perform poorly when the task involves interfering with the actual physical environment.

Ungar (2000) argues that regardless of the time an individual acquires the blindness, there is no difference in the ability of environmental configuration comprehension, lack of visual experience is the main cause of their shift of wayfinding strategy, where the reason white cane, prescription glasses were employed to compensate the defect of vision (Ungar, 2000, p.12). Consequently, it is important to acknowledge the importance of visual experience to sight loss individual's wayfinding understanding and performance.

2.3.3 Challenges for partially sighted wayfinders

Wayfinding is a destination-oriented exploration, it is essential to individual mobility (Passini and Proulx, 1988, p.228; Golledge, 1993, p.75), and to complete one wayfinding task requires individuals' both cognitive and behavioural efforts (Arthur and Passini, 1992, p.27; Vandenberg, 2016, p.23). The cognitive effort requires information processing, decision making, and behavioural effort to reflect the decision execution (Arthur and Passini, 1992, p.28). Kitchin et al. (1998) found that partially sighted and blind people experience two basic types of spatial confusion when at the mental stage of information processing. ***"Self-produced confusion"*** is usually caused by one's misperception of the environment, and ***"situational confusion"*** is usually caused by a permanent or temporary situation such as construction works within the surroundings. Both confusions promote negative feelings and lead to anxiety, embarrassment, frustration and loss of self-confidence (Arthur and Passini, 1992, p.8; Lawton, 1996, p.137; Gibson, 2009, p.14; Hunter et al., 2016b, p.4; Kanakri et al., 2016, p.251; Heylighen et al., 2017, p.512; McDonald-Yale and Birchall, 2021, p.1). Kanakri et al. (2016) suggest that **situational confusion** manifest as a perceivable difficulty that is positively associated with the level of stress, which might lead to an unsatisfactory wayfinding performance (Lawton, 1996, p.137). This point recognises and agrees with the emotional importance of the wayfinding design. The failure of the wayfinding design might lead to dis-orientation and negative impacts on emotional wellbeing (Arthur and Passini, 1992, p.67; Lawton, 1996, p.137; Calori and Vanden-Eynden, 2015, p.10; Kanakri et al., 2016, p.251).

However, the current building and signage graphic design guidelines do not guarantee the optimum experience of wayfinding functionality or emotional response (Rousek et al., 2009, p.531; Obeidat and Rashid, 2017, p.8). To provide a more satisfactory and effective wayfinding

design to fulfil the partially sighted individuals' practical and emotional needs. It is crucial to understand partially sighted wayfinders' needs from wayfinding design.

2.3.4 Sight loss and wayfinding strategy

2.3.4.1 Two types of wayfinding information models

There are two types of wayfinding information models that wayfinder develops during a wayfinding journey regardless of one's vision.

1) **Route-type information model** consists of **Route Information**: the unit-based sequential information placed along the route to a destination. It takes the shape of signage, landmark or configurational characteristics. For instance, one gets to a destination and relies on the direction from a series of different landmarks or signages along the route. This series of landmarks or signage along the route is considered route information. Route information could also be gathered from verbal instruction or through other sensations. Female wayfinders often utilises route information when completing a wayfinding task (Verghote et al., 2019, p.2).
2) The **survey-type information model** provides individuals with **Survey Information**: a built visualisation of the environment configuration. It takes the shape of a map, floor plan, or 3D model. For instance, the city map and shopping mall floor plan are typical forms of survey information. Survey information offers a holistic view of the environment configuration, and it produces higher accuracy in wayfinding results. This is especially significant for low spatial cognition individuals (Verghote et al., 2019, p.9). Male wayfinders tend to utilise survey information when completing a wayfinding task (Noordzij et al., 2006, p.321; Verghote et al., 2019, p.9).

2.3.4.2 Wayfinding strategy of partially sighted wayfinders

Due to their visual impairment, people who are partially sighted and those who are fully sighted individuals employ different strategies to acquire spatial knowledge and carry out wayfinding tasks (Ungar, 2000, p.7). Based on personal experiences, both groups of individuals frequently employ the same approach to acquire spatial information (Lawton, 1996, p.137; Verghote et al., 2019, p.2).

In general, the fully sighted individual acquires spatial knowledge by constructing a survey-type information model. The survey-type information model is an **allocentric model**[3]**,** which is comprised of survey information. It is the most comprehensive form of a spatial information model. It facilitates the individual configurational understanding of the environment (Golledge et al., 1995, p.154; Verghote et al., 2019, p.2). It was indicated by previous studies (Noordzij et al., 2006, p.321; Steyvers and Kooijman, 2009, p.223) that a fully sighted individual built-up mental representation more effectively from a survey-type information model. While blind (both congenitally and adventitiously blind) do better with a route-type information model.

In contrast to a fully sighted individual, the partially sighted individual has better performance when a route-type information model was given (Noordzij et al., 2006, p.321; Hölscher et al., 2006, p.284). The partially sighted individual develops a spatial understanding based on an **egocentric model**[4]. Their information mainly came from two different channels: the direct interaction with spatial layout through locomotion; and the indirect inference of spatial information that uses the heuristics (Golledge, 1993, p.74). To make it clear, Passini and Proulx (1988) explained that the most significant difference between fully sighted and partially sighted (and blind) is that partially sighted tend to rely on units of information to compensate for the fact of lack of access to distance cues. The defect of vision is restraining their collection of information from a long distance. **This indicates the importance of route-type information to wayfinder with sight loss conditions.** When individuals lose access to the distance cue, the need for spatial information naturally shifts from the survey-type information model to the more specific sequential units of the route-type information model.

Fully sighted and sight loss individuals both can utilise survey and route type of information model. However, the partially sighted mainly rely on units of information gathered from direct interaction with the surrounding and indirect infer about the surrounding that uses heuristics (Passini and Proulx, 1988, p.227 ; Golledge, 1993, p.74). Wayfinding signage provides prompt and consistent orientation information, directional information, and identification of destination in a wayfinding system. This signifies the importance of wayfinding signage to the partially sighted wayfinder. This suggested unit-based wayfinding information model – wayfinding signage graphic design has huge potential in improving the wayfinding experience for partially sighted individuals.

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[3] Allocentric model: encode surrounding information with the respect of object to object (Martinez-Martin et al., 2014, p.2)

[4] Egocentric model: encode surrounding information with the respect of self to object (Martinez-Martin et al., 2014, p.2)

2.3.5 The potential of signage graphic design for partially sighted wayfinders

Partially sighted wayfinders have the cognitive capacity to shape a mental understanding of the surrounding spatial configurations. The performance difference compared to fully sighted wayfinders can be explained by the ability to acquire distance cues due to the mixed ability in vision. Studies have suggested that partially sighted wayfinders experience challenges from ***"self-produced confusion*** (Kitchin et al., 1998, p.34)**",** which is usually caused by mixed vision abilities and ***"situational confusion*** (Kitchin et al., 1998, p.34)**",** caused by the surrounding physical environment. Therefore, they rely majorly on unit-based route types of information to carry out their wayfinding activities. Wayfinding signage serves as the predominant unit-based information in the wayfinding system, as the goal of signage graphic design identified in *2.2.3.6 Wayfinding difficulties and the goal of signage graphic* design*,* the availability, legibility, and readability determines the effectiveness of signage graphic design for partially sighted wayfinders. To improve the effectiveness of signage graphic design for the partially sighted, it is important to investigate user experience with the current signage graphic design, and their needs in design should be reflected.

2.4 Wayfinding signage graphic design in public space - academic settings

As discussed in previous sections, wayfinding is an essential human activity associated with human mobility and general well-being. Currently, the wayfinding needs of the partially sighted are not met by the wayfinding design in public spaces. As already discussed in *2.3 Wayfinding signage graphic design and partially sighted individuals,* partially sighted wayfinders possess the mental capacity for wayfinding, and wayfinding signages are able to provide them with the unit-based route information to carry out their wayfinding activities. To improve their wayfinding experience in public spaces, there is a need to investigate their experience with current wayfinding signage design in place and their need for the signage graphic design. My choice of investigating their wayfinding experience in academic settings is discussed in the following sections.

2.4.1 Obligation required by legislation

The academic campus environment influences the general well-being of the students. Studies have shown that the campus environment which promotes a sense of positive well-being for students, facilitates success rate in higher education through academic performance, student

retention, and graduation rate (McDonald-Yale and Birchall, 2021, p.13). Moreover, the wayfinding signage system plays a role in promoting safety, accessibility and well-being on academic campus (Arthur and Passini, 1992, p.67; Lawton, 1996, p.137; Gibson, 2009, p.14; Kim et al., 2011, p.39; Hunter et al., 2016b, p.11; Kanakri et al., 2016, p.255; McDonald-Yale and Birchall, 2021, p.13). Good wayfinding design and implementation can help the campus space user reach their destination correctly and safely (Thienmongko, 2018, p.15). Inadequate design and poorly placed signs cause visual and walking disturbance, resulting in an unsatisfying walking experience (Raswol, 2020, p.1).

Based on legislation, educational institutions have the obligation to make adjustments to ensure the accessibility feature in place for the disabled (Disability Discrimination Act, 1995). Moreover, *"Access to education for youth with disabilities is enshrined within the UN Convention on the Rights of Persons with Disabilities as a fundamental human right* (Sukhai and Mohler, 2016, xxv)." However, the current wayfinding design in academic settings is not optimised.

2.4.2 The impact of lack of effective wayfinding design

Finding familiar or unfamiliar locations is a frequent task for the campus inhabitants (Kanakri et al., 2016, p.251). Navigating around an academic campus confidently is essential to visitors, students and faculty members (Brown, 1997, p.127). Stress occurs when experiencing wayfinding difficulties on academic campuses. In a case study conducted on Carleton Campus by Oyelola (2014), students expressed frustration navigating the campus space even after more than one year spent on campus. The results show this frustration is even more significant for first-time campus visitors. In the study conducted by Obeidat (2016), the researcher conducted a survey study within the KU Edwards campus to investigate the correlation between user familiarity and their satisfaction with the signage system. The result indicates that 40-60% of first-time visitor thinks that signages on campus are not appropriately located and become frustrated by the existing print signage (Obeidat, 2016, p.1). Thienmongko (2018) conducted a mixed-method study to improve the map design at Mahasarakham University (Khamriang Campus). The data gathered at the observation stage, through observing users' wayfinding behaviours in campus buildings and environment, researcher found that the lack of quality wayfinding directories imposes a significant obstacle to new and return campus visitors (Thienmongko, 2018, p.15).

2.4.3 The challenge of wayfinding in academic settings

Academic settings impose their own challenges on wayfinding signage design. Wayfinding in indoor and outdoor environments involves similar activities but imposes different challenges to wayfinders. The outdoor spaces consist of sidewalk segments and intersections, regardless of which wayfinding task takes place (Karimi, 2015, vii). The indoor building structure is less uniformed, with each building having its characteristics composed of repetitive physical obstacles such as lifts, staircases, temporary installations and additional floors. These complex structures create impediments to the spatial visibility and complicate its relationship to the immediate context of the campus environment (Karimi, 2015, vii; Kanakri et al., 2016, p.255). With the GPS technology popularly used in outdoor navigation, indoor wayfinding mainly relies on signage and landmarks. Wayfinding in indoor space poses challenges not experienced in wayfinding in outdoor environments (Srinivas and Hirtle, 2015, p.14; Karimi, 2015, vii; Major et al., 2020, p.952). Despite the importance of the wayfinding system in academic settings, little research has been done to improve the signage design on academic campuses. Research speculates that there is still the appearance of attitude in some institutions that clearly marked signs are not necessary or appropriate on campus. Few consider it is the responsibility of the architects of the building, which is not likely to get a sufficient contribution to a comprehensive signage program (Brown, 1997, p.127). There is a lack of evidence of willingness to push back this speculation. However, enough evidence indicates the user difficulties interacting with the wayfinding system on academic campuses.

The university campus is a community space for students, academics, staff and others. As a community environment, university campuses need to be accessible to all as a space where students enjoy walking and social interaction. When the wayfinding signage is hard to be accessed by fully sighted users, it could be harder for partially sighted. To better understand more effective wayfinding signage graphic design needs of partially sighted, a user-centred inclusive design approach is recommended by scholars.

2.5 User-centred inclusive signage design

2.5.1 The definition of inclusive design

British Standards Institution (2005) defines inclusive design as "*the design of mainstream product and/or service that are accessible to and usable by, as many people as reasonably possible...without the need for special adaptation or specialised design*". Inclusive design is

neither a new design discipline nor a separated design specialism but an approach which aims to address as many product/services users' needs as possible regardless of their age or ability (Carroll and Kincade, 2007, p.289; Clarkson and Coleman, 2015, p.235; Coleman, 2016, p.18). **The inclusive design encourages the involvement of a wider range of users, such as elder or disabled users, as the "lead user" in the product development process to meet more users' essential needs** (Shiose, 2012, p.107). Inclusive design proactively includes elder and disabled users in the design development process, but that does not mean designing for the sake of the minority users (Shiose, 2012, p.107). It applies the understanding of user diversity in the product/service development process, which aims to satisfy as many people's needs as possible (Waller et al., 2015, p.297). It has a major difference between specialist design and accessible design. It treats everyone equitable by seeking resonance between the needs of people in particular disabling situations and society at large (Heylighen et al., 2017, p.507).

2.5.2 User-centred design and inclusive design

Derived from the discipline of the HCI (Human-Computer Interaction) (Maguire, 2001, p.588), user-centred design concerns incorporating user perspectives at the heart of the design process (Maguire, 2001, p.588; Newell et al., 2011, p.235). One of the key strengths of user-centred design is actively involving users who have knowledge of the context in which the product/service is being used at the very beginning of the design development (Maguire, 2001, p.588). However, the traditional user-centred design method provides little or no guidance on designing for mixed-abilities users (Newell et al., 2011, p.235).

Both inclusive design and user-centred approaches encourage close interaction between designers and users. An inclusive design approach aspires to include an extremely wide range of characteristics and disabilities, which sometimes can be impossible to achieve (Newell et al., 2011, p.235). *Adaptive* and *proactive* are the two principle strategies often considered in the inclusive design approach (Keates et al., 2000, p.46). *Adaptive* strategy refers to tailoring a design retrospectively to different abilities of users. *Proactive* strategy refers to adapting the definition of users at the very beginning of the design process to include a wider range of abilities. However, because of the practicality of including as many different abilities as possible, inclusive design is often carried out with an *adaptive* strategy, 'add-on' extra to a well-designed product, which, in most cases, creates compromises for both traditional user groups and user groups with diverse abilities (Newell et al., 2011, p.235).

This thesis aims to contribute to inclusivity by investigating signage design practices that improve the effectiveness of the wayfinding signage system for partially sighted individuals.

The *proactive* inclusive design strategy provides a framework (Keates et al., 2000, p.46) to address the partially sighted individuals' user abilities at the very outset of the design problem identification stage. The user-centred design approach helps the research to establish and sustain a focus on the design requirements of partially sighted individuals. In the context of this study, 'inclusive' is addressed in consideration of the diverse vision capabilities of partially sighted. 'User-centred' is addressed in the user-centred research activities to be carried out surrounding partially sighted individuals' knowledge of the context of signage design. Therefore, a user-centred inclusive design approach defined in this thesis is taking a *proactive* inclusive design approach to involve one specific group of users through user-centred design activities to gain a better understanding of this group of users and design for them.

2.5.3 The importance of user-centred inclusive signage design in academic settings

Academic campuses host and provide a variety of programs and services, and it is important that all must be accessible and usable by everyone, especially those with disabilities (Arthur and Passini, 1992, p.67). The academic campus environment influences the general well-being, safety and academic performance of students (McDonald-Yale and Birchall, 2021, p.13). The wayfinding signage system plays an important role in promoting safety and accessibility on academic campus (Arthur and Passini, 1992, p.67; Lawton, 1996, p.137; Gibson, 2009, p.72; Hunter et al., 2016b, p.11; Kanakri et al., 2016, p.255; McDonald-Yale and Birchall, 2021, p.9).

Partially sighted individuals rely heavily on units of information gathered from direct interaction with their surroundings to help shape their understanding of the physical environment (Passini and Proulx, 1988, p.227; Golledge, 1993, p.65). This suggests the importance of a more inclusive wayfinding signage system for partially sighted individuals.

The inclusive design approach improves the accessibility, opportunity, and usability of the built environment for all user groups (Alnawaisri, 2019, iv). **The user-centred inclusive design emphasises understanding a specific diverse user group, which then informs better design decisions** (Heylighen et al., 2017, p.513). Staeger-Wilson et al. (2012) involved both abled and disabled students in the campus recreation centre conceptualising and design process. The results show a higher quality design outcome following collection of data from user experience through the inclusive design process, leading to university campus becoming more user-friendly for students. This signifies the potential of involving partially sighted individuals in the signage design development process.

2.5.4 The challenges of user-centred inclusive signage graphic design

The user-centred design approach involves users in four stages of research activities to ensure usability and cost-effective and sustainable design solutions (Abras, 2004, p.12; Vermeeren et al., 2010, p.521): 1) Understanding and specifying the context of use, 2) Defining the user requirements, 3) Producing design solutions, and 4) Evaluation (Bevan, 2008, p.3; Bevan, 2009b, p.110; Bevan and Curson, 1998, p.111).

In theory, the benefit of introducing this user-centred inclusive design approach to signage graphic design for partially sighted individuals means reducing the required ability for them to be able to use the signage. This can then improve the user experience for a broader range of users in various using situations (Waller et al., 2015, p.297). Developing more effective signage graphic design can reduce health and safety risks and increase user satisfaction, increasing the attractiveness of the built environment and saving unnecessary costs from accidents and safety failures (Alnawaisri, 2019, p.10).

However, evidence shows a gap between user-centred inclusive design theory and practice. **Firstly**, in the context of industries, companies are confined by design constraints such as time and cost (Dong et al., 2003, p.112). It is challenging to make a client understand the importance of inclusive design and implementing user-centred inclusive design principles to achieve sustainability of the built environment, as it either adds cost or hinders some of the requirements desired by the owner (Alnawaisri, 2019, p.17). **Secondly**, the generic design process which the design consultancies follow has little involvement of the users due to a lack of experience working with people presenting different capabilities and time and money constraints (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289). **Thirdly**, the design process of traditional consultancies typically does not include explicit design assessment. Some occasionally carry out an informal assessment within which the designer plays the role of the consumer. Designers tend to rely on their personal experience and accessible information from, i.e., their co-workers, friends, or family members, which leads to the consequences of the user being more remote from the designer than from clients (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289). **Fourthly**, people of different ages, capabilities and social and cultural backgrounds have diverse needs and preferences. The concept of disability challenges the understanding of population diversity. Human ability is a spectrum rather than binary. Human needs come from a product that is also diversified under the different usage case (Waller et al., 2015, p.298). Commercial organisations overlook some minor disabilities due to the emphasis on coverage of severe disabilities and produce special design products.

Some with a minor disability might not be severe enough to meet the threshold definition of disability but may experience significant difficulty when using the product.

The user-centred inclusive design approach has been proven to be more cost-effective than implementing specific measures for certain individual cases (Heylighen et al., 2017, p.514; Alnawaisri, 2019, p.18). It is evident that valuing the disability experience led to higher design quality (Staeger-Wilson et al., 2012, p.37).

The gap between user-centred inclusive design theory and practice indicates that the challenge for implementing this approach lies in acquiring the feedback required to enhance the current design and then designing based on understanding the needs of users (Waller et al., 2015, p.301; Alnawaisri, 2019, p.18). As discussed in *2.2.3.6 Wayfinding difficulties and the goal of signage graphic* design, the availability, legibility, and readability of wayfinding signage design determine the effectiveness of the wayfinding system in public spaces. It is possible to improve the effectiveness of signage graphic design by involving partially sighted individuals in the design development process to interpret their needs and reflects on the availability, legibility, and readability of the design (Staeger-Wilson et al., 2012, p.37; Shiose, 2012, p.107).

2.6 Summary

Partially sighted individuals have the cognitive ability to wayfinding; as the predominant unit-based information in wayfinding - wayfinding signage, is significant to partially sighted wayfinders mobility, well-being and confidence. The wayfinding signage graphic design in academic settings is not effective for partially sighted wayfinders, and evidence has shown that partially sighted individuals are not satisfied with the current design. This impacts the well-being of the community and could lead to bad academic outcomes and social inequalities.

The impact of a negative wayfinding experience is discussed in *2.2.2.7 The impact of wayfinding difficulties.* Sufficient research provides evidence that some partially sighted individuals can use and desire for better wayfinding signage graphic design (Wu and Wang, 2017, p.335). However, there is little research that provides suitable answers to fulfil this desire. Most wayfinding studies for partially sighted individuals focus on the cognitive side of the partially sighted individual spatial competence (Passini and Proulx, 1988, p.227; Passini et al., 1990, p.91; Golledge et al., 1996, p.215; Kitchin et al., 1997, p.225; Fortin et al., 2008, p.2995), wayfinding confusion (Kitchin et al., 1998, p.34; Kanakri et al., 2016, p.251) and wayfinding performance (Passini and Proulx, 1988, p.227; Golledge, 1993, p.65; Mereu and Kazman, 1996, p.10; Jacobson, 1998, p.289; Ungar, 2000, p.1; Postma et al., 2007, p.1253; Wan

et al., 2010, p.344 ; Šakaja, 2018, p.1). There is a lack of understanding of what partially sighted individuals need in wayfinding signage graphic design.

The challenge of designing wayfinding signage for the partially sighted individual is that the existing design guidelines do not reflect the need of partially sighted but, instead, reflect the interpretation of what the designer thinks the partially sighted needs. Previous studies show that partially sighted individuals have difficulties accessing the wayfinding signage system in public spaces (Rousek et al., 2009, p.531; Khattab et al., 2015, p.172; Obeidat and Rashid, 2017, p.8). It became more difficult to design wayfinding signage for partially sighted individuals without understanding what does or does not work for them.

Adopting a user-centred inclusive design approach is a fantastic opportunity to help identify the wayfinding signage needs of the partially sighted. This is valuable because it would assist designers in the development of more effective wayfinding signage. The disconnection between theory and practice requires this study to commit to truly involving partially sighted individuals in the design development process. Therefore, this research proposes to adopt a user-centred inclusive design approach to involve partially sighted individuals in the design development process, in order to better identify a signage graphic design practice that improves the effectiveness of overall signage design.

Chapter 3 Research Methodology

3.1 Context and background

The current wayfinding signage design in the academic setting is not meeting the needs of the partially sighted, which could lead to frustration and impediment to their wellbeing and safety (Arthur and Passini, 1992, p.10; Lawton, 1996, p.137; Gibson, 2009, p.14; Hunter et al., 2016b, p.11; Kanakri et al., 2016, p.255; Heylighen et al., 2017, p.512; McDonald-Yale and Birchall, 2021, p.13). The ADA legislation requires academic institutions to provide an accessible service to all users. Nevertheless, little research has been done to provide integrated methods to improve the effectiveness of wayfinding signage design on academic campuses for partially sighted individuals. The industrial standard design adapts a generic approach that does not involve users during the design cycle. This leads to the poor usability of the product/service produced. However, evidence shows that involving target users at an early stage of the design development could lead to a cost-effective and sustainable solution (Abras, 2004, p.12; Vermeeren et al., 2010, p.521). Moreover, it can also lead to a more user-friendly, relaxed, and safer wayfinding experience. Therefore, this thesis will explore the value of involving partially sighted individuals in the signage graphic design process in improving the effectiveness of the wayfinding signage system in academic settings.

3.2 Overview of research position

A well-thought-through research philosophical stance constitutes the credibility of the research (Saunders et al., 2016, p.124). Therefore, I believe it is important to address my research philosophy stance and how it potentially influences my methodological choice and theory development in order to establish my role as a mixed-method researcher in this thesis.

Ontological, epistemological, and axiological assumptions

The assumption about human knowledge (epistemological assumptions), the assumption about reality (ontological assumptions) and the researcher's value (axiological assumption) constitute the research philosophical stance, which then informs the research approach, method, and the interpretation of the findings (Saunders et al., 2016, p.127; Qureshi, 2020).

*"**Ontology** refers to assumptions about the nature of reality* (Saunders et al., 2016, p.127)." Ontology concerns questions of *"what is reality? What shapes reality? What is the relationship*

between each component?" (Qureshi, 2020). In the context of this thesis, I argue in favour of one and many realities. The current wayfinding signage design in the academic setting is not inclusive enough to fulfil the functional and emotional needs of the partially sighted. There is more than one way to improve the inclusivity of signage design for partially sighted individuals. Therefore, this thesis will focus on improving the effectiveness of signage system for partially sighted individuals through signage graphic design. To achieve this, I need to capture as many of their design needs as possible. With this in mind as a priority, various research methods will be employed to gather insights from partially sighted individuals concerning the graphic design aspect of wayfinding signage.

*"**Epistemology** concerns assumption about knowledge, what constitutes acceptable, valid and legitimate knowledge, and how we can communicate knowledge to others* (Saunders et al., 2016, p.127)." Epistemology concerns *"How do we know reality or truth?"* (Qureshi, 2020). In the context of this thesis, I argue in favour of that knowledge can be measured and interpreted with the best tool available. The generic non-research-based design process that the design agencies follow has little understanding of the needs of the mixed-ability users due to a lack of experience working with people of different capabilities and time and money constraints (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289). This leads to a lack of understanding of partially sighted individuals' wayfinding signage design needs. Therefore, it is difficult for the design outcome to meet partially sighted individuals' design needs. In the context of this thesis, I aim to investigate the role of research-based wayfinding signage graphic design in improving the effectiveness of wayfinding signage design in the academic setting. Research activities will be carried out with partially sighted individuals, and tools and activities will be developed to facilitate the understanding of user experience and expectations of signage graphic design in academic settings. The participatory design approach will be adopted to further the understanding of effective signage graphic design for partially sighted individuals.

*"**Axiology** refers to the role of values and ethics within the research process,"* it concerns how the researcher deals with their value and those who participate in the research (Saunders et al., 2016, p.128). In the context of this thesis, I argue that partially sighted individuals understand their needs for signage graphic design. The researcher plays the role of providing accessible languages and tools to help translate their user needs into design practice. However, there is little research providing the methodological framework to support me in achieving that. Therefore, the goal of this thesis is to establish a research model that would

support the appropriate design decision when designing for partially sighted individuals through engagement with them in research activities.

3.3 Research approach and theory development

Pragmatism considers that "*'reality' is the practical consequence of ideas … flux of processes, experiences and practices.*" It considers *"true theories and knowledge are those that enable successful action … focus on problem-solving and inform future practice as a contribution.* (Saunders et al., 2016, p.142)." In the context of this thesis, I argue that there is more than one way to improve the effectiveness of signage graphic design for partially sighted individuals. Partially sighted individuals' experience and knowledge of a better design can be measured and interpreted as better design practice. Therefore, a mixed-method research approach is adopted to answer the research question.

This thesis follows a deductive to inductive theory development strategy. This will help me establish a good understanding of the context of the design 'problem' before I dive into finding a solution. This thesis proposes to use a research-based user-centred design approach to improve the effectiveness of wayfinding signage in academic settings for partially sighted individuals. However, there is a lack of studies identifying the design issue in academic settings for partially sighted individuals. Therefore, the research will start with exploratory activities to understand the context of signage design in academic settings and partially sighted individuals' experiences with signage design. This knowledge will support me in making informed decisions in the later inductive stage of research. Assumptions were formed to validate the research question:

- Partially sighted individuals have difficulty using the wayfinding signage graphic design in academic settings.
- There are not enough resources available to improve the effectiveness of wayfinding signage graphic design in academic settings for partially sighted individuals.
- The user-centred (inclusive) design approach improves the sustainability and usability of a product/service.
- There are user-centred design tools that are adaptable for wayfinding signage graphic design.

If these assumptions were true, I could deduce that the research-based user-centred design approach improves the effectiveness of wayfinding signage graphic design in academic settings. After these assumptions I formed based on a deductive approach, the inductive

approach will help me generate theory and validate it through the collected data. In-depth investigations will be conducted with partially sighted individuals to generate insights into using a research-based user-centred design approach to improve the effectiveness of wayfinding signage in academic settings. My data collection hypotheses are:

- Partially sighted individuals report difficulty using the wayfinding signage graphic design in academic settings.
- Partially sighted individuals are able to clear identify their needs for signage graphic design in academic settings.
- The involvement of the partially sighted individuals in the design process generates valuable insights that help us understand user needs and improve the design practice.
- Partially sighted individuals are satisfied with the user-centred signage graphic design outcomes which then leads to a better user experience.

Based on the data collected through the research, I would have evidence to support the belief that the user-centred design approach improves the effectiveness of wayfinding signage graphic design in academic settings for partially sighted individuals.

3.4 Overview of research activities

The research activities planned for this thesis are defined to meet the aim of the research and follow the research approach established in *3.3 Research approach and theory development.* The aim of this thesis is to investigate the role of a research-based user-centred design approach in improving the effectiveness of wayfinding signage in academic settings for partially sighted individuals. Therefore, four stages of research activities will be undertaken in accordance with the user-centred design defined by Bevan and Curson (1998)[5]. Deductive exploratory activities will help establish a good understanding of the context of the design 'problem'. This aligns with the first two stages of user-centred research activities: 1) Understanding and specifying the context of use; 2) Defining the user requirements.

Inductive in-depth investigations will help generate insights into the adoption of a user-centred design approach to improve the effectiveness of signage design for partially sighted

[5] A user-centred approach involves four stages of research activities: 1) Understanding and specifying the context of use, 2) Defining the user requirements, 3) Producing design solutions, and 4) Evaluation (Bevan and Curson, 1998, p.111).

individuals. This aligns with the latter two stages of user-centred research activities: 3) Producing design solutions; 4) Evaluation.

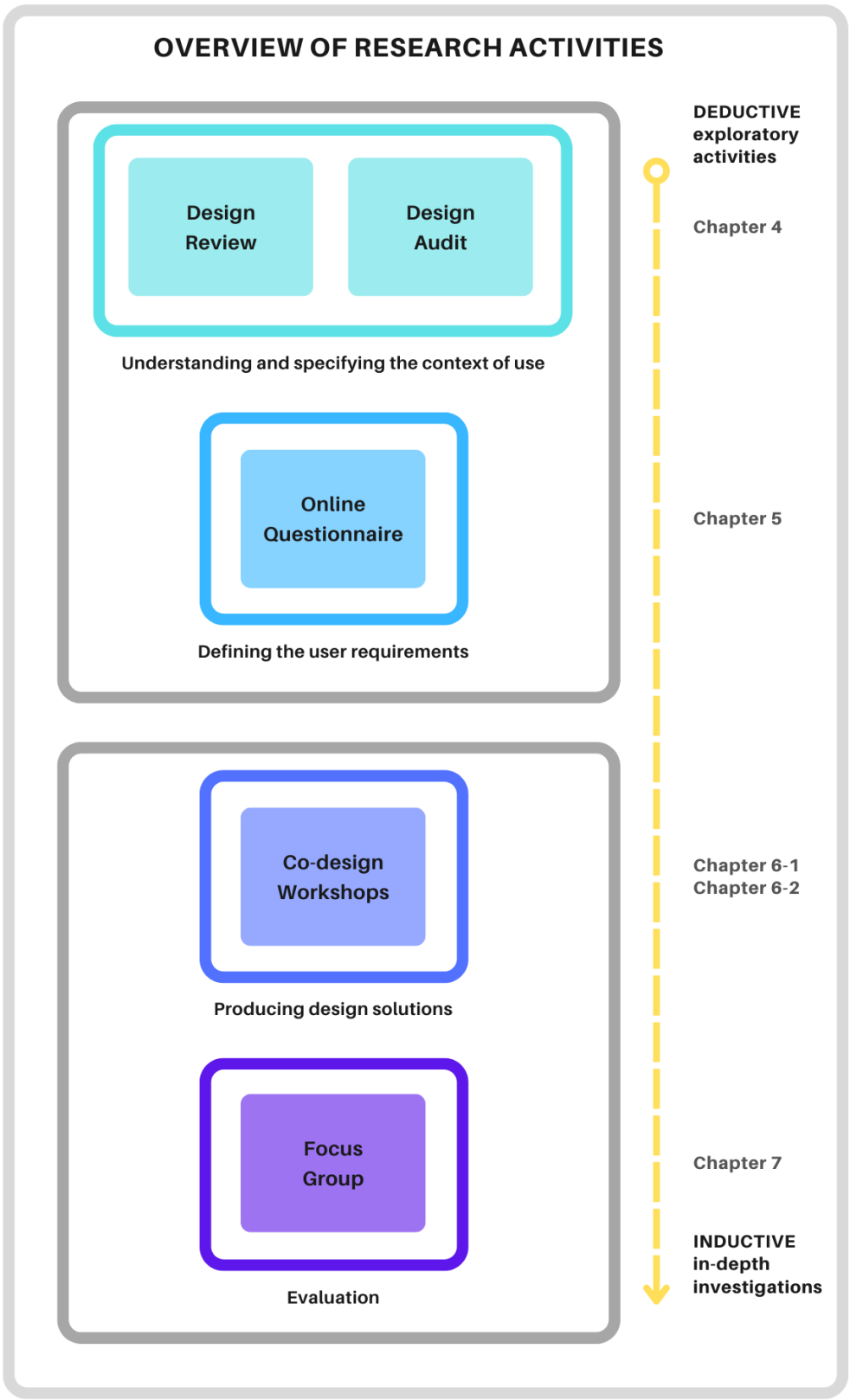


Figure 3-1 Overview of research activities

Figure 3-1 Overview of research activities presents an overview of the activities to be carried out in the thesis. The following section provides a brief introduction to these research activities, detailed procedures will be presented in corresponding chapters.

3.4.1 Understanding the context of use – design guideline review and audit

As highlighted in *2.3 Wayfinding signage graphic design and partially sighted* individuals and *2.6 Summary,* there is a lack of comprehensive understanding of partially sighted individuals' needs for wayfinding signage graphic design. This led to difficulties in designing effective signage to support their wayfinding activities. Therefore, a design review and a design audit will be conducted at the beginning of the research to explore the surrounding context of wayfinding signage design in academic settings and identify the critical design factors that contribute to signage design. This will create the basis for the later stage of user-involved research activities.

3.4.1.1 Wayfinding signage design guideline review

The signage design guideline review will be carried out to identify the design factors that are considered essential to the signage graphic design. Generic signage design guidelines published by individual scholars, design guidelines published by authorities such as ADA (American Disability Act), RNIB (Royal National Institute of Blind), and guidelines published by wayfinding design organisations will be reviewed at this stage of the study. A framework of a list of design factors that contribute to signage design is expected at the end of the review.

3.4.1.2 Design standards audit

The design standard audit will be carried out to identify the signage design factors that are essential to signage design in academic settings. Signage design standards published by (post-secondary) educational institutions will be collected through the search engine Google.com and institutions' websites. The design standard audit will help shape the understanding of the characteristics of signage graphic designs in academic settings. Cross-studying with the guideline framework will also be beneficial in identifying potential issues of signage graphic design in academic settings.

3.4.2 Defining the user requirements

As discussed in Chapter 2 *(2.6 Summary),* most wayfinding studies for the partially sighted focus on the cognitive side of the partially sighted individual spatial competence, wayfinding confusion and wayfinding performance. There is a lack of understanding of what partially

sighted individuals need in wayfinding signage graphic design. Therefore, in order to identify effective design solutions, there is a need to investigate partially sighted individuals' requirements for signage graphic design in academic settings.

3.4.2.1 Online questionnaire

The online questionnaire will investigate partially sighted individuals' experiences and opinions with wayfinding signage design in academic settings. This will help generate insights into partially sighted individuals' characteristics and issues with signage graphic design in academic settings. Participants will also be given opportunities to express their suggestions to improve the effectiveness of signage graphic design. The outcome of the questionnaire should provide an initial understanding of partially sighted individuals' needs in wayfinding signage graphic design in academic settings. These include but are not limited to users' motivation, pain points in use, design preferences, and design suggestions. The online questionnaire will help to establish and sustain a focus on the user and user needs at the beginning stage of the design.

3.4.3 Producing design solutions

The challenge of designing for mixed-ability participants is the difficulty of specifying the characteristics of the user group (Newell et al., 2011, p.236). Because the participatory design approach can incorporate user-specific requirements and insights through co-design activities (Thinyane et al., 2018, p.1; Cullen and Metatla, 2019, p.362), and co-design is considered an effective design method for people with mixed abilities (Cullen and Metatla, 2019, p.361). Therefore, I adopt a participatory approach to involve partially sighted participants in a series of co-design activities to produce an initial design solution.

3.4.3.1 Online co-design workshops

Co-design workshops will be conducted to identify partially sighted individuals' signage graphic design needs visually. Types of signs identified as essential in academic settings and reported to be challenging to use in the online questionnaire will be prototyped in workshops. During the co-design workshop activities, participants will be able to address their pain points and expectations regarding specific signage graphic design elements which identified during the design guideline review and audit. Co-design activities will be carried out independently and collaboratively to finalise the design prototype. As insights from the online questionnaire might be abstract, the outcome of co-designed signage prototypes could greatly supplement the insights from the questionnaire and depict a clearer view of partially sighted individuals'

expectations in signage graphic design specific to their vision condition. A collection of user-centred co-designed signage prototypes is expected at the end of the co-design workshops.

3.4.4 Evaluation

This thesis aims to determine the role of a research-based user-centred design approach in improving the effectiveness of the wayfinding signage system in academic settings for partially sighted individuals. Evaluation will be crucial to validate the undertaken research activities and to conclude the value of the thesis. Because the co-designed signage prototypes are developed 'by users' and 'with users' and iterated during the co-design activities. A focus group will be carried out to reflect on the value of co-designed signages and the potential of research activities in this thesis.

3.4.4.1 Online focus group

An online focus group will be carried out to reflect on co-designed signage, as well as the potential of the user-centred design approach in improving the effectiveness of wayfinding signage graphic design in academic settings for partially sighted individuals. The workshop participants will be invited to take part in the focus group. The discussion will be encompassing the theme of co-designed outcomes and the value of developed research methods that lead to the co-designed outcome. Insights into considerations to design for partially sighted participants will be generated, and the importance of a user-centred signage graphic design approach will be concluded.

3.5 Sampling and participants recruitment

This thesis aims to determine the role of research-based user-centred signage graphic design in improving the effectiveness of the wayfinding signage system in academic settings for partially sighted individuals. Therefore, the target population selected for this research study are individuals with sight loss conditions who have experience using wayfinding signage on academic campus.

There are an estimated at least 2.2 billion individuals have a near or distance vision impairment globally, of whom 1 billion have moderate or severe distance vision impairment (World Health Organization, 2020). However, finding a partially sighted participant without a gatekeeper can be challenging. Therefore, this research adopts a volunteering sampling technique, precisely, the **self-selection sampling** method. Self-selection sampling allows individuals to identify their desire to participate in the study. This is especially helpful as access

to the target research population can be challenging (Saunders et al., 2016, p.303). This approach is most beneficial for participant recruitment in the context of this thesis. I will initially publicise the needs of participants through social media such as Facebook social groups and relevant gatekeepers, institutions such as the Royal National Institute of Blind and Canada National Institute for the Blind (CNIB) mailing lists.

Word of mouth (**snowball sampling**) technique will also be adapted for recruitment after the initial publication of needs for participants. Snowball sampling is considered a technique that recruits future participants through initial contact with a few identified participants. It is commonly used to identify the difficult-to-access population (Saunders et al., 2016, p.305). Some participants might help me recruit or participate in the later stage of the co-design workshop.

The potential biases led by such sampling techniques are acknowledged. Snowballing sampling produces a homogeneous sample, which means the recruited population might share the same traits such as age, location, or employment (Saunders et al., 2016, p.303). This thesis investigates the usability of the wayfinding signage graphic design in academic settings and identifies the solutions to propose a more effective design practice for partially sighted individuals. Therefore, similar social traits should have a negligible influence on the data collection result for this study. In contrast, this sampling method could help me identify more participants, who are difficult to access.

The sample size in this study depended on the research aim and objectives (Patton, 2002, p.244; Saunders et al., 2016, p.304). Therefore, I aimed to reach data saturation at each stage of research activities rather than to reach an arbitrary fixed goal of sample numbers. For example, the data collection will be completed in the online questionnaire study when the additional data suggests a little new information.

For non-probability sampling techniques (self-selection and snowball sampling), generalisations were made for the initial understanding of an under-researched user group rather than testing a hypothesis about the population (Saunders et al., 2016, p.295). The aim of this thesis is to gather an initial understanding of partially sighted individuals' design needs from signage graphic design and address the potential and value of a research-based user-centred signage graphic design for them. These sampling techniques fit the purpose of the research.

3.6 Data processing

This thesis adopts a mixed-method approach to determine the role of research-based signage graphic design in increasing the effectiveness of the wayfinding system in academic settings for partially sighted individuals. Both qualitative and quantitative data will be obtained during the research, and different data processing methods will be used. Detailed data analysing techniques are presented in the corresponding chapters.

3.7 Ethical considerations

This study was granted ethical approval from the Faculty of Arts, Humanities and Cultures Research Ethics Committee, University of Leeds. The ethic reference: LTDESN-129. The data collection will be carried out in accordance with the ethical protocol of Data protection, anonymisation and storage and sharing of research data, and informed consent. Participants will be informed of the research activities procedure, data protection, and potential risks. Participants will be offered autonomy to withdraw from this study.

Chapter 4 Understanding Signage Design in Academic Settings – Design Guideline Review and Audit

4.1 Introduction

This chapter presents a design guideline review and audit. As highlighted in the literature *(Chapter 2 2.3 Wayfinding signage graphic design and partially sighted* individuals*),* there is a lack of comprehensive understanding of partially sighted users' needs for wayfinding signage graphic design. This has led to difficulties in designing effective signage to support their wayfinding activities. The purpose of this chapter is to develop an understanding of wayfinding signage design in academic contexts and to identify the essential graphic design variables that contribute to signage design. This chapter will lay the theoretical groundwork for next stages of user-involved research activities.

The design guideline review and audit align with the four human/user-centred design activities (Bevan, 2008, p.3; Bevan, 2009b, p.110; Bevan and Curson, 1998, p.111) that are set to be carried out in this thesis to improve the effectiveness of signage graphic design in academic settings. These activities include:

1) Understanding and specifying the context of use.
2) Defining the user requirements.
3) Producing design solutions.
4) Evaluation.

A comprehensive understanding of the surrounding context of signage design in academic settings is critical at this stage of the research. As a result, the first two research activities of this thesis will concentrate on defining the design aspects considered crucial to signage design in academic environments.

4.2 Method

A **guideline review** was carried out to identify the essential signage design factors in **generic wayfinding signage design guidelines**. Moreover, due to the lack of generic signage design principles targeted to academic settings, a **guideline audit** was carried out to audit the **wayfinding signage design standards produced by (post-secondary) educational institutions**. The guideline audit was carried out following the guideline review. These two methods will be

referred to as **the guideline review** (reviewing wayfinding signage design guidelines) and **the guideline audit** (auditing wayfinding signage design standards for academic settings) in the following sections.

4.3 Research design – The guideline review

4.3.1 Research material and procedure

Collected wayfinding signage design guidelines were reviewed in the form of content analysis, and a list of essential signage graphic design factors was expected by the end of this review.

Standards that align with the research question were established prior to searching for research material. The following materials were obtained:

1) Generic signage design guidelines for public spaces.
2) Guidelines that address the design aspect of wayfinding signage.
3) Signage design guidelines for partially sighted users.

Reviewed guidelines were obtained from the literature, wayfinding signage design organisations, and search engines such as Google Scholar. The goal of this guideline review was not to examine the quality, but rather to investigate the availability of guidelines.

4.3.2 Data analysis

Content analysis is considered a powerful analytical technique used for systematic analysis of qualitative data (Saunders et al., 2016, p.611), which helps to extract themes and define meaning from unstructured information (Martin and Hanington, 2012, p.40). The qualitative analysis tool NVivo was not considered for this review because a significant amount of material was only available in physical format. As an alternative, a document to collect all the guidelines was created, and manual type-in was the primary data organisation method. A deductive approach (Martin and Hanington, 2012, p.40) of analysis was carried out with the signage design guidelines review. A sequential content analysis procedure (Saunders et al., 2016, p.611) was followed. This procedure includes: 1) devising categories; 2) defining units of analysis; 3) coding; 4) quantitative analysis.

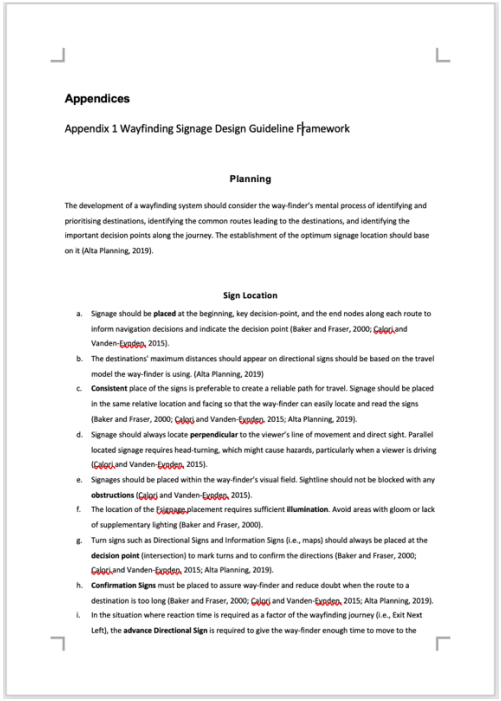
In response to the research question, factors related to signage design were used for devising the analytical categories. Categories of signage design factors emerged from samples collected in *4.3.1 Research material and procedure.* Guidelines that address the same theme were placed under the same categories on the document; the creation of these categories follows

the five principles of: 1) fitting the purpose of the research; 2) being collectively exhaustive; 3) being mutually exclusive; 4) being independent; and 5) being a single classification (Martin and Hanington, 2012, p.40; Saunders et al., 2016, p.611).

After the three major categories of signage design factors were created, guidelines gathered from their sample materials formed the basis of units of analysis and were coded under sub-categories to accommodate the variety of design factors. Guidelines address similar design ideas and indicate that identical design outcomes were combined. Eventually, all of the guidelines were reviewed and classified according to the various themes that emerged in the signage design.

4.4 Outcomes

A guideline framework was produced by the end of this review *(Appendix 1 - Signage Design Guideline Framework)*. Three main themes among reviewed guidelines have emerged: *Signage (System) Planning*, *Signage Design* and *Signage Practicality*.



Appendices

Appendix 1 Wayfinding Signage Design Guideline Framework

Planning

The development of a wayfinding system should consider the way-finder's mental process of identifying and prioritising destinations, identifying the common routes leading to the destinations, and identifying the important decision points along the journey. The establishment of the optimum signage location should base on it (Alta Planning, 2019).

Sign Location

a. Signage should be **placed** at the beginning, key decision-point, and the end nodes along each route to inform navigation decisions and indicate the decision point (Baker and Fraser, 2000; Calori and Vanden-Eynden, 2015).
b. The destinations' maximum distances should appear on directional signs should be based on the travel model the way-finder is using. (Alta Planning, 2019)
c. **Consistent** place of the signs is preferable to create a reliable path for travel. Signage should be placed in the same relative location and facing so that the way-finder can easily locate and read the signs (Baker and Fraser, 2000; Calori and Vanden-Eynden, 2015; Alta Planning, 2019).
d. Signage should always locate **perpendicular** to the viewer's line of movement and direct sight. Parallel located signage requires head-turning, which might cause hazards, particularly when a viewer is driving (Calori and Vanden-Eynden, 2015).
e. Signages should be placed within the way-finder's visual field. Sightline should not be blocked with any **obstructions** (Calori and Vanden-Eynden, 2015).
f. The location of the Signage placement requires sufficient **illumination**. Avoid areas with gloom or lack of supplementary lighting (Baker and Fraser, 2000).
g. Turn signs such as Directional Signs and Information Signs (i.e., maps) should always be placed at the **decision point** (intersection) to mark turns and to confirm the directions (Baker and Fraser, 2000; Calori and Vanden-Eynden, 2015; Alta Planning, 2019).
h. **Confirmation Signs** must be placed to assure way-finder and reduce doubt when the route to a destination is too long (Baker and Fraser, 2000; Calori and Vanden-Eynden, 2015; Alta Planning, 2019).
i. In the situation where reaction time is required as a factor of the wayfinding journey (i.e., Exit Next Left), the **advance Directional Sign** is required to give the way-finder enough time to move to the

Figure 4-1 Screenshot of guideline framework

Signage (System) Planning addresses where and when to assign signage on a wayfinding network and the types of signage needed. Twelve guidelines were collected within the *Signage (System) Planning* theme.

Signage Design addresses the graphic layout of the signage. Gathered guidelines address: language, wording, punctuation, typeface, type size, layout, information hierarchy, colour, and other design factors such as symbol, arrow, map, embossed, lift, and braille. Eighty-four guidelines were collected within the *Signage Design* theme.

Signage Practicality addresses the practical factors that need to be considered during the signage installation and post-installation maintenance. Gathered guidelines address: illumination and glare on signage, positioning of the signage, common maintenance, and signage alteration. Eleven guidelines were collected within the *Signage Practicality* theme.

4.5 Findings

4.5.1 The lack of updated comprehensive signage guidelines

As the signage design process involves signage system planning, signage design, and the practical aspect of signage installation and maintenance, a comprehensive signage design guideline must include these three aspects of signage design. A limited number of empirical publications provide comprehensive guidelines for wayfinding signage design, and even fewer are targeted at partially sighted individuals. A significant number of studies were found on individual wayfinding behaviour, sight loss pathology, and cognition facts related to sight loss and wayfinding competence. The majority of the publications provide a great understanding of how sight loss affects individual spatial-cognition abilities but a little understanding of how to design signage for partially sighted users. Most publications associated with signage design can be categorised into:

- Visual literacy (e.g., Uebele, 2007; Meuser et al., 2010; Viction:ary, 2014).
- Information design books briefly discuss wayfinding signage design (e.g., O'Grady and O'Grady, 2008; Gibson, 2009).
- Books discuss general wayfinding, signage, and architecture (e.g., Arthur and Passini, 1992, v; Barker et al., 1995; Calori and Vanden-Eynden, 2015).
- Journal paper focusing on one specific issue in wayfinding design (e.g., colour, landmark, illumination), (e.g., Helvacıoğlu and Olguntürk, 2011, p.410; Frankenstein et al., 2012, p.165).
- Accessible wayfinding signage design guidelines published by established organisations (e.g., ADA, 2010; Barker and Fraser, 2004).

One publication stood out because of its holistic coverage of signage design and complementary guidelines. The *Sign Design Guide* by (Barker and Fraser, 2004) is jointly published by the *Sign Design Society (SDS)* and the *Royal National Institute of the Blind (RNIB)*. This publication gives an insightful interpretation of the *Americans with Disabilities Act* (ADA 1991) and *Disability in Great Britain* (DSS 1999) with principles for designing signage. This publication helped build the foundation of the guideline framework.

Nevertheless, the information in this publication was more than a decade old when this research was conducted, which means it could be outdated. For example, updates of accessible design standards found in the *Americans with Disabilities Act (ADA)* (ADA, 2010) are absent in (Barker and Fraser, 2004, p.7). Guidelines such as embossed character proportion, character height, line spacing, and character spacing are inconsistent between these two publications.

4.5.2 Inconsistencies across publications

Inconsistencies across reviewed guidelines were identified. These inconsistencies emerge in three aspects: 1) Inconsistent signage naming strategy; 2) Confusing guideline arrangement; 3) Inconsistent guideline measurements; 4) Different connotations regarding accessibility.

4.5.2.1 Inconsistent signage naming strategy

The inconsistent signage naming strategy is especially significant with **information sign**. As mentioned in the literature review *(Chapter 2 2.2.3.4 Signage graphic* design categorisation*),* signage can be categorised and named based on signage information or location. For example, an information sign can also be considered both as a directional sign or a turn sign when the sign is located at a decision point. That inevitably changes how one sign is referred to because of the different contexts. Among reviewed guidelines, under the same context of signage categorised based on signage information, the information sign is also referred to as "*orientation signs"* (Arthur and Passini, 1992, p.143; Gibson, 2009, p.52), "*statutory information"*, or "*floor directory"* (Calori and Vanden-Eynden, 2015, p.95).

This might not seem like a critical issue in the design. However, it would make it more difficult for design professionals to follow guidelines. For example, this inconsistency was observed in a few independent wayfinding design proposals published by independent wayfinding design organisations. The information sign is referred to as *"information sign"* in Alvarez (Alvarez, 2019, p.17), but *"arrival totems"* and *"information board"* in ATKINS (ATKINS, 2014, p.61). Although these inconsistencies were found amongst signage design proposals that were

published independent to these guidelines, this finding indicates that the inconsistency of the generic guidelines influences the final signage design outcomes.

4.5.2.2 Confusing guideline arrangements in ADA standards

Confusing guideline arrangements were identified in the *2010 ADA Standards for Accessible Design* (ADA, 2010). The wayfinding signage system is developed following the planning, designing, and implementation (practicality) stages based on the reviewed literature. Accordingly, different specialities are involved in signage system development (Arthur and Passini, 1992, p.54; Gibson, 2009, p.32; Baker and Fraser, 2000, p.9). Therefore, signage guidelines should be categorised and fall into different themes based on the various stages of development in an intuitive sense.

However, in ADA (2010), the signage implementation (practicality) guidelines are often arranged amongst the signage design guidelines. As one of the few resources that provide signage guidelines for accessible signage design, this arrangement could affect design professionals' reading experience and design outcomes based on the *Gestalt* principles for information design (Black et al., 2017, p.425; Gab, 2018, iv). The integration of *Gestalt* principles could improve the accessibility of the information and encourage design professionals to follow the guidelines.

4.5.2.3 Inconsistent between ADA and accessible signage design guidelines

A considerable number of inconsistent guidelines were identified across reviewed guidelines; this is apparent between ADA guidelines and guidelines published with accessibility as part of the subject concern.

Guidelines such as, but not limited to, the letter spacing, line spacing, type case, and symbol size are suggested differently. For example, in generic and accessible signage design guidelines, symbols and pictograms are defined as the same design element and are recommended by similar guidelines. It is suggested that symbols and pictograms should be at least 100mm in height when space allows (Baker and Fraser, 2000, p.37). However, in *ADA 2010*, the pictogram is defined as glyphs which represent activities, facilities, and concepts, and are often accompanied by a description text below, such as the men's room sign. The symbol is defined as a *"symbol for accessibility* (ADA, 2010)*"*, which should be designed following the ISO standard examples. A minimum of 6 inches (150 mm) of field height is suggested for all the pictograms, and there were no clear size guidelines for symbol design identified in *ADA 2010*.

Apart from having different definitions of the same design factors, various measurements were found for the same design subject. For example, within accessible signage design guidelines, it is suggested to increase the space between words by 20 to 30 per cent; in the ADA, it is recommended to maintain the spacing between 10 to 35 per cent of character height. Within accessible signage design guidelines, it is suggested to increase line spacing by 15-20 per cent to maximise the readability of the text for partially sighted users; in the ADA, the line spacing between two baselines is suggested to be 135-170 per cent of the character height.

These confusions and inconsistencies increase the threshold for design professionals to decide which guidelines to follow, which makes it difficult and challenging to design better signage for partially sighted users.

4.5.2.4 Different connotations regarding accessibility

Different connotations regarding accessibility were identified among generic signage guidelines, accessible signage guidelines, and *ADA 2010*. In the generic wayfinding signage design publication, accessibility is often addressed as an independent feature. These publications acknowledge the importance of accessibility and briefly introduce the *Americans with Disabilities Act (ADA)*. However, it is important to acknowledge that the ADA is not the panacea to accessible signage design. The *ADA 2010* is designed to improve accessibility for all disabilities. There is little coverage of signage design for partially sighted users, and the majority of these guidelines are concerned with physical changes for various services and public facilities. *ADA 2010* provides a few guidelines for accessible signage design for partially sighted users. Nevertheless, it lacks guidelines for some fundamental signage layout elements based on generic guidelines such as arrows, symbols, colour, map and more. Compared to generic guidelines, few illustrative guidelines were found.

Accessible signage guidelines integrate accessibility throughout the publication, providing more informative guidelines on improving the accessibility of the wayfinding signage system. Most guidelines are presented with detailed illustrations. However, various guidelines were found to be outdated based on latest ADA regulations.

Because accessibility is presented in many contexts, different clarity regarding accessibility is evident among review guidelines. For instance, the ADA provides a detailed table on the correlation between viewing distance and the height of character size; accessibility signage guidelines show a more condensed version of this table; it is only briefly mentioned in generic wayfinding signage guidelines.

This inconsistency led to obscurity between the guidelines on relevant design subject matters for design professionals. This inconsistency could make it more difficult to follow guidelines and, as a result, develop accessible signage for partially sighted individuals.

4.6 Discussion

The available signage design guidelines can be insufficient to direct effective signage design outcomes for the sighted and partially sighted, in general, or academic settings. Wayfinding signage design is one of the two essential pieces of information for wayfinders' decision-making (Arthur and Passini, 1992, p.28); it determines the mental difficulty of the navigational task in the use of a wayfinding system (Vandenberg, 2016, p.26). Moreover, wayfinding signage design in academic settings is essential to its inhabitants' general wellbeing, safety, accessibility and even academic performance (Arthur and Passini, 1992, p.10; Lawton, 1996, p.137; Gibson, 2009, p.14; Hunter et al., 2016b, p.11; Kanakri et al., 2016, p.255; McDonald-Yale and Birchall, 2021, p.13). Findings suggest difficulties for design professionals in following the available signage guidelines to produce effective wayfinding signage; this can be the reason that the current signage design in public spaces is not fulfilling partially sighted users' wayfinding needs (Rousek et al., 2009, p.531; Khattab et al., 2015, p.172; Obeidat and Rashid, 2017, p.8).

The lack of updated and comprehensive guidelines can be more significant for partially sighted individuals. First, the accessibility consideration in generic signage design guidelines is more of a token than an integrated idea. Available, accessible signage design guidelines are not up to date with the latest accessible signage design guidelines published by *ADA Standards for Accessible Design*. As one of the only resources that provide signage guidelines targeted to partially sighted users, *ADA Standards for Accessible Design* have limited scope on signage design because it is one of its many priorities.

Partially sighted wayfinders are proven to possess spatial-cognitive competence to complete wayfinding tasks (Passini and Proulx, 1988, p.251; Passini et al., 1990, p.91; Golledge et al., 1996, p.242; Kitchin et al., 1997, p.225; Fortin et al., 2008, p.3001); they develop spatial understanding based on an egocentric model (Golledge, 1993, p.73) and they rely heavily on route-type information (Verghote et al., 2019, p.9). Therefore, signage plays a vital role for them in shaping their understanding of the surrounding physical environment. Ineffective signage design causes situational confusion (Kitchin et al., 1998, p.45) for partially sighted people during wayfinding tasks, which is reflected in their stress level (Kanakri et al., 2016,

p.251) and wayfinding performance (Lawton, 1996, p.137). The lack of updated and comprehensive guidelines for accessible signage design might have less impact on fully sighted wayfinders; for partially sighted wayfinders, signage is essential to their wayfinding activities.

4.7 Conclusion

This guideline review explored the design factors essential to wayfinding signage design and the importance of up-to-date and comprehensive signage design guidelines. Generic wayfinding signage design guidelines were reviewed, as well as accessible signage design guidelines and guidelines produced by the authority (ADA) to enforce accessibility in signage design.

During the review of guidelines, it was found that despite the availability of such guidelines, there is an inadequacy of updated and comprehensive design guidelines for signage design in academic settings or public spaces for fully sighted users or partially sighted users. Wayfinding signage is significant to partially sighted wayfinders' ability to navigate their way around unfamiliar spaces, and it is crucial to the accessibility of the campus space. The inconsistencies identified among guidelines affect design professionals' decision making and, thus, the design outcome.

Despite the inconsistencies identified in the reviewed guidelines, this review provides us with a good understanding of the surrounding context of wayfinding signage design – signage design factors that need to be considered when designing signage for public spaces. This sets the stage for future research and user-involved research activities.

4.8 Research design – The guideline audit

Understanding the context of signage graphic design in academic settings is the gateway to identifying better design solutions for partially sighted wayfinders in academic settings. The previous guideline review identified the unavailability of signage design guidelines for academic settings; the guideline audit will help us better understand the characteristics of signage graphic design in academic settings.

This audit aims to identify graphic design factors that are primarily considered in wayfinding signage design across academic settings. A content audit of the available wayfinding signage standards produced by (post-secondary) educational institutions will help achieve this goal.

Content audit is an effective way to examine the content as well as make recommendations for what is needed or lacking in the system (Martin and Hanington, 2012, p.42). The procedure of the audit follows: 1) the establishment of a content inventory; 2) auditing collected samples against an established inventory index. The outcome of the previous guideline review was used to form the inventory for the audit; an index of design factors generated from the review provided the basis for the audit table; the rules for establishing this index are introduced in *4.8.1 Review materials and procedure.* Sample materials were reviewed and audited against the established inventory index. Newly emerged design factors were also collected and coded in the audit table according to the principles of content analysis: 1) fitting the purpose of the research; 2) being collectively exhaustive; 3) being mutually exclusive; 4) being independent; and 5) being a single classification (Martin and Hanington, 2012, p.40; Saunders et al., 2016, p.611).

4.8.1 Review materials and procedure

A list of criteria was established before the search for signage standards. To answer the research question set at the beginning of this audit, the material must:

1) Reflect the wayfinding signage used in specific academic settings (interior or exterior spaces).
2) Contain a list of comprehensive signage design guidelines that addresses the aspect of signage graphic design (signage planning and signage practicality are not considered).
3) Published by a university/post-secondary education institution.

Signage standards were obtained from the internet through websites of (post-secondary) educational institutions and search engines such as *Google.com*. The search for new signage standards was completed after the data reached saturation - when no more new design factors emerged. In total, seventy-two documents published by 58 (post-secondary) educational institutions were collected. At the time this audit was conducted, six out of 58 institutions only had interior or exterior signage standards available; the majority of these documents cover the signage design guidelines for both interior and exterior campuses.

A spreadsheet was created with Microsoft Excel to audit all 72 standards. The names of the educational institutions' documents were listed in the first column. Each column from the second column onwards was used to record if these documents contain the specific design factors assigned to this column. New columns were added when new design factors emerged.

In total, 35 graphic design factors were audited. These factors were selected from the guideline framework generated from the previous guideline review.

The design factor selection procedure follows:

1) Remove guidelines that do not address a graphic design factor.
2) Bind guidelines that address the same graphic design factor.
3) Make sure all graphic design factors in the framework are covered.

These graphic design factors cover the five major signage design themes: *sign message, type, layout, colour,* and *other design elements*.

4.8.2 Data analysis

Obtained wayfinding signage design standards were audited according to the five themes of graphic design factors. Following the procedure introduced in *4.8 Research design – The guideline audit,* each of the 72 design standards was audited against the established 35 graphic design factors. The corresponding cells on the data sheet were marked when one standard contained any of the 35 listed graphic design factors, and extra columns were added when new graphic design factors were found. The 'Popularity' of identified graphic design factors was calculated in the last row of this spreadsheet. The popularity in this audit was defined as the average time of each graphic design factor found in 72 audited documents. A percentage of this value was calculated.

$$\text{Popularity} = \frac{\text{times one design factor found}}{\text{number of signage design standards}} \times 100\%$$

This value shows which graphic design factors were most and least considered in wayfinding signage design in academic settings. This helps identify graphic design factors that are essential to wayfinding systems in academic settings.

4.9 Results

This section presents the results of the guideline audit. In total, 72 design standards were reviewed and audited, covering the signage design on 58 independent (post-secondary) academic campuses. Five major signage design themes (*Sign Message, Type, Layout, Colour,* and *Other Design Elements*) were audited. A list of design factors primarily considered in the reviewed campuses was identified. The 'popularity' of each design factor was calculated.

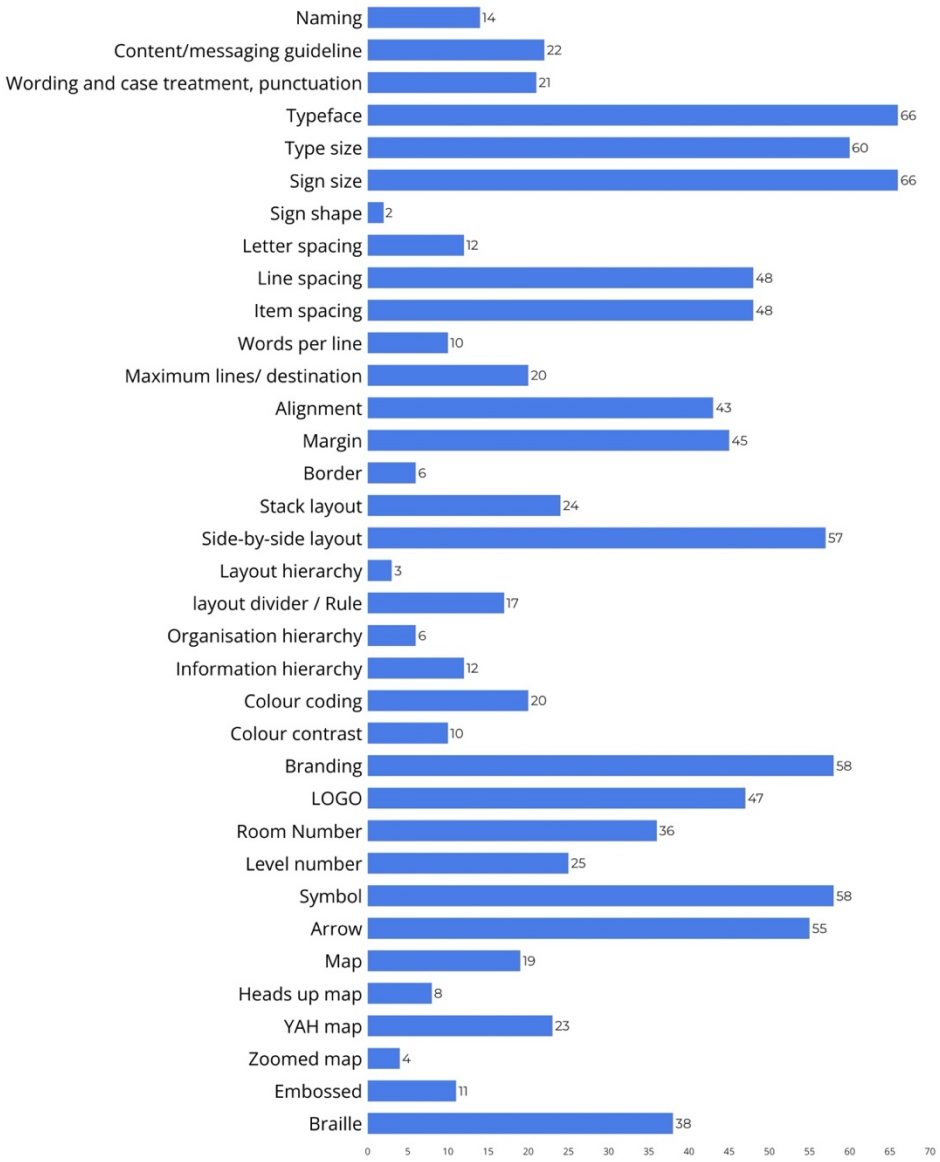


Figure 4-2 Glance of guideline audit data (N=72)

4.9.1 Sign message guidelines on campus

The *Sign Message Guidelines* affect the language (content), wording, and the case treatment on a sign. Overall, less than a third of wayfinding standards include these guidelines. The most included message guideline is *Content Guidelines*, and the least included is *Naming*.

Table 4-1 Sign messaging guidelines on academic campus

Sign Messaging Guidelines on Academic Campus (N=72)			
Messaging	• 30% Content Guideline	• 29% Wording & Type Case	• 19% Naming

The percentage value represents the average times of this design factor being found in 72 signage standards.

4.9.2 Type guidelines on campus

The *Type Guidelines* affect the use of typeface and type size on a sign. Type guidelines are one of the most considered guidelines among reviewed campuses. Overall, more than 83% of the reviewed standards included guidelines for typeface and type size for signage design. The most included *Type Guideline* is *Typeface*, and the least included is *Type Size*.

Table 4-2 Type guidelines on academic campus

Type Guidelines on Academic Campus (N=72)		
Type	• 92% Typeface	• 83% Type Size

The percentage value represents the average times of this design factor being found in 72 signage standards.

4.9.3 Layout guidelines on campus

The *Layout Guidelines* affect the overall layout of the signage design. Among the audited *Layout Guidelines*, guidelines for *Sign Size* are most included, as it has over 92% of popularity. The most included signage design factor is *Sign Size and Shape*, including guidelines for these two design variables. Overall, the least included design factor is the *(information) Hierarchy,* which includes guidelines for sign information hierarchy.

Table 4-3 Layout guidelines on academic campus

Layout Guidelines on Academic Campus (N=72)			
Sign Size and Shape	• 92% Sign Size	• 3% Sign Shape	
Spacing	• 67% Line Spacing	• 67% Item Spacing	• 17% Letter Spacing
Positioning	• 79% Side-by-side	• 33% Stack Positioning	
Hierarchy	• 17% LATCH Information hierarchy	• 8% Department Organisation Hierarchy	
Layout Factors	• 63% Margin • 24% Line Breaker	• 60% Alignment • 14% Words per Line	• 28% Maximum Lines • 8% Boarder

The percentage value represents the average times of this design factor being found in 72 signage standards.

4.9.4 Colour guidelines on campus

The *Colour Guidelines* affect the colour used in signage design. Overall, the majority of reviewed campuses (92%) include at least one of *Branding*, *Colour Coding*, *Colour Contrast* guidelines. Among the Colour factor, *Branding Colour* guidelines are the most included, and *Colour Contrast* guidelines are the least included.

Table 4-4 Colour guidelines on academic campus

Colour Guidelines on Academic Campus (N=72)			
Colour	• 81% Branding	• 28% Colour Coding	• 14% Colour Contrast

The percentage value represents the average times of this design factor being found in 72 signage standards.

4.9.5 Other design elements on campus

Other Design Elements include guidelines that are essential to signage design but do not fit into generic signage design factors such as *Sign Message, Type, Layout* and *Colour*. These include *Symbol, Arrow, Logo, Braille, Room Number, Level Number, Embossed Letters*, and *Map*. Within *Other Design Elements*, the most included guidelines are *Symbol* guidelines, and the least included are *Embossed Letters* guidelines.

Table 4-5 Other design elements on academic campus

Other Design Elements on Academic Campus (N=72)			
Others	• 81% Symbol • 53% Braille • 15% Embossed Letters	• 76% Arrow • 50% Room Number	• 65% Logo • 35% Level Number
Map	• 26% Map • 6% Zoomed Map	• 32% YAH Map	• 11% Head-up Map

The percentage value represents the average times of this design factor being found in 72 signage standards.

4.9.6 New design guidelines on campus

This audit identified new design guidelines that are not included in the framework *(Appendix 1 Wayfinding Signage Design Guideline Framework)*. These guidelines affect the overall outcome of the signage design on campus. However, they are not addressed in the reviewed signage

guidelines. These newly emerged guidelines can be categorised into *Signage Content* guidelines and *Signage Layout* guidelines based on how they affect signage design.

Table 4-6 New design guidelines on academic campus

New Design Guidelines on Academic Campus			
Signage Content	• Street Address	• Sign Type Code/Building Code	
Signage Layout	• Arrows Align to Text • Department Names Next to Building Name • Organisational Department Hierarchy	• Arrow Priority • Typography Hierarchy	• Lines of Text Based on The Traveller Speed • Size of Sign Based on Viewing Distance

4.10 Findings

4.10.1 Signage design in academic settings

Research outcomes suggest that different campuses adopt different signage design guidelines. Some institutions have more comprehensive coverage of most graphic design factors, whereas others are the opposite. This inconsistency identified in signage design standards can be the result of the lack of updated and comprehensive signage guidelines available in the first place, which was identified in the previous guideline review.

Type, Layout, and *Colour*—particularly *Branding Colour, Symbol,* and *Arrow*—are the most heavily considered design guidelines across audited campuses. This implies the importance of these design factors in academic settings in delivering sign messages.

There is little consideration for the legibility and readability of the signage design in academic settings. This is reflected in the low popularity of *Layout Hierarchy*, *Alignment*, *Colour Contrast*, *Heads-up Map, Zoomed Map*, and *Embossed Letters*. This finding indicates the opportunities to improve the effectiveness of wayfinding signage in academic settings for partially sighted users.

4.10.2 The inadequacy of ADA signage guidelines for academic settings

The ADA signage design guidelines are inadequate in providing guidelines for signage graphic design in academic settings. Based on the results of the audit, primary signage design factors found in academic settings such as *Arrow, Room Number, Level Number, Map*, and *Colour* are

little or not included in the ADA guidelines. As observed during the guideline review, the availability and consistency of generic design guidelines could potentially affect the final design outcome. This inadequacy of coverage of design factors in ADA signage guidelines can lead to an inconsistent approach to design, which could lead to inaccessible design outcomes.

4.10.3 Opportunities to improve signage design in academic settings

As discussed in the literature *(2.4 Wayfinding signage graphic design in public space - academic* settings*),* academic campuses impose their own challenges to wayfinding signage design due to the uniformity and repetitiveness of physical structures. The emerging new guidelines from this audit to some degree reflect the distinctiveness of signage design in academic settings, which is informed by its physical characteristics. Newly emerged content guidelines indicate the need for more detailed signage design in outdoor spaces on campuses, whereas newly emerged layout guidelines indicate the need for better information layouts to accommodate the complexity and uniformity of indoor spaces on campus.

The generic wayfinding signage guidelines do not accommodate this distinctiveness of the signage need in academic settings. Newly emerged guidelines indicate the opportunity to investigate and understand how to improve the effectiveness of signage graphic design in academic settings. For example, there is a lack of evidence that using an organisation/department hierarchy will improve the effectiveness of signage design in academic settings. There is a lack of evidence on the necessity and importance of having the street address on signage. There is a lack of evidence that the adaptation of *"arrow priority*[6]*"* will make the wayfinding information more accessible than other approaches. The opportunities arise from the inadequacy of generic and ADA signage design guidelines in providing consistent, comprehensive, and accessible guidelines for academic setting adaptation.

4.11 Discussion

Based on the literature, wayfinding signage design in academic settings is essential to its inhabitants' daily life and wellbeing (Arthur and Passini, 1992, p.67; Lawton, 1996, p.137;

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[6] **Arrow Priority**: is the guideline that suggests the arrow placement on signage should follow the designated priority. The arrows and sign messages on the top left side of the sign should follow (top to bottom): ahead, diagonally ahead or diagonally up, directing left, or diagonally left. The arrow on the right bottom side of the sign should follow (top to bottom): directing right, or diagonally right, directing down or diagonally down. It also suggests that arrows should always point away from the message.

Gibson, 2009, p.14; Hunter et al., 2016b, p.4; Kanakri et al., 2016, p.255; McDonald-Yale and Birchall, 2021, p.13). However, based on the findings, signage design guidelines in academic settings focus more on having signage available than making the sign legible, readable, and accessible. That could result from the inadequacy of updated and comprehensive signage design guidelines for academic setting adaptation.

As many benefits of using the symbol in signage design are raised by various scholars (Rousek and Hallbeck, 2011, p.771; Hassan, 2015, p.301; Potter, 2017, p.49; Wang et al., 2020, p.103), findings agree with the work of Korpi and Ahonen-Rainio (2015) that there is a growing popularity of symbols being used in wayfinding in public spaces (Korpi and Ahonen-Rainio, 2015, p.3). Significant numbers of campuses include guidelines for symbol usage in their campus signage designs. However, due to the lack of consistent guidelines from generic signage guidelines and ADA, it is difficult to determine the quality of these adaptations at this stage.

Among 20 common conditions causing visual impairment, 90% of these conditions would benefit from better contrast, print enlargement, and glare prevention in signage design (Arter et al., 1999, p.8). Findings support the importance of improving signage design in academic settings (Kilty-Padgett, 1987, p.245; Brown, 1997, p.127). However, the lack of an empirical research-based signage design approach for partially sighted users makes it difficult to create accessible signage for them; these findings signify the importance of this thesis.

4.12 Conclusion

This audit started by identifying the commonality of signage graphic design in academic settings. This audit also identified issues and the potential to improve the effectiveness of signage design in academic settings. Seventy-two signage design standards produced by 58 post-secondary educational institutions were audited. A list of signage graphic design factors primarily considered on these academic campuses was identified. This audit indicates signage design is inconsistently carried out among audited campuses, and there is a lack of a consistent standard for quality signage design in academic settings. Findings suggest that academic campuses focus more on having signage than having an effective and accessible signage system, which highlighting the significance of this thesis.

It is difficult to identify effective signage design practices for the partially sighted in academic campuses at this research stage, as there are very few empirically based signage design guidelines that target partially sighted users. However, what was found in this audit shapes the

primary understanding of signage design on academic campuses for later studies. The next stage of user-involved studies will provide more insight into partially sighted users' experiences with signage design on academic campuses and potential solutions to improve it.

This audit helped understand the signage designs on academic campuses by focusing on aspects that are crucial to signage graphic design in academic contexts. The potential to design more effective wayfinding signage for academic campuses was intensified. The insights gathered from the audit are adequate for planning and executing the subsequent investigations of signage design in academic settings.

Chapter 5 Defining Partially Sighted Users' Wayfinding Signage Design Needs in Academic Settings – Online Questionnaire

5.1 Introduction

This chapter presents an online questionnaire, which aims to explore partially sighted users' experiences with signage design in academic settings. Wayfinding signage design in academic settings is essential to its inhabitants' general wellbeing, safety, accessibility and even academic performance (Arthur and Passini, 1992, p.10; Lawton, 1996, p.137; Gibson, 2009, p.14; Hunter et al., 2016b, p.4; Kanakri et al., 2016, p.251; McDonald-Yale and Birchall, 2021, p.13). However, the previous signage guideline review and audit *(Chapter 4)* discovered a lack of comprehensive signage design guidelines for academic settings which cater to partially sighted individuals. This affects the accessibility and usability of signage design on academic campuses. To establish a better understanding of partially sighted users' design needs in wayfinding signage, this online questionnaire complies with the human-centred/user-centred design approach *(Chapter 2 2.5.4 The challenges of user-centred inclusive signage graphic design)* to explore partially sighted users' experience and design requirements for wayfinding signage in academic settings.

The online questionnaire is considered one of the primary tools for gathering user requirements at the early stage of user-centred design (Bevan, 2003, p.434; Martin and Hanington, 2012, p.140). This provides a basic understanding of the design 'problems'. It helps the researcher establish and sustain focus on partially sighted users (Gulliksen et al., 2003, p.401) by addressing the user characteristics - such as goal activities, user preference, and user experience with wayfinding signage.

Participants were given opportunities to clarify their experience and preferences with signage design. The emerged themes/signage design factors from **Chapter 4** *(4.4 Outcomes)* of the guideline review were used to devise the analysis of the online questionnaire. Participants' experiences and preferences were collected against the three main themes: Signage *Planning*, *Design*, and *Practicality*.

5.2 Method

5.2.1 Research design

The questionnaire design is coherent with the research sub-question of identifying partially sighted participants' experience and needs for signage design in academic settings. This online questionnaire collects both quantitative and qualitative data. Quantitative data reveals the phenomenon (Saunders et al., 2016, p.496), which helps measure participants' satisfaction, experience with the effectiveness of signage design in academic settings. Qualitative data explains and justifies the observed phenomenon (Saunders et al., 2016, p.566), it supplements the quantitative data and provides a richer understanding of participants' experiences and needs for the signage design in academic settings.

The online questionnaire was divided into **three sections** accordingly (a detailed questionnaire can be found in *Appendix 2 Academic Setting Wayfinding Signage Inclusivity Survey 2020 – Online Questionnaire*).

The **first section** starts the questionnaire with simple questions, which ease participants into filling out the rest of the questionnaire (Martin and Hanington, 2012, p.140). Participants were asked for personal information such as gender, age, education level, first language, and the country they lived in most of their lives. These questions provide a general understanding of the user group demographics.

A set of self-assessment questions about their vision condition[7] were added in this section. These questions help identify the target users – partially sighted individuals with functional vision. Questions were adapted from the *Washington Group Extended Set on Functioning (WG-ES)* (The Washington Group on Disability Statistics, 2022).

In addition, participants were asked about their familiarity and opinion with reading text-based signage and symbol-based signage. These questions help identify users who have experience with wayfinding signage.

The **second section** helps identify the need for effective signage design on academic campuses and the importance of this study. This section started by asking participants to identify a

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[7] The **vision condition** self-assessment questions are adapted from The Washington Group Extended Set on Functioning (WG-ES), produced by ***The Washington Group on Disability Statistics*** through thorough research and studying in the past 20 years over 135 countries, which is known to be the best in producing a reliable self-identified disability result (The Washington Group on Disability Statistics, 2022).

familiar academic campus. Because participants could have experiences with a few wayfinding systems, asking participants to sustain the focus on one specific campus at the start would allow participants to draw their experiences from specific memories.

Afterwards, participants were asked to identify their commute, quest and explore activities (Allen, 1999, p.554) on this campus. In addition, a five-point Likert Scale was used to rate their satisfaction with the signage, the effectiveness of signage graphic design on academic campuses, and how much they think it needs to be improved on this campus. Participants were asked to justify their choices.

The **last section** explores partially sighted participants' experiences and opinions with the wayfinding signage. Participants were asked their opinions on aspects of wayfinding signage (system) design, planning, and practicality. In the theme of signage *Design*, the value of design factors such as signage message, type, colour and layout were explored with multi-option and open questions. Signage placement and maintenance were investigated in the signage *Planning* and *Practicality* themes. In the end, participants were given the opportunity to make suggestions for improving the effectiveness of the signage system.

5.2.2 Participants

In total, 37 partially sighted participants were recruited for the online questionnaire. The sampling techniques and methods were discussed in detail in *Chapter 3 Methodology (3.5 Sampling and participants recruitment).* The gender distribution of this study is relatively balanced, with 17 males, 17 females, 2 others, and 1 prefer not to say. Participants' age ranged from 23 to 83 years old. The majority of participants (86%) were recruited from the North American region, and 89% of participants are native English speakers. All participants have at least a secondary school or equivalent education, and more than 81% of participants are familiar with reading wayfinding signage.

All participants are qualified for this study based on the World Health Organisation definition[8] of visual impairment and low vision.

5.2.3 Online questionnaire platform and accessibility consideration

The online questionnaire was hosted by the Joint Information Systems Committee (JISC) platform - a UK-based online questionnaire service organisation. The questionnaire was tested

[8] **Visual impairment** and **low vision** are defined as individuals with *"severe reduction in vision that cannot be corrected with standard glasses or contact lenses and reduces an individual's ability to function at specific or all tasks"* (World Health Organization, 2020).

to be accessible for participants to access through mobile phone devices or personal computers with the help of a screen reader. The text in the questionnaire was enlarged for better legibility *(Figure 5-1 Original questionnaire (top) and text enlarged questionnaire).* Alt text/image descriptions were added to every image presented in the questionnaire to improve accessibility *(Figure 5-2 Example of image descriptions in questionnaire).* The questionnaire was tested to be screen-reader friendly.

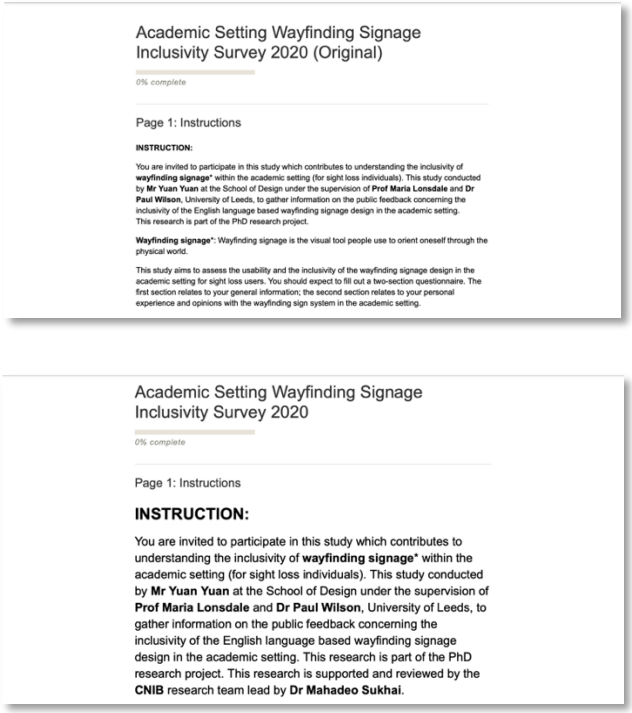

Figure 5-1 Original questionnaire (top) and text enlarged questionnaire

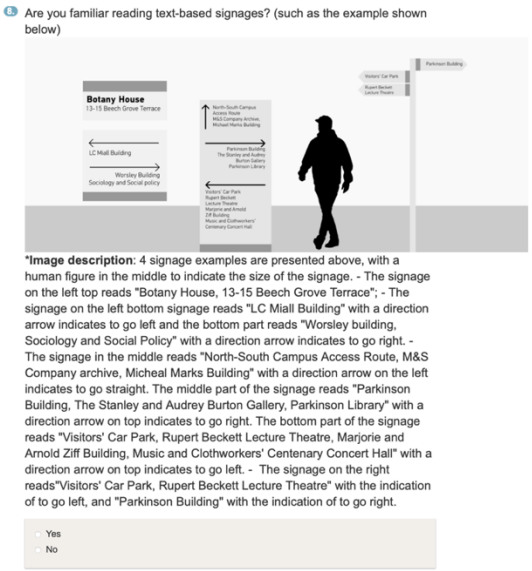

Figure 5-2 Example of image descriptions in questionnaire

5.2.4 Ethical considerations

This study was granted ethical approval from the Faculty of Arts, Humanities and Cultures Research Ethics Committee, University of Leeds. The ethic reference: LTDESN-129. The data collection was carried out in accordance with the ethical protocol of Data protection, anonymisation and storage and sharing of research data, and informed consent. Furthermore, people with visual impairments could experience a sense of vulnerability, which is defined as physiological/psychological factors inequalities that cause diminished autonomy (Moore, 2002, p.559). Strategies were put in place to address the sensitivity to vulnerability. Firstly, as discussed in Chapter 3 Methodology *(3.5 Sampling and participants recruitment*), participants were recruited through blind and visual impairment charity organisations and internet community groups. This gives participants autonomy to decide to participate in or opt-out of the project. Secondly, participants were informed of the questionnaire procedure, data protection, and potential risks. The research only continues after participants confirm their willingness to proceed with the questionnaire. Thirdly, participants were offered autonomy to withdraw from this study; “prefer not to say” options were also available on certain sensitive subject matters.

5.2.5 Data Analysis

Two types of data variables were collected from the online questionnaire. These includes: 1) factual or demographics; and 2) attitudes and opinions (Saunders et al., 2016, p.445).

The **first type of data** was gathered from participants’ responses to the single/multi-option questions, which were organised and analysed using the JISC online questionnaire platform. This data reveals participants' demographics and characteristics as wayfinding signage users on academic campuses. All information pertinent to answering the research sub-questions *(Chapter 1 1.3 Research questions)* was coded and analysed.

The **second type of data** was gathered from participants’ justifications of their answers to the single/multi-option and open questions. These justifications were coded, organised, and analysed within **themes** using NVivo 12[9]. The second type of data supplements and clarifies participants' responses to single/multi-option questions.

The following qualitative data coding procedures are used to make sure the coding themes accurately reflect the range of responses (Saunders et al., 2016, p.506):

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[9] NVivo 12 is a qualitative data analysis software developed by QSR International. NVivo 12 helps organise, analyse and identify insights in qualitative research data.

1) Analysing the information and develop overarching themes.
2) Breaking down general themes into more focused sub-themes.
3) Assigning codes to each theme's exact level.
4) Indexing all the themes and sub-themes.
5) Sub-themes that have the potential to combine are adjacent to facilitate re-coding.

The **primary themes** of the questionnaire findings were organised in accordance with the wayfinding guidelines framework established in the previous chapter *(Chapter 4).* Themes were created around aspects of signage *Planning*, *Design* and *Practicality*; qualitative data was coded against the theme it defined.

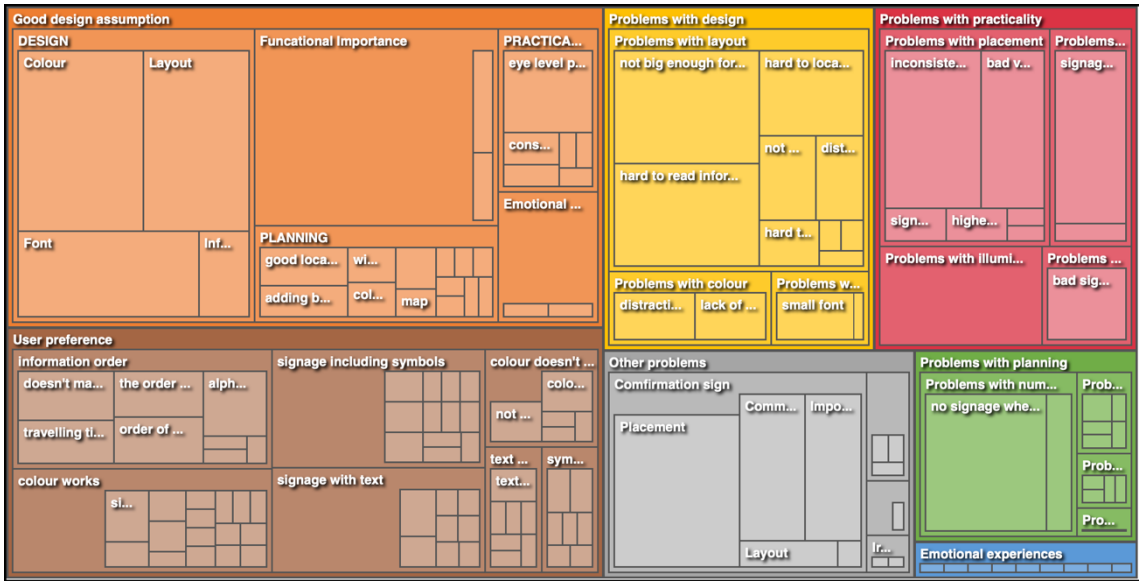

Figure 5-3 Themes of the online questionnaire data coded by Nvivo12

This questionnaire was designed to investigate partially sighted participants' experiences and design preferences for signage graphic design in academic settings. Therefore, specific themes were also created to answer the research question. These themes are *User Satisfaction, Effectiveness of Signage Design,* and *Good Design Assumptions.*

The reviewed literature also contributed to the creation of themes of *Functional Importance* and *Emotional Importance*, which are considered two major determining factors of a successful signage design system (Ittelson, 1960, p.212; Lawton, 1996, p.137; O'Grady and O'Grady, 2008, p.72; Montello, 2010, p.284; Garip, 2011, p.1770; Calori and Vanden-Eynden, 2015, p.41; Kanakri et al., 2016, p.255).

The theme of *Other Issues* was created to accommodate the irrelevant responses and what does not appeal to the research interests.

5.3 Findings

This section presents the findings of the online questionnaire; it is divided into three parts. These three sections address the goal of the online questionnaire, beginning with the surface level of partially sighted participants' experience with signage graphic design in academic settings and progressing to a deeper level of issues with the existing design and ideas for a more effective signage graphic design. The **first part** presents findings related to participants' user behaviour and experience with the signage system, as well as their overall satisfaction with signage and perceptions of its effectiveness. **The second part** identifies issues with wayfinding signage in terms of *Planning*, *Design*, and *Practicality*. **The last part** discusses findings related to effective signage design practice and the functional and emotional significance of signage design.

5.3.1 User characteristics and experience

5.3.1.1 Partially sighted participants' wayfinding activities

Findings suggest that partially sighted participants use signage in their wayfinding activities. Allen (1999) classifies wayfinding activities into three primary groups based on the purpose of travel*: Commute, Exploration* and *Quest* Activities. This classification is determined by the wayfinder's familiarity with the destination and travel functionality (*Chapter 2 2.2.2.1 Types of wayfinding tasks)*. *Table 5-1 Signage usage in academic settings* shows that the majority of partially sighted participants use wayfinding signage in their *Commute*, *Explore*, and *Quest* Activities; this is especially significant with *Quest* Activities (when finding specific places with signage).

Table 5-1 Signage usage in academic settings

SIGNAGE USAGE IN ACADEMIC SETTING (N=37)					
%	**Commute**	**%**	**Explore**	**%**	**Quest**
37	• Sometimes	29	• Sometimes	51	• Very often
34	• A few time	29	• A few times	30	• Sometimes
17	• Very often	26	• Never	14	• A few times
11	• Never	17	• Very often	6	• Never

5.3.1.2 Partially sighted participants and campus facilities

Partially sighted participants require access to a variety of campus facilities. Seven major types of facilities (Douglas et al., 2006, p.251; Kärnä and Julin, 2015, p.54) on campus were provided as example options, which included: *Lecture Facilities, Library Facilities, Faculty Offices, Workspace, Recreational Facilities, IT Facilities, Laboratory Facilities* and *Other* (for participants to justify). More than half of the participants suggested visiting most *Lecture Facilities, Library Facilities,* and *Faculty Offices* on academic campuses.

Table 5-2 Academic facilities usage

ACADEMIC FACILITIES USAGE (N=37)	
%	**Facilities**
78	• Lecture Facilities
65	• Library Facilities
57	• Faculty Offices
43	• Workspace Facilities
38	• Recreational Facilities
32	• IT Facilities
21	• Laboratory Facilities
14	• Others (as following) • Student Service/Union • Bookshop • Foodservice • Theatre Arts • Radio Studio • Chapel • Parking

5.3.1.3 User satisfaction and signage effectiveness

Participants are overall more unsatisfied than satisfied with the signage design on academic campuses. *Figure 5-4 Participants' attitude towards wayfinding signage design in academic*

settings shows a relatively higher negative rating trend towards the participants' satisfaction and the effectiveness of the wayfinding signage on academic campuses. The peaks of these two rated subjects were found at the neutral point of the Likert scale. However, this result could be an indication of central tendency bias, as one of the common weaknesses of the Likert scale; participants may have avoided extreme responses due to social desirability and *"to please"* (Bertram, 2006, p.7).

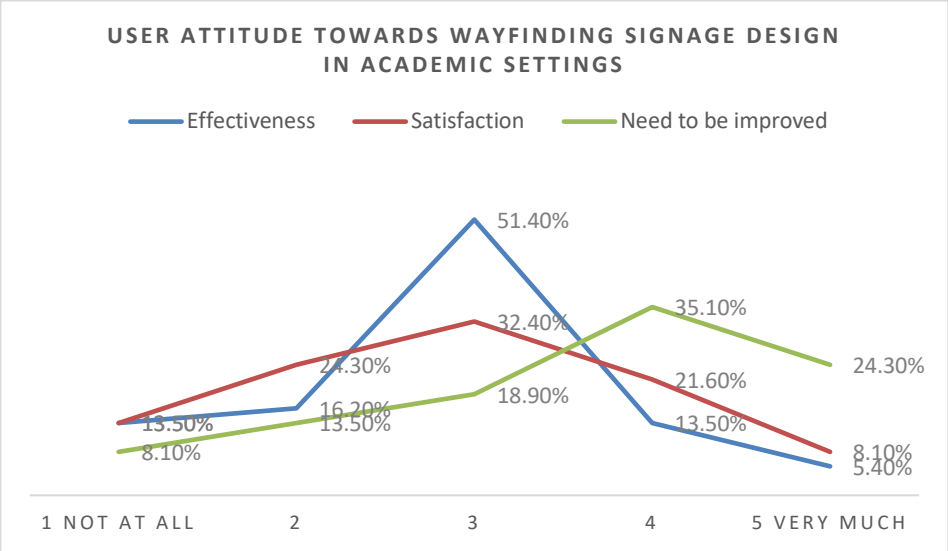

Figure 5-4 Participants' attitude towards wayfinding signage design in academic settings

Nevertheless, more participants suggested that wayfinding signage design in academic settings needs improvement. The data in this chart may not present predominating evidence of participants' satisfaction with the wayfinding signage. A more in-depth analysis of the participants' justification was carried out to interpret the rating.

5.3.1.3.1 Justified user satisfaction

Participants' satisfaction with the signage is associated with the effectiveness of the wayfinding signage. A significant number of participants provided the same justification for their satisfaction and the effectiveness of the signage. While participants expressed more dissatisfaction with the theme of signage graphic design, fewer comments were made on the themes of planning and practicality.

Table 5-3 Justification for user satisfaction

USER SATISFACTION JUSTIFICATION		
Planning	**Designing**	**Practicality**

Satisfy with (None)	**Satisfy with** • Consistent colour • Clear font • High contrast x 2 • Room numbers are easy to see • Detailed and simple to understand • Effective arrow	**Satisfy with** • Well positioned
Dissatisfy with • Insufficient signage x 2 • Not available in tactile and braille x 2 • Difficult to locate x 2	**Dissatisfy with** • Small text x 2 • Small signage x 2 • Not readable x 2 • Poor contrast x 2 • Room numbers are a real problem • Do not have symbol sign	**Dissatisfy with** (None)

("x number" means the times this issue has been mentioned, for example, "Insufficient signage x 2" means there were 2 participants who raised the issue with "Insufficient signage")

5.3.1.3.2 Signage ineffectiveness

Participants' justification confirms the overall ineffectiveness of signage design in academic settings. Although a few participants indicated that they had a good experience with signage on campus, they elaborated that the signage was *"Fairly clear text-based signs and directional arrows."* *"Clear, concise, well presented, good contrast."* The majority of the responses reflect the ineffectiveness of *Planning, Design*, and *Practicality* themes, which confirmed the central tendency bias observed in the Likert Scale results.

Table 5-4 The ineffectiveness of wayfinding signage in academic settings

SIGNAGE INEFFECTIVENESS		
Planning	**Designing**	**Practicality**
• Inconsistently located • Difficult to locate • Insufficient signage x 5 • Incorrect placement • Outdated sign information x 2 • No tactile nor braille x 2	• Small font/text x 5 • Low colour contrast between lettering and background x 3 • Difficulty with room numbers • Not clear marked • Small sign x 2 • Outdated sign design	• Obscured sign x 2 • Too high to be read x 3 • Poor visibility x 3 • Poor lighting condition

("x number" means the times this issue has been mentioned, for example, "Insufficient signage x 5" means there were 5 participants who raised the issue with "Insufficient signage")

5.3.1.3.3 Challenges with ineffective sign

Ineffective signage design causes difficulties during partially sighted participants' wayfinding activities. Along with the justification of the ineffectiveness of the signage design in academic settings, participants raised challenges they have had with the ineffective signage on campus. These include:

1) The challenge of finding their way: Participants found it difficult to find where they were due to insufficient signage; increasing the frequency of signage placement to "*reassure ... I was on the right path*" was recommended.

2) The challenge of finding the location: Participants found it a *"great issue"* to find the correct building from the main road without a *"You are Here stand"* or "*Large sign in front of the building"*.

3) The challenge of difficult to read information: Participants expressed that they must *"get to a sign to see if it is a sign that might help me. This means going up to every sign until I find the right one ... I often plan my trip 1 1/2 hours ahead ... in case I have a lot of signs to find."*

4) The challenge with independence: Participants expressed the need to *"… usually travel with others or ask others for directions to places I am less familiar with".*

5.3.1.3.4 The need to be improved

Participants' feedback supports the need to improve the signage design in academic settings. The result presented in *Figure 5-4 Participants' attitude towards wayfinding signage design in academic settings* suggests that more participants think the signage in academic settings needs improvement. With only a few participants, 8% (N=37) think there is no need for improvement; most of the participants' justification for signage improvements can be categorised into themes of *Planning, Design,* and *Practicality*.

Table 5-5 Suggested improvements

SUGGESTED IMPROVEMENTS		
Planning	**Design**	**Practicality**
• Better location x 2 • More signage x 2 • Braille • More direction signs at intersections • Up-to-date sign information • Placed near the pedestrian	• Consistent room number sign • Larger text x 5 • Better contrast x 5 • Large sign x 3 • Larger symbol • Modernised design • Add symbol x 2	• Eye-level placement x2 • Better visibility x 2

("subject x number" means the times this subject has been mentioned, for example, "More signage x 2" means there were 2 participants who suggested having "more signage")

5.3.2 Issues with wayfinding signage in academic settings

The following section presents issues identified in academic settings based on participants' responses and justifications. Participants' responses were coded against the theme of *planning, design*, and *practicality*. As this thesis is interested in the graphic *Design* factors of signage design in increasing the effectiveness of wayfinding signage, the theme of *Design* will be further discussed.

5.3.2.1 Issues with planning

Four planning factors are significant to the effectiveness of wayfinding signage in academic settings. As presented in *Table 5-6 Issues with signage planning* the issue with signage planning is evident in *Information Accuracy*, *Quantity* of the signage, *Accessibility* features, and signage *Location. Information Accuracy* indicates the scenarios that cause inaccurate sign information. *Quantity* indicates when the quantity of the signage leads to unsatisfactory wayfinding experiences. *Accessibility* indicates the lack of accessibility factors on signage. *Location* indicates the type of ineffective sign location placements.

Table 5-6 Issues with signage planning

ISSUES WITH PLANNING			
Information Accuracy	**Quantity**	**Accessibility**	**Location**
• Outdated signage • Inadequate information • Hard to understand information • Inaccuracy direction • Generalised direction, lack of specification of which door to enter	• No signage when needed • Not enough signage	• No tactile or braille	• Crowded location • High traffic location • Hard to locate signage

5.3.2.2 Issues with design

Three *Design* factors are evident to the effectiveness of wayfinding signage in academic settings. As presented in *Table 5-7 Issues with signage design,* the issue of *Colour* indicates when the use of colour hinders the effectiveness of signage design. These issues with *Colour* make it difficult for some partially sighted participants to discern and read, as some are *"profoundly colour blind"* and can only see *"black and white".*

The issue with *Font* indicates the types of fonts which were considered ineffective by participants. Participants commonly express that these *Type* issues often make the signage difficult or unable to be read, especially when paired with low colour contrast and above-eye-level signage placement.

The issue with *Layout* indicates types of layouts that cause problems for participants. These *Layout* issues severely affect partially sighted participants' ability to read, process information and make an informed decision in wayfinding.

Table 5-7 Issues with signage design

ISSUES WITH DESIGN		
Colour	**Type**	**Layout**
• Distracting colour scheme • Lack of strong colour contrast	• Small fonts • Stylish fonts	• Confusing arrow • Disturbance from decorative elements • Hard to locate information • Hard to read information • No symbol or hard to understand the symbol • No braille or braille errors • Not accessible • Not big enough for reading • Not modernized

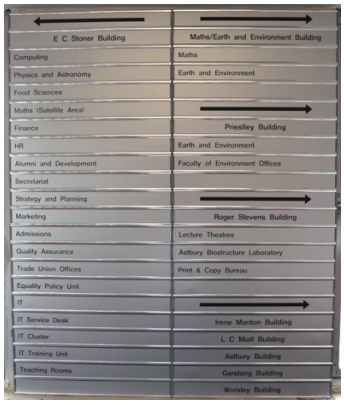

Figure 5-5 Examples of signage with design issues

5.3.2.3 Issues with practicality

Four *Practicality* factors are evident to the effectiveness of wayfinding signage in academic settings. As presented in *Table 5-8 Issues with practicality of signage*, the issue with *Placement* indicates types of signage placement that make the signage difficult to use. The issue with *Visibility* indicates situations that lead to poor visibility of signage. The issue with *Maintenance* indicates the issues after the signage was installed. The issue with *Illumination* indicates the illumination issue around the sign.

Table 5-8 Issues with practicality of signage

ISSUES WITH PRACTICALITY			
Placement	**Visibility**	**Maintenance**	**Illumination**
• Bad viewing angle • Braille placed too high • Out of vision range • Difficult to locate • Higher than eye level placement (ceiling sign) • Inconsistent placement	• Obscured signage • Signage not noticeable or recognisable	• Old sign • Bad signage condition	• Inadequate illumination on signage

Figure 5-6 Examples of signage with practicality maintenance issues

5.3.3 Redefining good signage practice

Based on participants' justification of their experiences with signage design on academic campuses, the qualitative data helped shape the understanding of a satisfactory wayfinding experience and more effective signage design for partially sighted participants.

5.3.3.1 Definition of satisfactory wayfinding experience for the partially sighted

Most participants are not satisfied with the signage design in academic settings. Participants commonly express this opinion: *"I never considered wayfinding to be potentially relaxing … even as a seasoned traveller.";* they feel left out by design because it seems that signs are designed for *"adequate vision".*

Based on the gathered data, factors that constitute a satisfactory wayfinding experience for partially sighted participants are highly associated with the functional importance of the signage graphic design. Participants were not having a satisfactory experience with the signage design on academic campuses due to the design's functional failure, which raises negative emotional responses towards signage. As shown in *Table 5-9 Satisfactory wayfinding factors for partially sighted users,* signage design should provide sufficient and prompt information about the wayfinders' location, destination, and pathways. Negative emotions such as anxiety often develop when this information is unavailable to partially sighted participants. Participants expressed the feelings of *"stress"* and the *"fear of getting lost".* Therefore, for signage to promote a satisfactory experience, it is essential for signage to meet its functional importance and reduce the negative emotion caused by functional failures.

Table 5-9 Satisfactory wayfinding factors for partially sighted users

Satisfactory Wayfinding Factors			
Functional importance	**Emotional responses**	**Emotional importance**	**Emotional responses**
• Provide prompt information about the direction • Clarifies the structure of the surrounding • Show where to go • Show where you are (department, building, location)	• Never feel relaxed with wayfinding • The fear of getting lost • Stressed	• Promote a relaxing wayfinding experience • Alleviate the anxiety of reading the sign • Reduce the fear of getting lost • Destressing	• Feeling signs are designed for adequate vision • Time consuming (when need to read every sign to see if it helps) • Feeling left out by design • Anxiety when using signage • Need to read at a close distance • Anxious about blocking others

	• Never feel relaxed with wayfinding

A satisfactory signage design should also fulfil its emotional importance to facilitate a satisfactory wayfinding experience for its users. Negative emotional responses still occur when a sign provides prompt and sufficient information about the wayfinders' location, destination, and pathways. This negative emotional response is caused by the difficulty for partially sighted wayfinders to read the information from the sign. Participants expressed the feelings of *"anxious"* when using signage. This anxiety came from the time-consuming aspect of reading signage, as well as the psychological concern of potentially blocking others when undertaking a close-up reading. Therefore, to alleviate the stress of sign reading, more effort must be made into sign design to make the signage available and easy to read by the user.

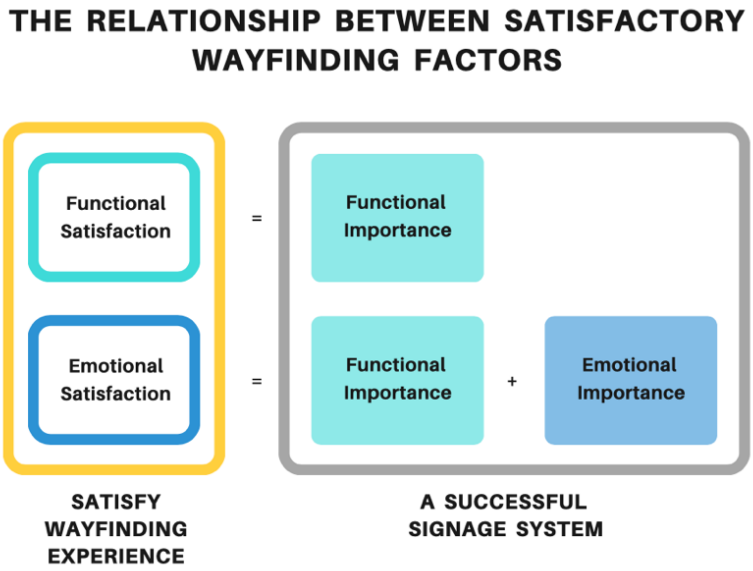

Figure 5-7 The relationship between satisfactory wayfinding factors

5.3.3.2 Definition of effective wayfinding signage design

Based on the gathered data, factors that constitute an effective signage design are identified in the three main themes of signage design - *Planning, Design*, and *Practicality*. As emerged from these three main themes of signage design, the assumptions of effective signage design practice were made according to participants' justifications.

5.3.3.2.1 Assumption of effective planning

The assumption of effective signage planning in the academic setting is addressed under four factors. These include *Information accuracy, Quantity, Accessibility,* and *Location,* as presented in *Table 5-10 Assumption of effective signage practice – planning.*

Information accuracy addresses the types of accurate information that would make the signage system more effective for partially sighted users; standardisation and consistency are considered two of the major considerations for signage information accuracy.

Quantity addresses the need for more signs in the wayfinding system; providing sufficient confirmation and directional signs would make the wayfinding system more effective.

Accessibility addresses accessibility features that would make the signage more effective for partially sighted wayfinders. Signage design to comply with the protocols produced by the *American Disability Act (ADA)* is essential.

Location addresses the locations where the signage should be assigned. Suggestions made under this factor show participants' struggle with finding signage when needed. Signage to be placed in open areas and where partially sighted wayfinders would use the sign, such as in front of the building and near pedestrian walks, would make the wayfinding system more effective.

Table 5-10 Assumption of effective signage practice – planning

ASSUMPTION OF EFFECTIVE SIGNAGE PRACTICE – PLANNING			
Information accuracy	**Quantity**	**Accessibility**	**Location**
• Standardization • Consistency • Distance indication • Adding map	• More signage • Signage to confirm arrival • Signage to assure direction/path	• Complies to ADA • Adding braille or embossed letter • Adding tactile	• Large sign in front of the building • Near pedestrian walk • Open area, not high traffic

5.3.3.2.2 Assumption of effective design

The assumption of effective signage graphic design in the academic setting is addressed under four factors. These include *Colour, Font, Information/message* and *Layout* as presented in *Table 5-11 Assumption of effective signage practice – design.*

The original assumption of good design was addressed in three factors of *Colour, Font,* and *Layout* to correspond to the design issues identified in *5.3.2.2 Issues with design.* The factor of

Information/Message originated from the *5.3.2.1 Issues with planning* and was added to the assumption of effective design because the nature of this factor inevitably influences the outcome of the design. For example, participants suggested that signage need to be simple to understand but in fewer words; a good information hierarchy can achieve this goal. Moreover, this decision aligns with the research interests of this thesis.

Colour addresses the colour design practices that benefit the effectiveness of signage design. Evidence shows that more than half (62.2% (N=37) of the partially sighted participants consider the use of colour helps them to find, read and understand the information better. Those who selected that colour does not help with the design justified that they have the condition of *"colour blindness",* and colour contrast is an issue for them. This indicates the importance of thoughtful colour decisions in signage design, such as choosing a contrasting colour combination that is also colour blindness-friendly.

Colour improves the effectiveness of signage design in a few ways. Participants suggested that coloured signage draws their attention, as expressed as "*easier to see*" and "*see colour faster*". Alternating coloured rows and colour coding were suggested to help them locate the information. Black and white were suggested as a good and legible colour combination for participants. Moreover, consistent application is also considered crucial to signage effectiveness.

Type addresses the type choices that improve the effectiveness of signage design. Partially sighted participants prefer bold, clear and large text on the signage. Sans-serif is suggested as a good option for a legible typeface.

Information/Message addresses the characteristics of sign information that promote effectiveness in signage design. These characteristics can be achieved by the combined efforts of signage planning and signage layout design. For example, *"simple to understand"* and *"accessible room number sign"* require signage planning to simplify the content, and through other design factors to maximise the effectiveness of signage.

Layout addresses the effective arrangement of design elements on the signage. Based on *(Chapter 4 4.10 Findings),* signage layout in academic settings often involves *type, arrows* and *symbols*; *Table 5-11 Assumption of effective signage practice – design* presents a series of goals that an effective signage layout should achieve through the organisation of these layout elements, such as clarity, succinctness and conciseness. Overall, partially sighted participants prefer large and simplified signage layouts, with *Type* and *Colour* should comply with what was discussed previously, the importance of consistent application is again emphasised.

Symbols and arrows (a form of symbol) play a significant role in the effectiveness of signage layout. Symbols are *"quicker to get the meaning and larger",* and *"symbols are universal and easier to discern than text"*. Partially sighted participants prefer to have larger but fewer symbols on signage to reduce distraction. However, symbols are also considered to be *"subjective".* They can be difficult to interpret when *"symbols and text are stylised"* or when *"signage containing symbols are often smaller than text-based sign".* As using symbols in signage design has become a common practice, there is a need to investigate the use of symbols in affecting the effectiveness of signage design.

Table 5-11 Assumption of effective signage practice – design

ASSUMPTION OF EFFECTIVE SIGNAGE PRACTICE – DESIGN			
Colour	**Type**	**Information/message**	**Layout**
• Coloured signage • Consider colour blindness • Alternating coloured rows • Better contrast • Colour coding • Consistent colour • Consistent contrast • Eye-catching colour • Black and white • Colour-coded environment (e.g., colour path)	• Bold text • Clear text • Large text • Sans-serif	• Consistent information system • Detailed information • Fewer words • More descriptive (text vs symbol) • Simple to understand • Accessible room number sign	• Using arrows • Brighter image and letter • Clear, succinct and concise • Use symbols • Fewer symbols • Larger signs • Larger symbols • Simplified signage • Consistency

Evidence shows that the choice of layout hierarchies might not significantly affect the effectiveness of signage in academic settings; the important thing is to have the hierarchy in place rather than which type to use. Evidence shows that participants have a relatively equal preference for the five types of layout hierarchy. 18.9% (N=37) selected preferences in *Alphabetical order*, the *Order of travelling time*, the *Order of the department*, and the *Order of campus zone*. And 21.6% (N=37) of participants consider the style of information order does not make a difference to them. It is assumed that this is less significant to them in determining the accessibility rather than readability of wayfinding signage in the academic setting.

5.3.3.2.3 Assumption of effective practicality considerations

The assumption of effective signage practicality considerations in the academic setting is addressed under four factors. These include signage *Placement, Visibility, Maintenance,* and *Illumination (Table 5-12 Assumption of effective signage practice – practicality considerations).*

Placement addresses types of signage placement that would improve the effectiveness of wayfinding signage in academic settings. Consistently placing the signage based on partially sighted reading needs is considered crucial.

Visibility addresses the visibility of the signage placement. Apart from increasing the signage visibility through colour and layout design as discussed in *(5.3.3.2.2 Assumption of effective design), a* good viewing angle also improves the visibility of the signage.

Maintenance addresses the maintenance needed after signs are installed. Maintaining a good signage condition is beneficial to the effectiveness of signage design.

Illumination addresses the lighting conditions needed for signage to be effective for partially sighted wayfinders. Reducing the glare on signage by using matt finish material and placing it under sufficient lighting is crucial for the partially sighted.

Table 5-12 Assumption of effective signage practice – practicality considerations

ASSUMPTION OF EFFECTIVE SIGNAGE PRACTICE – PRACTICALITY			
Placement	**Visibility**	**Maintenance**	**Illumination**
• Consistent placement • On the wall placement • Eye-level placement • Consider the user who touches the sign	• Improve visibility • Good viewing angle	• Good signage condition	• Reduce glare

5.3.3.2.4 Alternative solutions

A few participants claimed they were totally blind (with no functional vision), so they would not be able to use graphic-based signage and always required braille. These participants suggested alternative creative solutions to improve the effectiveness of the signage in academic settings. Wayfinding apps and wireless Bluetooth beacons were proposed as solutions. These ideas provide a good starting point for future research to explore. However, because this thesis is concerned with the graphic design aspect of improving the effectiveness of signage in academic settings, these ideas will not be discussed further.

5.4 Discussion

5.4.1 Partially sighted wayfinders

Findings support the importance of route-type information (Verghote et al., 2019, p.9) for partially sighted individuals' wayfinding performance (Hölscher et al., 2006, p.284; Noordzij et al., 2006, p.321). Route-type information is defined (Verghote et al., 2019, p.2) as the unit-based sequential information placed along the route to a destination; signage is the primary route-type information unit in a wayfinding system. Partially sighted wayfinders develop a spatial understanding based on an **egocentric model**[10] (Martinez-Martin et al., 2014, p.2), and they gather information from direct interaction with spatial surroundings (Golledge, 1993, p.73). Findings suggest that partially sighted wayfinders rely on signage for their commuting, questing and exploring. Therefore, signage in academic settings is essential to their information processing and decision making (Arthur and Passini, 1992, p.28; Vandenberg, 2016, p.26).

Findings support the difficulty (Karimi, 2015, vii) of indoor wayfinding in academic settings. The challenges of indoor wayfinding are fundamentally different from outdoor wayfinding due to the lack of visibility and restricted movement (Srinivas and Hirtle, 2015, p.14). Partially sighted participants have raised issues with indoor location signs, especially with room number signs. The indoor location sign confirms arrival (Calori and Vanden-Eynden, 2015, p.103) and signifies closure to wayfinders (Gibson, 2009, p.48). The finding suggests that partially sighted participants need to frequently visit lecture facilities, library facilities, and faculty offices in academic settings. Because these academic facilities include indoor spaces, it is critical to provide effective indoor location signs, such as room number signs, to alleviate the challenges that partially sighted participants face in academic settings.

There is a lack of studies that provide an understanding of partially sighted wayfinders' signage needs. A considerable body of related studies (Molton et al., 2002, p.251; Dakopoulos and Bourbakis, 2008, p.1; Giudice et al.,2012, p.103; Liu et al., 2007, p.1655; Hersh, 2008, p.83) looking into assistive technology to enhance partially sighted wayfinders' perception of the surroundings with auditory and tactile cues. These practices, to some degree, resolved the **"Self-produced confusion"** (Kitchin et al., 1998, p.45) caused by partially sighted wayfinders' misperception of the environment. Nevertheless, it does not resolve the **"Situational**

[10] **Egocentric model:** encode surrounding information with the respect of self to object (Martinez-Martin et al., 2014, p.2)

confusion" (Kitchin et al., 1998, p.45) imposed by the surrounding environment. There is a need to improve the signage design in academic settings for partially sighted users.

5.4.2 Effective signage design for partially sighted users

The finding support for the importance of user-involvement in design decision making (Sanders and Stappers, 2008, p.11; Magnusson et al., 2018, p.415). Partially sighted participants are the *"expert of their experience"* (Sanders and Stappers, 2008, p.15); evidence suggests that participants are able to clarify the issue with signage graphic design they have had experience with and provide feedback for better design.

The finding suggests that the effectiveness of signage design is affected by the essential graphic design factors greatly. Accessible features such as Braille and Tactile are essential for signage accessibility. However, based on evidence, participants have more issues with the fundamental graphic design factors than accessible features. The traditional construct of effectiveness in usability is measured by the time it takes to complete the task and the error rate (of completing the task) (Petrie and Bevan, 2009, p.4; Bevan, 2009a, p.14). However, this traditional construct of effectiveness does not provide the framework needed for effective signage design for partially sighted users. There is a lack of a developed framework that suggests effective signage graphic design for partially sighted users. Findings suggest the five primary design factors identified in *(Chapter 4 4.10 Findings)* of *Sign Message, Type, Colour, Layout*, and *Other factors* are significant to the effectiveness of signage graphic design for partially sighted users. The effectiveness of signage graphic design is determined by the type, colour and other design factors and whether these choices are consistently well-executed. For example, choosing a large, bold, clear, and Sans-serif typeface would improve partially sighted users' ability to read the information. A well-organised, clear, succinct and concise layout would reduce the time pressure of partially sighted wayfinders trying to locate the information. Overall, findings agree with Arthur and Passini (1992) that better signage graphic design can resolve most users' issues with wayfinding signage. This demonstrates that one of the most difficult aspects of creating effective signage is recognising the user's capacity to properly read the information on the sign as the sign message intended (Arthur and Passini, 1992, p.33).

5.4.3 The value of consistency in effective signage design

Findings suggest the importance of consistency in signage design throughout the three stages of sign system development of: *Planning*, *Design*, and *Practicality*. The literature defines the principle of consistency in signage design as applying similar attributes such as shape, colour,

size, and texture throughout the spatial network. It suggests that a consistent and unified signage system knits a site informationally and visually (Calori and Vanden-Eynden, 2015, p.6; Alta Planning + Design, 2019, p.21). The finding agrees with the importance of consistency in signage design (O'Grady and O'Grady, 2008, p.71; Calori and Vanden-Eynden, 2015, p.108) and suggests that consistency in signage design is crucial to the partially sighted.

5.4.4 Satisfy wayfinding experience for partially sighted users

There is a lack of a framework of user satisfaction in the construct of usability in signage design. Bevan (2008) expands the matrix of satisfaction to *Likability, Pleasure, Comfort*, and *Trust*. The finding suggests that partially sighted users have little pleasure and comfort in using wayfinding signage in academic settings. Their unsatisfaction mainly comes from the signage failing to fulfil its functional importance (Montello, 2010, p.284; Garip, 2011, p.1770) and emotional importance (Lawton, 1996, p.137; Calori and Vanden-Eynden, 2015, p.10; Kanakri et al., 2016, p.251). The failure of the signage function could lead to the failure of its emotional importance. However, achieving only the signage function does not guarantee user satisfaction. Partially sighted participants' wayfinding satisfaction is associated with the anxiety and stress of reading the signs and the fear of getting lost. There is a lack of studies that provide guidelines to design signage that accommodates partially sighted wayfinders' both functional and emotional needs. Therefore, considering partially sighted users' experience in signage design is essential to their wayfinding satisfaction.

5.5 Conclusions

This chapter presented an online questionnaire conducted with partially sighted participants to investigate their experience and opinion of wayfinding signage design in academic settings. The questionnaire provided a better understanding of issues and potential solutions for three aspects of wayfinding system development in academic settings involves planning, design, and practicality.

Firstly, the findings recognise the need for a more effective signage graphic design. Partially sighted users rely on signage for their wayfinding tasks in academic settings, and overall, they are not satisfied with the current signage design in place. The literature provides a more generic design guideline for wayfinding signage design in public spaces. In contrast, participants provided an intuitive and personal outlook on what works and what does not work for them based on their experiences. Participants' 'expertise' in their experience was

identified. Partially sighted participants have a good understanding of what contributes to a satisfactory wayfinding journey. Participants need the signage design to provide prompt information during their wayfinding journey, and the effectiveness of the wayfinding information determines participants' emotional satisfaction during wayfinding tasks.

The findings redefined effective signage practice for partially sighted participants (*5.3.3.2 Definition of effective wayfinding signage design*). Emerging from issues identified in signage graphic design in academic settings by participants, this chapter outlines clearer design practices in delivering more effective signage design for the partially sighted. Five design factors were found to be crucial to the effectiveness of signage design. These include *Colour, Type, Information/Message, Layout,* and *other design factors* such as *arrows* and *symbols*. The functional importance of the signage system is determined by the consistent application of purposeful design practice. The framework produced in this chapter that embodied partially sighted direct feedback in design was not available in the literature.

The findings of this online questionnaire provide a good understanding of the surrounding context of 'problems' of signage design within academic settings for the partially sighted. It provides a clearer view of effective signage design practice for partially sighted participants. However, the collected feedback and assumptions for better design, such as *"concise", "simplified",* and *"clear",* are far from being quantified to suggest actual signage graphic design. Suggestions such as *"using arrows"* and *"larger symbols"* are too abstract to guide signage graphic design for partially sighted users. Therefore, to move to the stage of *prototyping (Chapter 1 1.2.2 Research objectives),* partially sighted participants will need to be involved in providing a clearer 'picture' of the more effective signage design practice. The subsequent co-design will help to explore and bring these concepts to visualisation.

Chapter 6 - 1 Visualising Partially Sighted Participants' Design Needs for Wayfinding Signage in Academic Setting – The Theoretical Foundation

6.1 Introduction

Chapter 6 *(6-1* and *6-2)* presents the development and implementation of co-design workshops which aim to visualise partially sighted participants' ideas of effective signage graphic design in academic settings. In 2020, COVID-19 led to social environment change - working from home impacted my ability to carry out research in person. Therefore, co-design workshops had to be carried out online. Adapting this traditionally in-person research method to an online environment posed challenges in developing data collection tools to achieve the research goal. On the positive side, this helped to reduce the difficulty of participant recruitment. Due to challenges identified in achieving the research objective, a unique data collection tool for online co-design with partially sighted participants was developed. Which consequently resulted in the development of four connected online co-design workshops. These workshops are structured as follows: first, identify and develop tools that support online co-design visualisation with partially sighted participants; second, use the tool to co-design signage online with partially sighted participants; and third, visualise and develop primary signage prototypes that reflect the signage graphic design needs of partially sighted participants.

Due to the amount of information and reflection gathered during the co-design workshops. **Chapter 6** is divided into two sub-chapters. Chapter 6-1 **- The Theoretical Foundation** establishes the development of the workshop method in response to the research aim. This chapter discusses the development of the co-design process as well as the reasoning for selecting certain workshop activities. Chapter 6-2 **- The Practical Implementation** documents the implementation of the developed co-design workshops. This sub-chapter covers the iterative workshop process, workshop findings, and insights from the developed online co-design method.

6.2 Method

This thesis proposes to adopt a proactive inclusive design strategy[11] in which partially sighted individuals are actively included in user-centred design activities[12] *(Chapter 2 2.5.4 The challenges of user-centred inclusive signage graphic* design*)* to generate design prototypes that reflect their design needs. Previous chapters (*Chapter 4* and *Chapter 5*) established an understanding of signage graphic design in academic settings, as well as identified pain points and suggestions for effective signage graphic design in academic settings. Nevertheless, insights such as *"concise", "simplified",* and *"clear"* are far from being quantified enough to suggest actual signage design; suggestions such as *"using arrows"* and *"larger symbols"* are too abstract to be implemented. As identified in *(Chapter 5 5.4.2 Effective signage design for partially sighted users),* partially sighted participants understand and are able to clarify the design practices which would make the signage more effective. Therefore, inviting participants to be actively involved in the stage of prototyping would be beneficial in identifying a more effective signage design practice for the partially sighted.

PD (Participatory Design) is an emerging design practice that involves target users in co-design activities throughout the design process (Sanders et al., 2010, p.195; Martin and Hanington, 2012, p.128). The goal of PD is to assist the target users in articulating the design specifications and deliver a starting point for subsequent professional design development (Sanders et al., 2010, p.195). The underlying philosophy of PD is that the design is done *with* the user rather than *for* the user (Magnusson et al., 2018, p.414). In the PD process, target users' role are considered beyond those of informant; they are active in the design process and contribute knowledge and perspectives that would not be reached otherwise (Martin and Hanington, 2012, p.128; Raman and French, 2021, p.11). Target users are given the position of 'expert of their experience' and are actively engaged in knowledge development, idea generation, and concept development through purposefully designed co-design activities (Sanders and Stappers, 2008, p.15). By incorporating user-specific requirements and insights into the design process (Thinyane et al., 2018, p.1), PD is able to provide a better understanding of the design 'problem', hence, producing design solutions that better support the users' needs (Cullen and

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[11] The proactive inclusive design strategy (Keates et al., 2000, p.46) suggests the inclusion of users with diverse capabilities to be adopted to the design development strategy: Stage 1: The target users should be explicitly mentioned in the problem definition; Stage 2: An appropriate design strategy should be used; and Stage 3: The target users should be involved in the evaluation stage.

[12] The four stages of activities of the user-centred design approach are: 1) Understanding and specifying the context of use, 2) Defining the user requirements, 3) Producing design solutions, and 4) Evaluation (Bevan, 2008, p.3; Bevan, 2009b, p.110; Bevan and Curson, 1998, p.111).

Metatla, 2019, p.361; Sanders et al., 2010, p.195). This makes co-design an ideal method to design for/with people of mixed abilities.

6.2.1 Research design

The rationale for using the PD co-design method at this stage of the research is to gain a better understanding of the specific signage design needs of partially sighted individuals and then co-create signage design prototypes based on this understanding. Participatory design emphasises on user involvement (Sanders et al., 2010, p.195; Martin and Hanington, 2012, p.128), as well as co-design *with* target user (Magnusson et al., 2018, p.414). However, with most traditional co-design activities devised for in-person engagement (Sanders et al., 2010, p.196), there are little framework available to support partially sighted participants to co-design visualisation online. Therefore, the development of the PD co-design activities in this chapter reflects the challenges of working with partially sighted participants in general and the challenges of working with them in an online setting. There are two challenges which prevent the accomplishment of this research objective: the challenge of a **lack of online co-design methodology** and the **consideration of accessibility**.

6.2.1.1 The lack of online co-design visualisation activities

Depending on the purpose of the research, the traditional co-design activities consist of the stages of *probing, priming, understanding* and *generating* through the activities of *making, telling* and/or *enacting* (Sanders et al., 2010, p.196). The composition of co-design activities is determined by the purpose of the co-design workshop, the form it takes, and the context of the design problem (Sanders et al., 2010, p.196). Therefore, it is difficult to find a one-size-fits-all set of activities in co-design. With the majority of co-design activities often carried out in person, very little research discusses the application of carrying out PD practice online (Friedrich, 2013, p.3; Tsuda and Sakuragi, 2020, p.502; Kamat, 2021, p.3), and even less is focused on partially sighted individuals (Lee, 2021, p.28).

Within the domain of online PD practices, novel approaches are identified. For example, using social media community page to post instructions for making face masks (Tsuda and Sakuragi, 2020, p.502), participants' comments in response to the quality of the instructions form the basis of the data collection. Using online forum to carry out digitalised focus groups, user diaries, surveys, brainstorming, prototyping and user testing through the observed interaction of participants (Friedrich, 2013, p.3). Through a video conference call, carry out co-creation activities with participants using materials they could find in their rooms (Kamat, 2021, p.15). These activities use the internet as a communication channel or as a new 'activity room' where

co-design activities can take place; however, because each approach is tailored to their research purposes and 'designed for fully sighted' participants, adapting these methods with partially sighted participants in co-design would raise accessibility concerns as well as data collection quality concerns.

6.2.1.2 Accessibility and cross-sensory approach

Most of the existing frameworks for engaging people with cognitive and sensory abilities/impairments focus on extreme needs and reduced participation (Raman and French, 2021, p.3). Some scholars chose to work with carers of the cognitive and sensory disabled, however, in the context of the goal of this chapter, working with a carer through developed workshop activities would relieve the challenge of accessibility; but this also means missing the opportunity to interpret what partially sighted individuals would want in signage design (Brewer, 2018, p.4; Raman and French, 2021, p.3).

The main challenge to co-designing with people who have mixed vision abilities is drawing out feedback from the participants (Brewer, 2018, p.1). Therefore, using multiple modalities (visual, auditory, tactile, and kinetic) to communicate the same information is the best way to guarantee getting the message through (Arthur and Passini, 1992, p.140). Most studies (Andrews, 2011, p.2; Schiafone et al., 2015, p.13; Brewer, 2018, p.1; Cullen and Metatla, 2019, p.361; Lee, 2021, p.3; Kamat, 2021, p.3) involving partially sighted participants are carried out in person or substitute visualisation activities with other methods to accommodate mixed vision abilities. The cross-sensory approach relies on more than one sensory element to facilitate communication, discussion, and artefact-making with mixed-ability participants. This has shown positive benefits in supporting co-creation with people with learning disabilities (Raman and French, 2021, p.11) and people with mixed vision abilities (Andrews, 2011, p.2; Thieme et al., 2017, p.739; Brewer, 2018, p.4; Chick, 2019, p.39). In a broader sense, the cross-sensory approach enhances understanding of the presented artefact and builds confidence in partially sighted participants (Chick, 2019, p.57). Moreover, when it is used in a collaborative workshop environment, it facilitates creativity and collaboration and supports participants with mixed-vision abilities to create and share stories through storytelling (Cullen and Metatla, 2019, p.361).

As a result, the cross-sensory approach is widely used in a variety of practices with partially sighted participants. Practices such as making simple and accessible cross-sensory prototypes using simple materials in participants' homes (Schiafone et al., 2015, p.13; Cullen and Metatla, 2019, p.364), mood boards/collage (Andrews, 2011, p.126), card sorting (Andrews, 2011, p.138), modelling with Styrofoam (Andrews, 2011, p.153), mock-up with wax sticks and

creating 3D models with playdough (Kamat, 2021, p.29). These practices accommodate participants' vision capabilities and produce some degree of 'visualisation'.

However, in relation to the goal that this chapter aims to achieve – facilitate visualisation in an online setting, these methods can also make it more challenging for participants, in terms of sourcing materials and creating a shared visual representation (Brewer, 2018, p.1). Therefore, to visualise with partially sighted participants online, the tool must be accessible to source, non-technical, low effort and able to be adopted by participants with different vision abilities.

6.2.1.3 The need for new online co-design approach

There was a need for a new online data collection approach that prioritised accessibility while also supporting online co-visualisation. This workshop aims to co-design signage with partially sighted participants online by helping them visualise their ideal wayfinding signage in the academic setting. To conclude the previous discussion, the challenges of this workshop are:

1) **Traditional workshop tools rely on in-person visual artefact making might require special adjustment in order to work with partially sighted participants' online.**
- Potential solution: Develop visualisation tools that are accessible and able to be used in online co-design workshops.
2) **Due to partially sighted participants' have different vision capabilities, the visualisation approach must be adaptable to all the participants to ensure data quality.**
- Potential solution: Provide participants with alternative methods to contribute to the workshop.

6.2.1.4 Visualisation through drawing tools

The breakthrough of the workshop redevelopment was the identification of the drawing/interpreting drawing capability of the partially sighted. Drawing is considered a universal tool for individual expression; study suggests that humans have innate pictorial abilities independent of their sight conditions and can interpret outline drawings (Kennedy, 1983, p.26). According to research (Kennedy, 1983, p.26; Kamel and Landay, 2002, p.39), blind individuals can create and interpret outline drawings. The challenges are to *relocate important points, determine angles*, and *communicate the whole structure of the drawing internally*. Even though drawing is considered a versatile tool accessible to different conditions of visual impairment, the lack of visual feedback makes it difficult for partially sighted individuals to produce well-structured drawings. Two major solutions are practiced by researchers to compensate for the absence of visual feedback.

The first solution is to substitute touch feedback for visual feedback. For example, providing specially designed paper and pen to partially sighted participants to create drawings that would leave tactile outlines on the canvas (Hamid and Edwards, 2013, p.37; Kamel and Landay, 2000, p.34) or providing specially made wax sticks and play dough to create 2D and 3D models (Kamat, 2021, p.29). These tactile methods support partially sighted participants in creating and communicating their drawings, as well as allow for shared visual representation in an in-person workshop environment. However, physical, static, and tactile images can be difficult to transfer, store, and retrieve.

The second solution is to substitute auditory feedback for visual feedback. Kamel and Landay (2002) developed computer software that generates a 3 x 3 grid canvas to support partially sighted and blind participants in producing drawings (Kamel and Landay, 2002, p.39). The 3 x 3 grid mimics the layout of the telephone keypad to promote a familiar interface; therefore, blind users may recognise and use the grid canvas immediately. Each grid can then be divided into its own 3 x 3 grid; the software would annunciate the grid position of the cursor (controlled by keyboard) to give auditory feedback to partially sighted participants to complete their drawing. Partially sighted and blind participants found it easy to locate and execute the command within the fixed grid structure. The grid-based model assists participants to understand the computer-generated graphics by providing a mental structure to identify relative and absolute positions on the canvas. Together, the auditory feedback and the grid model support partially sighted participants to overcome the challenges induced by lack of visual feedback and create drawings successfully. Nonetheless, this could take weeks of practice for partially sighted participants to communicate graphic information through the computer software efficiently.

6.2.1.5 The potential of the grid method for signage design

Wayfinding signage designs are commonly comprised of verbal (typographic) information and non-verbal (pictographic) information, together compacted into a rectangular-shaped format (Arthur and Passini, 1992, p.150). Therefore, the visualisation that needed to be achieved in the workshop is the composition of the typographic and pictographic information, which should illustrate partially sighted participants' needs regarding the layout of the signage design. Kamat (2021) provides a reliable solution to co-creating 2D/3D prototypes with partially sighted participants with the substitution of touch feedback for visual feedback. The use of modularized drawing units such as wax sticks and play dough would make creating and communicating signage layouts effective in an in-person environment. This technique,

however, also makes it challenging for participants to communicate the signage layout via the internet, as the workshop will be conducted online.

The 3 x 3 grid model developed by Kamel and Landay (2002) substitutes auditory feedback for visual feedback to support partially sighted participants in creating outline drawings. When a participant uses the grid model to complete a sketch, in addition to receiving auditory feedback about the position of the cursor, the fixed grid structure helps them understand the computer-generated graphics by providing a mental structure for identifying relative and absolute positions on the canvas. This solution would be effective for co-designing visualisation online. However, for participants to be efficient in sketching using the programme, considerable training is required, which may lead to more challenges. Nevertheless, the grid model, to some degree, compensates for the absence of visual feedback to support partially sighted participants in creating and communicating their drawings with a fixed structure. As discussed earlier in *6.2.1.2 Accessibility and cross-sensory approach,* to visualise with partially sighted participants online, the tool must be accessible to source, non-technical, low effort and able to be adopted by participants with different vision abilities; there is a potential to transform the grid model into a physical format to create a visualisation tool that embodies these criteria.

6.2.1.6 The birth of the new workshop tool

Kamel and Landay (2000) concluded that four essential criteria must be provided for partially sighted and blind individuals to complete a successful drawing task: a) Participants must be able to target an abstract point in relation to the drawing; b) Participants must be able to evaluate the length of a line; c) Participants must be able to assess the curvature of a drawing; d) Participants must be able to determine angles in relation to the drawing (Kamel and Landay, 2000, p.38).

A grid model was therefore created inspired by the grid developed by Kamel and Landay (2002), which aims to provide conditions required for blind and partially sighted participants to draw in real life. The grid model is constructed from squared post-it notes to replicate the grid's layout and to give tactile feedback for the edge of each grid cell. As the original grid design takes the resemblances of a mobile phone keyboard *(Figure 6-1 Drawing made by blind user using the grid drawing software (Kamel and Landay, 2002,* p.39*),* the layout of the grid used for this workshop bears the resemblances of a braille keyboard to promote *familiarity (Figure 6-2 Braille keyboard on iPhone (left) and concept of the grid (right)*. The grid model takes the importance of a fixed structure and assists in identifying the key drawing points on

the canvas. Because the majority of signage is designed in a rectangular shape, the grid model is an ideal tool for signage design, making drawing signage on the grid much more intuitive.

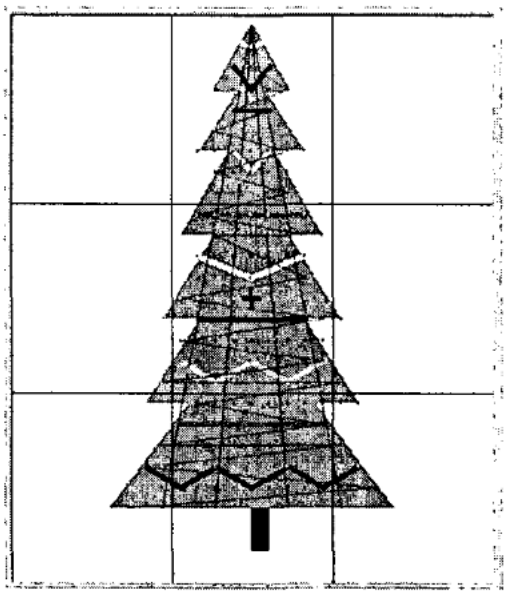

Figure 6-1 Drawing made by blind user using the grid drawing software (Kamel and Landay, 2002, p.39)

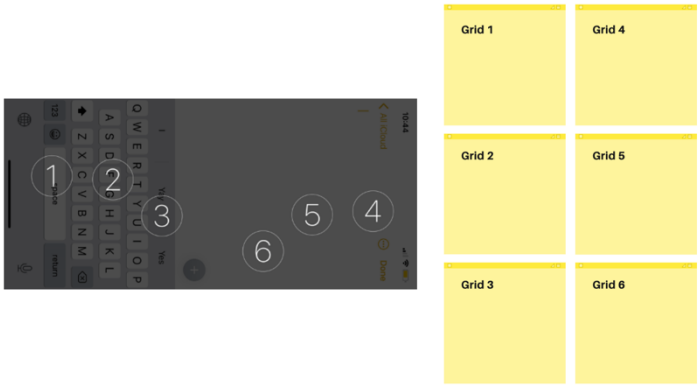

Figure 6-2 Braille keyboard on iPhone (left) and concept of the grid (right)

The overall grid shape will resemble the signage to be co-designed. The grid should present a miniature version of the under-designed signage. Each grid cell is numbered in a certain order to facilitate communication among partially sighted participants in online workshops. In the case of identifying pain points in signage design, instead of commenting about specific parts of signage design, participants may reference grid numbers to make comments and make direct drawings of ideas on the grid, making the online co-design activities much more efficient. This should also help participants to build a shared visualisation of the co-designed subject.

As discussed earlier, the four essential criteria must be met in order for partially sighted and blind users to successfully complete a drawing task. A post-it note grid, to some degree, compensates for the absence of visual feedback by providing tactile feedback with the edge of the grid cells (post-it note), and a fixed structure to assist participants to locate relative and absolute positions on the grid. Therefore, participants are likely to be able to locate and relocate the drawing on the canvas in relation to the reference framework provided by the fixed grid. Determining drawing angles should be easier on the grid compared to non-grid canvas. Assessing precise curvature can be difficult for them because of the requirements of the next level of the grids within a grid cell. However, because of the rectangular shape nature of the signage layout, this should have little impact on using a grid to facilitate the drawing of a signage design. Overall, the grid tool meets the criteria of being easy to source, non-technical, low effort, able to be adopted by participants with different vision conditions, and facilitating shared visual representations.

6.2.1.7 Reconsidering online co-design accessibility

The main challenge to co-designing with people with mixed vision abilities is drawing out feedback from the participants (Brewer, 2018, p.1). The developed grid tool would be an ideal based tool to support partially sighted participants in sketching their ideal signage design during the workshop activities, thus achieving visualisation. Reflecting on the challenges identified in *6.2.1.3 The need for new online co-design approach,* in order to accommodate the varied vision capabilities of participants, it would be beneficial to provide participants with alternative methods to contribute to the workshop. This could help to pre-empt the situation where the grid tool fails to collect feedback from participants. Considering the benefit of cross-sensory approaches in increasing the accessibility of data collection with mixed-ability participants *(6.2.1.2 Accessibility and cross-sensory approach),* it was decided to incorporate a cross-sensory approach to improve the accessibility of the grid tool for those with less functional vision.

Storytelling is an ancient practice of generating and conveying narrative structures out of words, sounds, or actions in order to amuse audiences, maintain cultures, or impart knowledge (Garzotto, 2014, p.5). Rooted in social science method of narrative inquiry, storytelling enables researchers to gather in-depth insight into participants' lived experiences through speaking (Martin and Hanington, 2012, p.68). Given the context of this thesis's intended goal, storytelling fit the need to foster the development of creativity in design workshops (Catala et al., 2017, p.237). Storytelling starts with researcher providing guidance to guide the flow of the narrative (Martin and Hanington, 2012, p.68), by incorporating

storytelling in the workshop, we would provide participants with a different outlet to express their creativity if they were not comfortable contributing to the workshop through drawing.

Writing has always played an essential role in co-design workshops; writing on sticky notes is popularly employed in the creative toolkit of PD workshops for low-fidelity prototypes (Martin and Hanington, 2012, p.78) or brainstorming. Writing as part of the creative toolkit of PD workshops can facilitate participatory exercises (Martin and Hanington, 2012, p.48), which project ideas, sentiments, aspirations, and sensations that would be challenging to express using conventional research techniques. Writing meets the criteria for being used repeatedly in different co-design sessions in the workshop; using writing as a different creative tool in the workshop would give participants another outlet to express their creativity without compromising accessibility. With online co-design practices utilising the benefit of online chat (Friedrich, 2013, p.3; Tsuda and Sakuragi, 2020, p.502; Kamat, 2021, p.3), participants would be able to use the chat function of the video conference call to participate in co-visualisation activities.

As discussed earlier, partially sighted individuals possess abilities for drawing/interpreting drawings; this is considered a universal tool for individual expression (Kennedy, 1983, p.26; Kamel and Landay, 2002, p.39), with the development of grid tool, which provides structure to the canvas and allows participants to locate and relocate relative points on the canvas, achieving low-fidelity in the workshop of visualisation is possible. Together with storytelling and writing as two other alternative creative tools, this should give participants more opportunities to contribute to the visualisation process by talking about, writing about, or drawing on the grid to communicate their design ideas, thus ensuring the workshop's accessibility and data quality.

6.2.1.8 Workshop Plan

At the time the workshop was designed, there was little framework available for co-design with partially sighted participants online. Moreover, there was uncertainty about whether the newly designed approach would be accessible enough for data collection. Also, the facilitator was not experienced in facilitating online co-designing workshops with partially sighted participants. Hence, four iterative workshops are necessary to achieve the goal of the study.

Table 6-1 Co-Design workshop framework

CO-DESIGN WORKSHOP FRAMEWORK		
Workshop	**Goals**	**Activities**

1	• To gain experience in facilitating online co-design workshops with partially sighted participants through a pilot study.	• Introduce the Grid tool for co-design. • Co-design a mobile video call app interface. • Gather feedback about online workshop facilitation.
2	• To test the application of the grid tool with co-design activities.	• Co-design a mobile video call app interface. • Gather feedback about the co-design workshop activities.
3	• To improve the grid tool for co-designing wayfinding signage.	• Co-design outdoor signage. • Gather feedback about the co-design workshop.
4	• To use the grid tool to co-design wayfinding signage.	• Co-design indoor signage.

For reasons discussed above, these four goals *(Table 6-1 Co-Design workshop framework)* are critical in achieving the goal of co-designing signage with partially sighted participants online. The attached activities for each goal require approximately an hour of time to complete. It would not be ideal to carry out a four-hour workshop with a small group of participants via the internet in one go. Moreover, four hours of the online workshop require commitment from the participants; this would increase the difficulty of participant recruitment. Dividing the workshop activities into four interrelated one-hour workshops would give the facilitator sufficient time to reflect on the completed workshop as well as make improvements in the subsequent workshops. Therefore, four interconnected workshops were carried out in four meetings.

The current workshop plan ends at the fourth workshop. The workshop starts with a structured plan; the activities of each workshop evolve during the four workshop sessions based on participants' feedback and observed engagement. Details of how each workshop was iterated are discussed later *(Chapter 6-2)* in each workshop section. Because of the novelty of the research method, the quality of this method was yet to be validated; adding more workshops after the goal of co-design signage is achieved does not necessarily add value to the research but increases the challenge for participant recruitment. Therefore, carrying out further research to validate this method is necessary before the further application of the developed method.

6.2.2 Workshop procedure and activities

The procedure of each of the workshops follows the framework developed by Sanders et al. (2001), which consists of the activities of the *probe*, *prime*, *understand* and *generative*. The goal of the prime activities was to prime participants and immerse them in the subject of the design. The goal of the understanding activities was to establish a good understanding of design problems through brainstorming and visualising solutions for identified pain points. The goal of generative activities was to evaluate prototypes and generate solutions for future design. The probe and prime activities were carried out through storytelling, and participants were asked to discuss the design problems through guided questions. The understanding and generative activities were carried out through speaking, writing and simple drawing. Participants were asked to develop design solutions that reflect their pain points with the design and make design proposals on the grid through speaking, writing and drawing. Theoretically, this approach empowers participants to co-design visualisations regardless of their vision ability.

Table 6-2 Workshop activities at a glance

WORKSHOP ACTIVITIES AT A GLANCE		
Sessions	**Purpose**	**Activities**
Probe	• To identify pain points and design 'problems' from the participants' perspectives.	• Participants are asked to discuss the challenges they have experienced with the design subject. • Questions are asked, "What do you find most challenging when using this product/service?", "Where on the layout of the design do these challenges occur".
Prime	• To prepare participants to be immersed in the design subject. • To identify the pain points of design on the grid. • To introduce the use of the grid.	• Questions are asked, "Which grid cell position on the design do you find most challenging to use?", "Do you think this challenge can be resolved by redesigning the design layout?".
Understand	• To establish a good understanding of design problems through brainstorming and visualising solutions for identified pain points	• Participants are given time to propose their design solution on the grid through speaking, writing or drawing. • Participants are asked to make design proposals on the grid where it represents the position on the design.
Generative	• To evaluate prototypes and generate solutions for future design.	• Participants are asked to present and explain what they have designed in each grid from grid 1 to grid 6, then all the grid cells together.

	• Participants are asked to talk about the changes they have made and why they proposed such design changes.

As discussed in *6.2.1.6 The birth of the new workshop tool,* the gird tool serves as the primary tool for the workshop activities. Participants may contribute to the workshop through speaking, writing or drawing on the grid to communicate their ideas about the design in reference to the grid. The speaking was carried out in the form of *storytelling,* which allows participants to have opportunities to express their experiences and concerns with the signage design on the grid through speaking (Andrews, 2011, p.133; Brewer, 2018, p.2). For example, when generating ideas for a specific position on the grid, participants can talk about their specific ideas for this area of the grid; the facilitator would take notes on the ideas and later compile them with other participants' writing or drawing ideas into a more sophisticated drawing. Writing and simple drawing allow participants to express themselves creatively when proposing a design solution; these activities were used alongside speaking as different methods to contribute to the workshop. Sophisticated drawing was carried out during the generative session; this was carried out on a shared screen by the facilitator, which let participants build a shared visualisation of the design by giving feedback and iterating on the co-designed prototypes together. A more detailed workshop plan can be found in *Appendix 3 Co-design Workshop Procedure, Script, and Time Arrangement.*

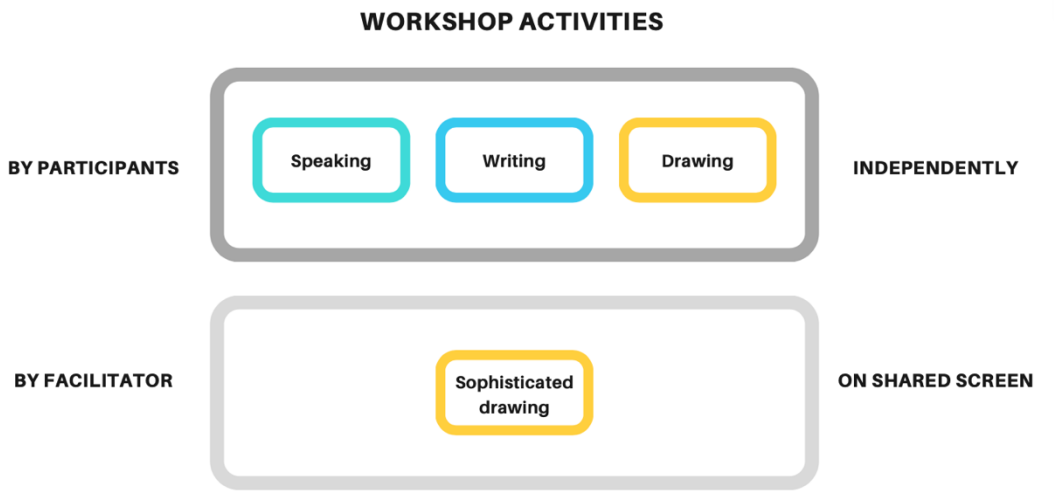

Figure 6-3 Workshop activities

6.2.3 Workshop participants

The ideal participants must have mild to severe visual impairment to fit the purpose of this thesis. This means one must have functional vision whilst having difficulty seeing, even when wearing glasses. This was emphasised in the participant recruitment materials.

Participants were recruited through partially sighted and blind organisations and charities such as the CNIB mailing list and word-of-mouth. Social media, such as Facebook Groups, were also used as a participant recruitment channel. I received eight interests at the initial recruitment stage. Incentives were included to show appreciation for participants' time and to encourage participation. However, I assume that, because of the time commitment required for the four workshops, a few participants who had registered their interest dropped out on the day of the first workshop.

An online questionnaire *(Appendix 4 Co-design Workshop Recruitment Questionnaire (Information Sheet & Consent Form)* that offers information consent, collects participants' general information and validates participants' vision condition was sent once the participant expressed interest in participating.

A total of **four** participants participated in this study. Three females and one male, all participants are native English speakers, and all participants are educated to at least an undergraduate degree.

Based on the self-assessment question set produced by The Washington Group on Disability Statistics[13], all participants are visually impaired and have functional vision.

[13] The **vision condition** self-assessment questions are adapted from The Washington Group Extended Set on Functioning (WG-ES), produced by ***The Washington Group on Disability Statistics*** through thorough research and studying in the past 20 years over 135 countries, which is known to be the best produce a reliable self-identified disability result.

Table 6-3 ICD categorisation of visual impairment (ICD-10, 2016)

Category	Presenting distance visual acuity	
	Worse than:	Equal to or better than:
0 Mild or no visual impairment		6/18 3/10 (0.3) 20/70
1 Moderate visual impairment	6/18 3/10 (0.3) 20/70	6/60 1/10 (0.1) 20/200
2 Severe visual impairment	6/60 1/10 (0.1) 20/200	3/60 1/20 (0.05) 20/400
3 Blindness	3/60 1/20 (0.05) 20/400	1/60* 1/50 (0.02) 5/300 (20/1200)
4 Blindness	1/60* 1/50 (0.02) 5/300 (20/1200)	Light perception
5 Blindness	No light perception	
9	Undetermined or unspecified	
	* or counts fingers (CF) at 1 metre.	

Based on the vision condition standard produced by ICD (International Statistical Classification of Diseases) and the visual acuity participants provided, participants are experiencing moderate to severe vision impairment and blindness.

6.2.4 Accessibility consideration in participants recruitment

The online questionnaire sent to participants at the beginning stage of the workshop is hosted by the Joint Information Systems Committee (JISC) platform - a UK-based online questionnaire service organisation. The questionnaire was tested accessible for the participants to access through mobile phone devices or personal computers. The text in the questionnaire was enlarged for better legibility for partially sighted participants. No imagery was included in this questionnaire for maximum accessibility. The questionnaire was tested to be screen-reader friendly. Workshop activities were developed with accessibility in mind. Participants can participate in the activities through speaking, writing, and drawing based on their preferences.

6.2.5 Ethical considerations

This study was granted ethical approval from the Faculty of Arts, Humanities and Cultures Research Ethics Committee, University of Leeds. The ethic reference: LTDESN-129. The data collection was carried out in accordance with the ethical protocol of Data protection, anonymisation and storage and sharing of research data, and informed consent. Participants were informed of the workshop procedure, data protection, and potential risks. Participants were offered autonomy to withdraw from this study.

Furthermore, people with visual impairments could experience a sense of vulnerability, which is defined as physiological/psychological factors inequalities that cause diminished autonomy (Moore, 2002, p.559). Strategies were put in place to address the sensitivity to vulnerability. Firstly, as discussed in *Chapter 3 Methodology (3.5 Sampling and participants recruitment),* participants were recruited through blind and visual impairment charity organisations and internet community groups. This gives participants autonomy to decide to participate in or opt-out of the project. Secondly, participants were informed of the online co-design workshop procedure, data protection, and potential risks. The research only starts after participants' consent to participate. Thirdly, participants were offered autonomy to withdraw from this study. Fourthly, due to participants being based in the North American region, the workshops were carried out at a time that was most suitable for them. Fifthly, participants were given incentives for their time due to the time commitment to this study.

6.2.6 Data analysis

Because each workshop (*6.2.1.8 Workshop Plan*) was planned with a specific goal to achieve, the data analysis method varied depending on the goal of this workshop. However, the core value of the data analysis follows content analysis for qualitative data (Saunders et al., 2016, p.611). First, data generated from the workshop will be categorised based on the nature of the data, for example, transcript from storytelling, writing, drawings.

Second, a framework will be employed to analyse the data. For signage design, this framework derives from the fundamental graphic design factors of signage design in academic settings identified in previous research (Chapter 5), which consist of typeface, type size, colour, layout, symbol and arrow.

Third, generated data will be broken down and coded under the framework themes.

Fourth, patterns observed among participants' prototypes will be recorded and presented in the findings.

The devising of the framework suits the principle for developing analytical categories of: 1) alignment to the purpose of the research, 2) being collectively exhaustive, 3) being mutually exclusive, 4) being independent, and 5) developed from a single classification (Saunders et al., 2016, p.611).

The first workshop aims to help the facilitator gain experience in facilitating online co-design workshops with partially sighted participants. This workshop focuses on the facilitator’s feedback on the workshop process. This part of the data was mainly gathered from observation; the challenges of facilitating an online workshop with partially sighted

participants were concluded. Handwritten note was the main type of data gathered during this workshop. The note focused on the insights of facilitating online co-design workshops with partially sighted participants as well as the technical aspect of the online workshop.

The second workshop aims to test the grid tool application in terms of achieving the goal of visualisation. Therefore, this workshop's data analysis focused on whether the grid tool can handle the probe, prime, understand, and generative activities in online co-design workshop with partially sighted participants. Participants' feedback on using the grid for visualisation was also discussed. The main data gathered from this workshop were audio recordings and the artefacts (writing and drawing) created during the workshop. This data was synthesised to address the capability of the workshop activities and tools in terms of drawing out contributions from participants.

The third workshop aims to improve the grid tool for co-designing wayfinding signage with partially sighted participants. The outcome of co-designed signage was the focus of data analysis, and participants' feedback on using the grid for co-designing signage was also discussed. The main data gathered from this workshop were audio recordings and the artefacts (writing and drawing) created during the workshop. This data was synthesised to address the participants' idea of effective signage design and insights into improving the workshop activities for co-designing signages.

The fourth workshop incorporates the insights from the first to the third workshops and aims to co-design wayfinding signage with partially sighted participants. Co-designed wayfinding signage outcomes were discussed. The main data gathered from this workshop were audio recordings and the artefacts (writing and drawing) created during the workshop. This data was synthesised to address participants' ideas of effective signage design.

6.3 Conclusion

Chapter 6-1 aims to establish the theoretical foundation of the co-design workshop and provide the rationale for the workshop activities carried out in the following **Chapter 6-2**. The challenge of co-designing visualisation with partially sighted participants online lies in the lack of online co-design tools and activities and the lack of accessible online data collection tools. To solve these problems and create an online co-design workshop that would be accessible to co-design visualisation with participants online. During the research tool development, it was realised that **to develop an online workshop that would be accessible to partially sighted participants, accessibility needs to be placed at the centred of the workshop tool and activity**

development. Extensive research and reflection were carried out in order to ensure the accessibility of the data collection tool in the redeveloped workshop plan.

A grid tool, which theoretically injects accessibility into the online visualisation activities, was devised during the extensive research for online co-design tools for partially sighted participants. This tool, combined with (cross-sensory) multi-modalities, should provide participants options in contributing to the workshop, therefore improving accessibility. The developed workshop plan built on the framework of the probe, prime, understand, and generative stages produced by (Saunders et al., 2016, p.611), because it provides a good structure for the workshop activities. With the newly developed online co-design tool that improves the accessibility of the workshop activities, the workshop should gather valid data to achieve the goal of assisting online co-design visualisations with partially sighted participants. Because of the novelty of the newly developed online co-design tool. To make sure this approach is effective in achieving the goal of the study, four iterated workshops were developed to ensure the validity of the data collection.

The next sub-chapter (6-2) focuses on implementing the redeveloped workshop plan. Each of the four workshops was carried out to achieve a small goal that led to the accomplishment of the aim of Chapter 6. The iterative workshop process and how the workshop outcome informs the signage design practice that better meets users' needs will be discussed.

Chapter 6 - 2 Visualising Partially Sighted Participants' Design Needs for Wayfinding Signage in Academic Settings – The Practical Implementation

6.4 Introduction

Chapter 6-2 presents the implementation of co-design workshops developed in *Chapter 6-1.* This chapter aims to prototype signage graphic design with partially sighted participants through online co-design activities established in the previous chapter *(Chapter 6-1)*.

The challenge of online co-design visualisation with partially sighted participants, as discussed in *Chapter 6-1*, comes from a lack of online co-design tools and activities, as well as accessible online data gathering methods. Strategies were put in place to ensure the accessibility of the online workshop. The (post-it notes) grid, a cross-sensory drawing tool, was created for this purpose. A framework for four iterative online co-design workshops was devised to validate the cross-sensory (grid) drawing tool and to build visual prototypes of signage graphic design with partially sighted participants online.

These four workshops are designed to be interconnected and iterative. Each workshop informs the activities to be carried out in the subsequent workshop. The first workshop assists the facilitator in gaining experience facilitating online co-design workshops with partially sighted participants; the second workshop investigates the use of the cross-sensory drawing tool in co-design activities; the third workshop improves the cross-sensory drawing tool for co-designing wayfinding signage; and the final workshop co-designs wayfinding signage. Therefore, this chapter will be focusing on discussing two aspects of the co-design workshop: the outcome of the co-design activities and the progression of the co-design workshop.

In order to present a clearer picture of how the workshop progression informs and leads to the achievement of the aim of Chapter 6, this chapter starts with the presentation of an overview of each workshop. The chapter will then dive into each workshop's results and insights. The outcome of the workshop and the methodological approach used to achieve this outcome are discussed at the end of this chapter.

6.5 Overview of workshop activities

Table 6-4 Overview of co-design workshops activities presents an overview of the workshop activities carried out in this chapter. As discussed in *Chapter 6-1 (6.2.1.8 Workshop Plan),* these

four interconnected workshops were developed in response to a lack of methodological frameworks to support online co-design visualisation with partially sighted participants, as well as concerns about the accessibility of the newly developed data collection tool (cross-sensory drawing tool). As a result, with all workshops being self-contained design workshops, the first three workshops provide insights into co-designing signage with partially sighted participants online, as well as support the development and refinement of workshop activities. The fourth workshop incorporates all the insights and generates data to answer the research question - visualising partially sighted participants' design needs for wayfinding signage in academic settings.

The first workshop *(6.6 Workshop 1)* was carried out for the facilitator to gain experience facilitating online co-design workshops with partially sighted participants. Therefore, this workshop will be focused on the aspects of facilitation and the technical aspects of conducting co-design online. Insights gathered during this workshop relevant to online workshop facilitation with partially sighted participants will be discussed.

The second workshop *(6.7 Workshop 2)* was carried out to improve the developed grid drawing tool and activities in facilitating visualisation with partially sighted participants. Therefore, this workshop will focus on getting feedback on the capability of developed workshop tools and activities in terms of generating input from participants. Insights into improving the workshop tool and activities for co-designing visualisation will be discussed.

The third workshop *(6.8 Workshop 3)* was carried out to improve the grid drawing tool and workshop activities to support partially sighted participants in visualising signage graphic design online. Therefore, this workshop will be focused on getting feedback on improving the workshop tools and activities for signage graphic design. Insights into improving the workshop tool and activities for co-designing signage with partially sighted participants will be addressed.

The fourth workshop *(6.9 Workshop 4)* was carried out to co-design signage with partially sighted participants. Therefore, this workshop will be focused on participants' design needs and the outcome of co-designed signage. The overall co-designed signage outcome and co-design process will be discussed.

Table 6-4 Overview of co-design workshops activities

OVERVIEW OF CO-DESIGN WORKSHOPS ACTIVITIES

Workshop	Goals	Activities	Outcomes	Implications to the following workshop
1	• To gain experience in facilitating online co-design workshops with partially sighted participants.	• Introduce the workshop. • Introduce the Grid tool for co-design. • Co-design a mobile video call app interface. • Gather feedback about online workshop facilitation.	• Insights into facilitating co-design workshop with partially sighted participants online	• Record the workshop (with consent). • Create a scenario using the video call app that leads to participants' storytelling. • Add a time limit to each workshop activity. • Give more positive feedback to participants when they present their work.
2	• To test the application of the grid tool with co-design activities.	• Co-design a mobile video call app interface. • Gather feedback about the co-design workshop activities.	• Insights into using the grid tool to co-design visualisation with partially sighted participants online • Insights into the co-design activities	• Provide design examples of wayfinding signage (selected based on the previous online questionnaire study). • Provide design elements that are available for wayfinding signage. • Provide basic design knowledge of the signage design process. • Instead of participants drawing their prototype and not being able to present it through the camera, try to create it together on the shared screen.
3	• To improve the grid tool for co-designing wayfinding signage.	• Co-design outdoor signage. • Gather feedback about the co-design workshop.	• Insights into using the grid tool to co-design wayfinding signage with partially sighted participants online	• Keep providing design examples of wayfinding signage (selected based on the previous online questionnaire study). • Provide basic design knowledge to put signage together. • Let participants draw their prototype, then create it together on screen.
4	• To use the grid tool for co-designing wayfinding signage.	• Co-design indoor signage.	• Co-designed wayfinding signages	

6.6 Workshop 1 – Pilot study

6.6.1 Workshop goal and procedures

Workshop 1 was carried out with the topic of designing a mobile video call app for the facilitator to gain experience in co-designing with partially sighted participants online. This workshop was divided into four sessions (*Table 6-5 Workshop 1 procedure at a glance*). Before the workshop sessions, participants were introduced to the design tasks (design a video call app) and the grid tool that needed to be used in the workshop. A detailed introduction of the grid tool can be found in *Appendix 3 Co-design Workshop Procedure, Script, and Time Arrangement*. A mobile video call app was chosen to be co-designed instead of wayfinding signage to test the tool and to help stay focused on building up the co-design tool and activities rather than signage graphic design at this stage of research. Also, this should have less influence on the co-designed signage in later studies.

Table 6-5 Workshop 1 procedure at a glance

WORKSHOP 1 PROCEDURE AT A GLANCE		
Sessions	**Goals**	**Activities**
1	• To identify pain points during using the mobile video call app interface.	• Participants were asked to discuss the challenges they have experienced when using any existing video call app. • Questions were asked, “What do you find most challenging when using this online video call app?”, “Where on the screen do these challenges occur”.
2	• To identify the pain points of design on the grid.	• Questions were asked, “Which grid cell position on the design do you find most challenging to use?”, “Do you think this challenge can be resolved by redesigning the interface?”.
3	• To brainstorm and visualise solutions for identified pain points.	• Participants were given time to propose their design solution on the grid through speaking, writing or drawing. • Participants were asked to make design proposals on the grid where it represents the position on the interface.
4	• To evaluate prototypes.	• Participants were asked to present (on camera) and explain what they have designed in each grid from grid 1 to grid 6, then all the grid cells together.

	• Participants were asked to talk about the changes they have made and why they proposed such design changes.

6.6.2 Outcomes

The workshop finished right on time. The first three activities were carried out smoothly, with the fourth session of activities rushed due to running out of time.

Pain points that partially sighted participants encountered in real life using a mobile video call app were identified on the grid. Design solutions to improve the app were collected on the grid. Participants found ease in using the grid; participants could communicate about the design features through the grid.

The challenges in facilitating a co-design workshop with partially sighted participants online were identified through the notes taken after the workshop.

> *"The workshop today finished on time. However, I had to rush through the final activities because the previous activities took longer than expected. A few things need to be considered in the next workshop.*
>
> *1) Participants have various degrees of interest in mobile video calling apps. I need to create activities to facilitate their interest in designing the app.*
> *2) Participants were not sure how to visualise a video call app on paper because of their different experiences with different apps.*
> *3) Due to the different camera quality, it does not seem suitable for participants to show their design through the camera.*
> *4) The third session of brainstorming ideas took too long, and I had to rush through the final session. In my next workshop, I need to set a time limit for each activity."*
>
> ------ Facilitator's Note

Challenge during session 1 – Pain points identification:

- **Challenge 1:** Participants have varying degrees of experience with video call apps; this influenced participants' enthusiasm to participate.

Challenge during session 2 – Pain points identification on the grid:

- **Challenge 2:** Participants got into chatting away from the subject with each other when a relatable situation was identified.

Challenges during session 3 – Idea generation and visualisation:

- **Challenge 3:** One participant found it difficult to visualise ideas. Participants with less drawing skill shy away from presenting their ideas due to one of the participants in the group being considered *"very creative".*
- **Challenge 4:** When each task was given to participants without any time limit, participants tended to wait until the last participants completed their task to speak up.

Challenge during session 4 – Evaluation:

- **Challenge 5:** Participants had difficulty presenting their drawings on camera to other participants due to different camera quality. However, this does not impact their communication through the grid.

Technical challenges:

- **Challenge 6:** The pilot study was not recorded; therefore, it was difficult to catch up with each participant's discussions and, at the same time, keep facilitating the workshop.

6.6.3 Findings

6.6.3.1 Insights from online co-design with partially sighted participants

Creating scenarios to help participants brainstorm ideas might be necessary. One participant had little experience using a video call app on their mobile phone device and found it difficult to contribute to the discussion. The reason for the lack of experience using the app is the lack of accessibility features in the current app. Creating a scenario where participants have an opportunity to experience an imaginary accessible mobile video call app would help participants envision a future that does not exist yet; it would be beneficial for them to engage in the conversation and contribute to brainstorming (Brewer, 2018, p.2; Williams et al., 2015, p.4).

Reintroducing the subject into the conversation when necessary. One of the challenges in this workshop was that the conversation deviated from the workshop subject when participants identified similar experiences (as partially sighted individuals) with others. This type of discussion was, sometimes, beneficial for the workshop to learn about participants' experiences and facilitate collaboration between participants. However, it is important to ensure the conversation stays focused on the workshop goal and let the participants know that this discussion can also be continued after the session.

The developed grid model might not be the best tool for detailed app interaction design. The grid tool was considered capable of being used to communicate and visualise the static visual

design of the app interface. However, design solutions such as gestures on the screen and utilising the placement of the physical buttons are considered to increase the accessibility of the app but were considered difficult to visualise on the grid.

Overall, the workshop approach enables online communication and collaboration among partially sighted participants. The pilot workshop was carried out without pauses caused by lack of accessibility or participants' inability to participate. This was apparent during the last session – evaluating prototypes. Participants can communicate and contribute their ideas through the grid despite the different quality of their cameras and lighting. Participants can grasp different design ideas in real-time through the grid placement and make comments on other prototypes effortlessly.

6.7 Workshop 2 – Co-design tool and activities development

6.7.1 Workshop goal and procedures

This workshop aims to test the application of the grid tool in facilitating visualisation with partially sighted participants in online co-design workshops. Workshop 2 was carried out in accordance with the insights generated from the pilot study.

This workshop was divided into four sessions. Before the workshop sessions, participants were introduced to the design tasks (designing a video call app interface) and the grid tool that needed to be used in the workshop. The procedure of this workshop follows the previous pilot workshop *(6.6 Workshop 1 – Pilot study)* with a few changes to mitigate the challenges identified in the previous workshop; these changes are:

1) This workshop was recorded (with consent).
2) A scenario of using the video call app that leads to participants' storytelling was provided.
3) A reasonable time limit for each workshop activity was given to participants at the beginning of each task.
4) Considering the difficulty of presenting drawings on camera, the fourth session was carried out more verbally than visually.

Detailed workshop 2 procedures can be found in *Appendix 5 Co-design Workshops Procedures.*

At the end of the session, participants were asked to give feedback about the workshop activities and make overall suggestions for the workshop.

6.7.2 Outcomes

The workshop outcomes showed that the developed workshop tool and activities facilitate visualisation with partially sighted participants in online co-design workshop. This is reflected in online prime, understanding and generative activities.

6.7.2.1 Grid tool and prime activities

The purpose of the prime activity in the online co-design workshop was to immerse participants in the design subjects that needed to be co-designed. During the prime activity (second session) of the workshop, participants were asked to identify their pain points with a mobile video call app they had in mind and translate these on-screen problems into corresponding grid positions *(Figure 6-4 Illustration of the screen space (left) and corresponding grid (right).* This activity prepared them to communicate their ideas specific to locations on the 'screen' in later understanding and generative activities.

Participants mainly relied on storytelling to communicate their pain points and complete the task; therefore, no visual artefacts were created in this activity. Participants were able to address their pain points to a specific grid position throughout the prime activity, and primary problems with using the video call app were collected (*Appendix 6 Data from Co-design Workshops 2 – Prime Activities).*

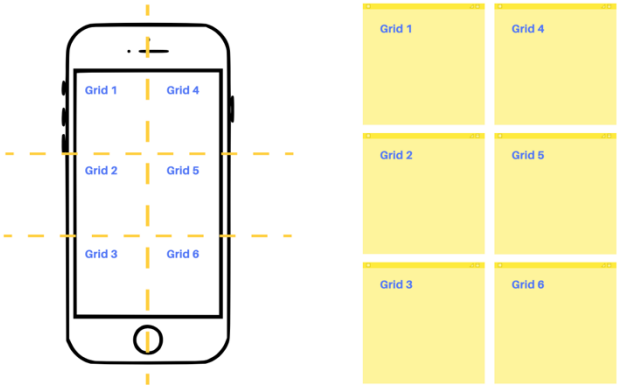

Figure 6-4 Illustration of the screen space (left) and corresponding grid (right)

6.7.2.2 Grid tool and understanding activities

The purpose of the understanding activity in the online co-design workshop was to help participants establish a good understanding of design problems through brainstorming and visualising activities. During the understanding activity (third session) of the workshop, themes of design problems were identified through the grid. These themes and generated ideas

prepared participants for the next stage of generative activities. Design themes and ideas that emerged during understanding activities can be found in *Appendix 7 Data from Co-design Workshops 2 – Understanding Activities*. *Figure 6-5 Examples of grids created by participants* presents participants' different approaches to prototyping app interfaces using the grid tool.

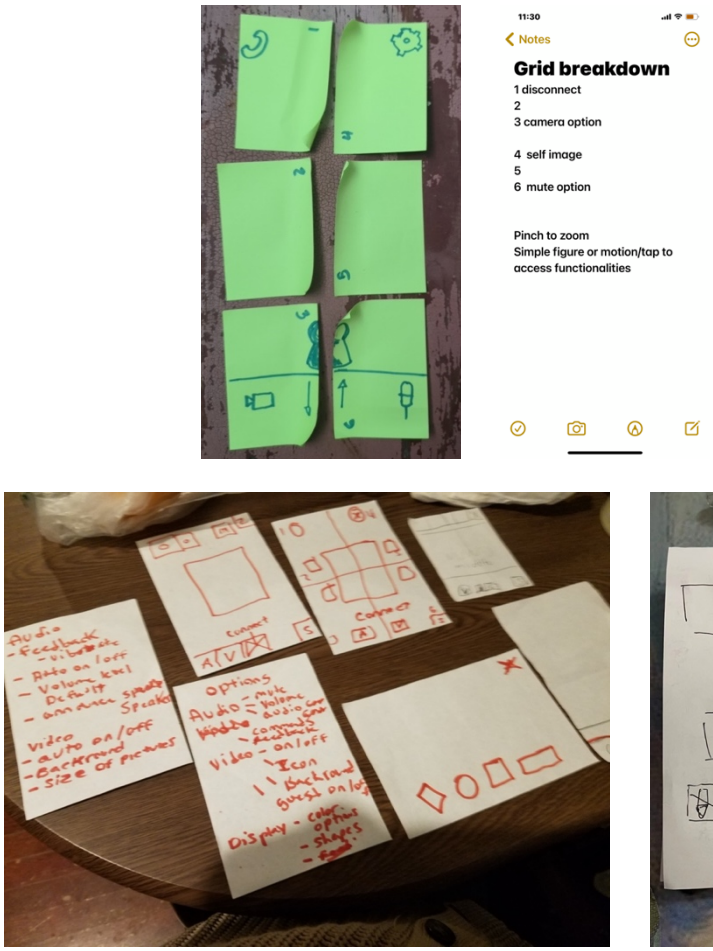

Figure 6-5 Examples of grids created by participants

6.7.2.3 Grid tool and generative activities

The purpose of the generative activity in the (fourth session) online co-design workshop was to evaluate prototypes and generate solutions for future design. Participants successfully used the grid tool to produce a visualisation based on previous activities. *Figure 6-5 Examples of grids created by participants* presents participants' different approaches to prototyping the app interface design through the different modalities provided in the workshop. Due to the technical challenge identified in the pilot workshop *(6.6.2 Outcomes),* the difference in camera quality made it difficult for participants to present their thoughts in real-time. Participants were asked to send a picture of their prototype to the group chat and explain while everyone has the picture of the prototype. Because participants were not able to collaborate on one final design solution. In the end, a prototype that is inclusive of participants' ideas for the

design solution was created on the shared screen by the facilitator. *Figure 6-6 Co-created app interface prototype* presents the final design idea of the video call app interface, which was iterated to common agreement among participants. Detailed information about the prototype can be found in *Appendix 8 Data from Co-design Workshops 2 – Generative Activities*.

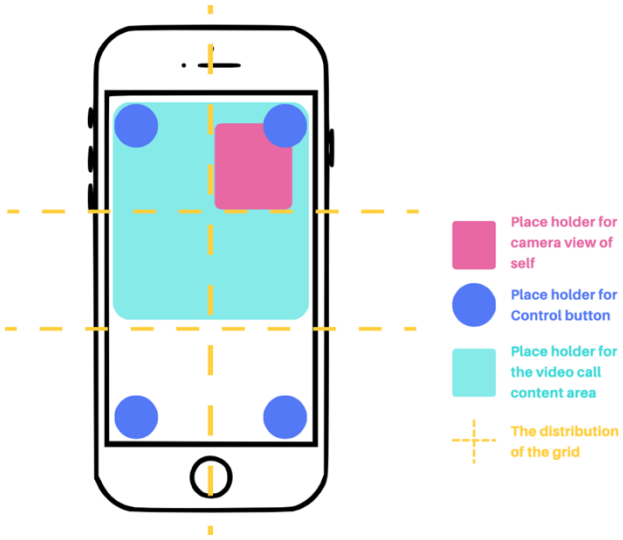

Figure 6-6 Co-created app interface prototype

6.7.2.4 Feedback on the grid and the workshop

Feedback about the grid tool was collected during the course of the workshop. For example, during the prototyping activities, participants were asked, *"how are you getting on with the grid?"* At the end of the prototyping activities, participants were asked, *"how do you feel about using the grid tool for prototyping?"* At the end of the workshop, participants were asked, *"Overall, how do you feel about the grid tool, in general, being used in the workshop?"*

Overall, participants found the grid *"organised", "easy to identify areas", "good for explaining the design verbally, works well for that",* and *"easily expressible"*. However, participants struggled to use the grid when needed to address human-screen interactions such as pinch to zoom, or when interaction led to interface page changes such as pop-up windows or screen changes.

Limitations with the workshop activities were identified during idea generation and prototype activities. Participants found it *"hard to visualise"* when having to create a design on *"blank paper",* in which case participants suggested the need to provide a *"template of interface"* to inspire. One participant commented, *"it is ironic that we are visually impaired, but we are visual learners. It would be helpful to have a visual template… so we can jump in a little bit faster; I can provide feedback better rather than react to comments, better than adding comments on the abstract grid."* This suggests that providing visual examples to partially

sighted participants before prototyping might be beneficial. The lack of visual examples can be the reason that some generated design ideas were not made into the final prototypes because participants were not sure of the ways to visualise them.

6.7.3 Findings

6.7.3.1 Grid tool facilitates visualisation in online co-design

Evidence shows that the grid tool facilitates visualisation with partially sighted participants through prime, understanding and generative activities *(Chapter 6-1 6.2.2 Workshop procedure and activities).* The prime activities are often used in co-design workshops to immerse participants in the design subjects that need to be co-designed. Accompanied by the grid tool, in this workshop, the prime activities helped participants identify pain points on the 'screen' through the grid *(6.7.2.1 Grid tool and prime activities).* This facilitated participants' familiarity with the screen space of the app interface.

The understanding activities are often used in co-design workshops to help participants establish a good understanding of design problems. Accompanied by the grid tool, in this workshop, the understanding activities helped participants identify themes of design 'problems' and reflect on where these 'problems' are best addressed on 'screen' *(6.7.2.2 Grid tool and understanding activities).* Prototypes produced during the understanding activities helped participants establish a connection between their pain points with the app interface and their ideal design solutions.

The generative activities are often used in co-design workshops to generate solutions for future design. This was carried out through the review of a 'collaborated' design solution. Accompanied by the grid tool, in this workshop, the generative activities incorporated insights from prime and understanding activities, and a co-created visualisation that reflects participants' pain points and ideal design was produced *(6.7.2.3 Grid tool and generative activities).* The grid tool was well received by participants during the workshop *(6.7.2.4 Feedback on the grid and the workshop).* This could be the result of 1) the grid tool supported participants to co-create with multi-modality creative tools such as verbal expression, writing, and drawing; 2) the pilot study familiarised participants with the grid tool. This finding implies the potential of using the grid tool for co-designing wayfinding signage.

6.7.3.2 The potential of providing visual examples

Providing visual examples of expected outcomes might facilitate participants' creative engagement. For example, a design template, or a design example. Participants raised the

difficulty in visualising the app interface design due to the lack of a mental image of the available design. This led to a more text-based than visual-based prototype *(Figure 6-7 Participants' prototypes of app interface).* This was found significant with a participant who had little experience using the video call app on mobile phone devices. The lack of understanding of visual expectations can be the reason for the 'text-based prototype'. Therefore, participants seeking visual examples to support their visualisation ruled out the possibility that participants were not comfortable drawing on the grid; instead, they used writing as their creative tool.

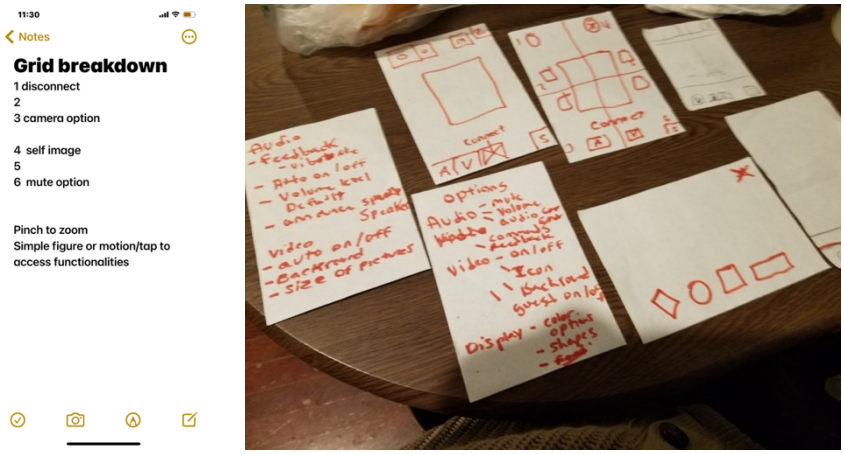

Figure 6-7 Participants' prototypes of app interface

Based on the literature, the facilitator's role is to provide accessible information and tools to help translate participants' experiences and their needs into design practice in co-design (Sanders and Stappers, 2008, p.13). Therefore, in the next workshop, visual examples of expected outcomes will be provided during the prime activities.

6.8 Workshop 3 – Co-design outdoor signage

6.8.1 Workshop goal and procedures

This workshop aims to refine the co-design tool and activities for co-designing wayfinding signage with partially sighted participants in online workshop. Outdoor wayfinding signage was used as the design subject of this workshop because outdoor wayfinding is less complicated than indoor wayfinding *(Chapter 2 2.4.3 The challenge of wayfinding in academic settings).* Starting with a less complicated outdoor wayfinding scenario would help me focus on developing the grid tool for co-design signage.

The procedure of this workshop follows the structure of the second workshop with changes applied based on the insights gathered in the previous workshops *(6.7 Workshop 2 – Co-design tool and activities development).* These changes are:

- Providing a wayfinding scenario at the beginning of the workshop to lead the storytelling.
- Providing design examples of wayfinding signage (selected based on the previous online questionnaire study).
- Providing information of the fundamental elements and components of signage graphic design.
- Providing basic design knowledge of the signage graphic design process.
- Instead of participants drawing their prototype and not being able to present it through the camera, try to create it together on the shared screen.

Table 6-6 Workshop 3 procedure at a glance presents the procedure of this workshop.

Table 6-6 Workshop 3 procedure at a glance

WORKSHOP 3 PROCEDURE AT A GLANCE

Sessions	Goals	Activities
1	• To identify the user journey and challenges during wayfinding.	• Participants were given a scenario: "You are at the entrance of a campus. Please walk us through the process of finding a specific building (i.e., School of Mathematics) on campus using only signage". • Participants were asked to discuss the information and signage they would need to find the building and the challenges they might encounter based on their experience. • Questions were asked, "What would be the initial information you look for?" "How would you get to this location?"
2	• To introduce participants to basic signage design elements and examples. • To help participants learn about the basic design elements they can use in their idea generation and prototype.	• A shared google slide was used to present all the examples; participants were given time to zoom up to view examples in detail. • Participants were introduced to the variation of signage design layout, the variation of symbols, the variation of arrows and different types of signage designs. • Participants were asked to give feedback on the design elements.
3	• To identify the pain points in a series of examples of signage design.	• Design factors such as layout, type case, information organisation, and symbols were evaluated.

		• Participants were asked to review a series of common signage designs.
4	• To create signage prototypes together on the shared screen.	• Participants were asked to contribute to the design by justifying their ideas and instructing the facilitator to make real-time changes on the shared screen. • Questions were asked, "would you say that design change improves the signage for you?" "Is that what you mean?". • Each example was modified until the group was satisfied with the design. • At the end of each modification, participants were offered the opportunity to give feedback on the final prototype.

6.8.1.1 Workshop materials – visual examples

It was raised in workshop 2 *(6.7.2.4 Feedback on the grid and the workshop)* that participants would want design examples to be provided in the workshop to inspire their visualisation. Therefore, signage examples were prepared for relevant workshop activities.

It was identified in *Chapter 4 (4.10.1 Signage design in academic settings)* that design factors including *Type*, *Layout, Colour*, *Symbol,* and *Arrow* are essential in delivering the sign message in academic settings. Variations of these design elements were provided during the second session (prime activities) of the workshop to gather participants' feedback on preferences and inspire participants that there is more than one way to design signage.

Collections of outdoor signage examples were produced by the facilitator incorporating these design elements *(Figure 6-8 Outdoor signage design examples).* The categorisation of sign examples was chosen according to Chapter 2 *(2.2.3.5 Signage categorisation based on signage information).* These design examples were produced following the design guidelines *(Appendix 1 Wayfinding Signage Design Guideline Framework)* collected in *Chapter 4 – Design review.* Examples were created using the grid model *(Chapter 6-1 6.2.1.6 The birth of the new workshop tool)* to make it easier for participants to address the positions of design examples and to demonstrate how a signage graphic design may be placed on the grid.

These design examples simplify signage graphic design by incorporating the four most important signage graphic design elements: *type, layout, symbol*, and *arrow*. The purpose of the simplified design was to, on the one hand, illustrate the potential of the grid tool to be used as a design canvas; on the other hand, to increase the accessibility of the image by using a high contrast colour combination (black and white).

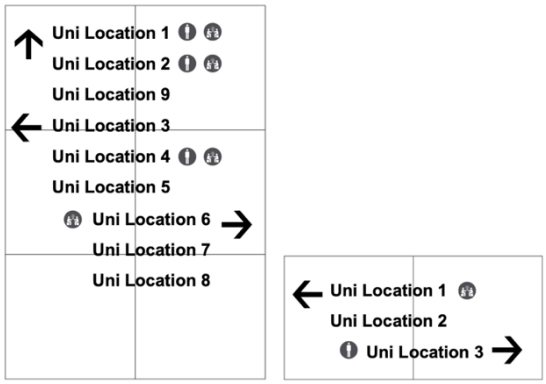

Figure 6-8 Outdoor signage design examples

6.8.2 Findings

The findings of this workshop are presented following the timeline of *Table 6-6 Workshop 3 procedure at a glance.* The finding of the wayfinding scenario is presented in *6.8.2.1 Participants' outdoor wayfinding journey;* this finding shows the importance of signage graphic design in partially sighted participants' outdoor journey, as well as common problems participants have with the outdoor signage graphic design.

Participants' preferences for signage graphic design elements were identified during the session of prime (preparation) activities; detailed feedback regarding participants' design elements preferences can be found in *Appendix 9 Preference for Signage Design Elements.*

One of the improvements in this workshop was that participants were given design examples prior to the idea generation activities. With the use of the design examples, participants' pain points with types of signage graphic design were identified *(6.8.2.2 Pain points with outdoor direction sign – 1* and *6.8.2.4 Pain points with outdoor direction sign – 2).*

All the co-designed prototypes were developed together on a shared screen by the facilitator. The design prototypes will be discussed in *6.8.2.3 Prototype of the outdoor direction sign – 1* and *6.8.2.5 Prototype of the outdoor direction sign – 2.* Participants won't be producing individual prototypes in this workshop because of the difficulty of presenting their prototypes on camera.

6.8.2.1 Participants' outdoor wayfinding journey

Based on gathered data *(Table 6-7 Partially sighted participants' wayfinding journey – outdoor),* partially sighted wayfinders initially need the location information of themselves and the destination to start a wayfinding journey. After acquiring this information, they relied on the ongoing directional information to guide them to their destination. Challenges during this

journey are often associated with **difficulty finding** or **reading** signage. This supports the importance of signage availability in wayfinding information processing and decision making (Arthur and Passini, 1992, p.28). This supports the significance of route-type information (Verghote et al., 2019, p.9) in partially sighted wayfinders' wayfinding performance (Noordzij et al., 2006, p.321; Hölscher et al., 2006, p.284).

Table 6-7 Partially sighted participants' wayfinding journey – outdoor

USER JOURNEY			
User journey	**Information**	**Challenges**	**Suggestions**
• To learn the name of the destination building • To learn about the building around me • To learn where I am	• Looking for the name of the location • Looking for where I am at • Looking for the entrance of the destination building • Looking for the map on an **Information sign**	• Unable to locate the sign	• Using lighted sign • Predicable location • Consistent side of the road • Consistent size • Eye level placement
• To find how to get there • To follow the path of arrows	• Arrows (**Directional sign**)	• celling sign and post sign are too high up	• Use colour • Coloured lines on the floor • Follow the line that made of shapes (circles/rectangles) or a mixture • contrast just black and white • *"simple is good"* • Eye level placement

6.8.2.2 Pain points with outdoor direction sign – 1

Prior to the idea generation and prototyping, participants were asked to review and evaluate signage examples; common pain points they experienced with this type of signage graphic design were identified.

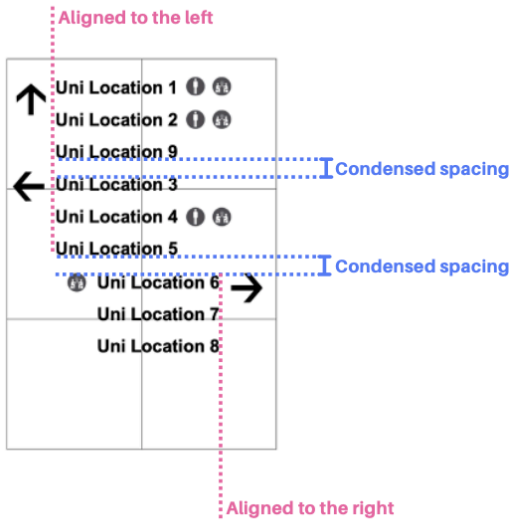

Figure 6-9 Outdoor direction sign example – 1

Participants identified two pain points with the outdoor direction sign example. The **first pain point** is anxiety caused by inconsistent arrow alignment. Contrary to what (Baker and Fraser, 2000, p.39) suggested, participants, feel anxious rather than intuitively convenient when sign messages are aligned to the side of where the arrow points towards. It was raised that *"when (arrow) miss-aligned… it makes me more and more anxious the longer I look at this. I am looking at the sign to give me direction, but it is giving me immediate anxiety," "This type of sign, obviously, we are looking for a location, it would be helpful if it's all completely all aligned… in the real-life if it is all lined up... I can just scan to the bottom…".* Participants suggest the information hierarchy on the direction sign should follow the location name *("where I am going"),* direction arrow *("the direction I am going"),* and then the (symbols) information of what is available also in the destination.

The **second pain point** is the confusion caused by the condensed spacing between different groups of locations. Participants raised that it can be especially confusing when location names are not consistently aligned. For example, for participants' vision conditions, *"Uni location 5" (Figure 6-9 Outdoor direction sign example – 1)* can be interpreted as both going left or going right at the same time.

Participants appreciate grouping locations based on directions because it *"reassures"* them that they are *"going in the right direction"* when familiar location names are identified on the journey.

6.8.2.3 Prototype of the outdoor direction sign – 1

The facilitator created the prototype by compiling participant suggestions provided in response to identified pain points. Participants' suggestions *(Table 6-8 Design suggestions for*

outdoor direction sign – 1) were implemented on the prototype in real-time while it was being created and displayed on a shared screen.

Table 6-8 Design suggestions for outdoor direction sign – 1

OUTDOOR DIRECTION SIGN – 1		
Pain Points	**Suggestions**	**Grids**
Inconsistent alignment	• All the arrows on the left side • Followed by location • Followed by symbol	• Grid 3 • Grid 6
Type case	• Prefer to be all CAP for the location names instead of mix case	• Grid 1 - 6
Information organisation	• Larger spacing between each direction • List in alphabetical order	• Grid 1 - 6

According to participants' feedback and suggestions, compared to the example, three main design differences were identified in co-created outdoor direction signage - 1 *(Figure 6-10 Outdoor direction sign - 1 original (left) and prototype (right)*

1) Larger **spacing** between the three groups of locations.
2) All the text messages are **left-aligned** to the arrows.
3) All the location names are in **uppercase** instead of sentence case.

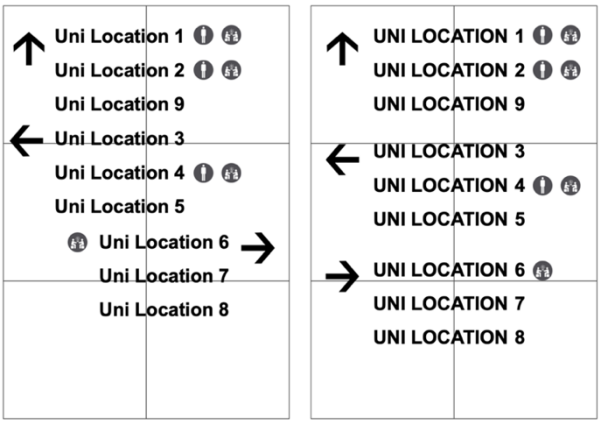

Figure 6-10 Outdoor direction sign - 1 original (left) and prototype (right)

6.8.2.4 Pain points with outdoor direction sign – 2

The pain points identification process of outdoor direction sign - 2 follows the same process discussed in *6.8.2.2 Pain points with outdoor direction sign* – 1.

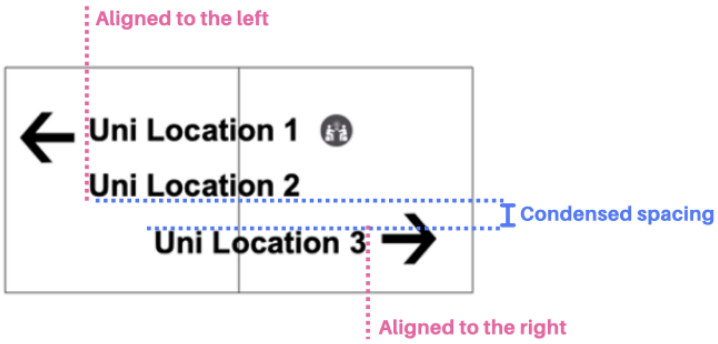

Figure 6-11 Outdoor direction sign example – 2

Pain points identified in the outdoor direction sign example - 2 *(Figure 6-11 Outdoor direction sign example – 2)* are identical to those found in *Figure 6-9 Outdoor direction sign example – 1.* Inconsistent alignment and condensed spacing are two major pain points of this design.

Again, participants also raised their preference for uppercase signage location names. One participant considered mixed cases can give the shape of the word better and help them understand the word faster, which aligns with Baker and Fraser's (2000) suggestion on type cases for blurred visions. However, others prefer all-uppercase, considering uppercase to be larger and simpler. The participant later clarified that the typecase does not matter as much as the type size as long as it is consistently applied throughout the signage system. It was assumed these preferences on type case could be the result of individual preferences rather than the usability of the signage layout. Therefore, there is a need to investigate the usability of type case usage in signage graphic design for partially sighted individuals.

6.8.2.5 Prototype of the outdoor direction sign – 2

The facilitator created the prototype by compiling participant suggestions provided in response to identified pain points. Participants' suggestions *(Table 6-9 Design suggestions for outdoor direction sign – 2)* were implemented on the prototype in real-time while it was being created and displayed on a shared screen.

Table 6-9 Design suggestions for outdoor direction sign – 2

OUTDOOR DIRECTION SIGN - 2		
Pain Points	**Suggestions**	**Grids**

Inconsistent alignment	• All the arrows on the left side • Followed by the location name • Followed by the symbol	• Grid 1 • Grid 2
Information organisation	• It is not clear uni location 2 is to the left of to the right due to the lack of spacing • adding spacing	• Grid 1 • Grid 2
Type case	• Prefer to be all CAP • Mix case gives the shape of the word • Size is more important than the typecase	• Grid 1 • Grid 2

According to participants' feedback and suggestions, compared to the example, four main design differences were identified in co-created outdoor direction signage - 2 *(Figure 6-12 Outdoor direction sign - 2 original (left) and prototype (right).*

1) Consistent **alignment** was applied to match the design of the previous outdoor signage prototype.
2) A strong **line break** was added to separate the two groups of locations.
3) Because of the line break, the arrow for “location 1” and “location 2” was centred between these two location names.
4) **Coloured blocks** were added under arrows to emphasise the direction information and indicate different groups of locations without reducing the contrast of the text message for readability. Colour acts as a direction reinforcer in this case.

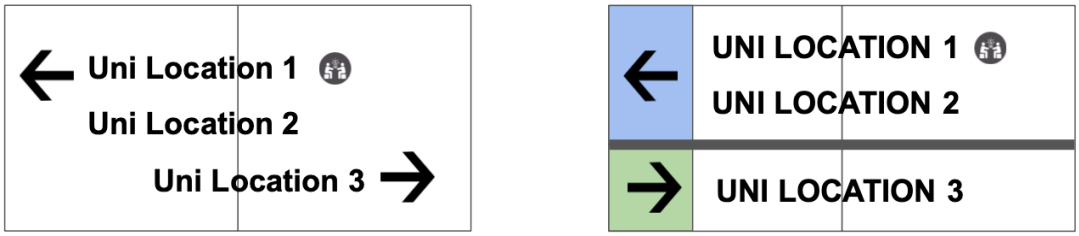

Figure 6-12 Outdoor direction sign - 2 original (left) and prototype (right)

6.8.2.6 Feedback about the Workshop

Overall, participants enjoyed the co-creating session of having the facilitator make changes to the prototype. They suggested that co-creating a signage prototype on a shared screen carried out by the facilitator works well since they are already on a video call on the screen. It is considered *“easier”* by the few participants who found it *“hard”* to draw and create a prototype independently.

However, one of the participants raised that they prefer to be able to create prototypes independently before the facilitator makes the final prototype for evaluation. This participant expressed that it is *"easier for me to explain by drawing"*, and the changes made by the facilitator are less direct.

6.8.3 Discussion

6.8.3.1 Participants Wayfinding Journey

The wayfinding journey of the partially sighted participants identified in this study supports the four stages of the cognitive process of wayfinding identified in the literature: 1) Information processing; 2) Decision making; 3) Decision execution; 4) Closure (Arthur and Passini, 1992, p.26; Vandenberg, 2016, p.20). Participants' wayfinding journey and in terms of using signage consists of issues with signage visibility and readability. This hinders participants' ability to complete the wayfinding task. This reinforces the significance of signage (route-type information (Verghote et al., 2019, p.9) for partially sighted wayfinders, which was also identified in *Chapter 5 Online Questionnaire.* This also indicates the importance of thesis in identifying effective signage graphic design practices for partially sighted individuals.

6.8.3.2 The appropriate condition for co-designing signage online

Participants were less enthusiastic about drawing independently in previous workshops *(6.7 Workshop 2 – Co-design tool and activities development),* and, therefore, more text-based prototypes were produced at the end of the workshop. This is assumed to be related to participants' lack of a mental representation of the expected design output. As discussed in *6.7.3.2 The potential of providing visual examples,* participants raised the need for visual examples to help them gain perspective on the expected workshop outcome. Therefore, in this workshop, basic signage graphic design elements and examples were introduced before the co-design session to help participants understand the co-design subject. To reduce the difficulty that some participants had in visualising as well as the difficulty of sharing their drawings via their cameras; the activities that required participants to prototype individually were also removed.

However, as a result of the introduction of design concepts and visual examples in this session, participants expressed a desire to prototype independently and convey their ideas directly in this workshop. This demonstrates the importance of visual examples in assisting participants in comprehending the design subject regardless of their visual abilities and facilitating visualisation. However, it also demonstrates that removing the ability of participants to prototype independently was a waste of an opportunity to improve the developed grid tool.

This suggests that because the workshop conditions did not encourage the participants' generating activities, more text-based prototypes were developed during the second workshop.

In this workshop, the grid tool was utilised to address precise positions in the signage graphic design. It was effective because participants were able to effectively communicate their ideas to one another and direct the facilitator in making precise changes to the prototype. It was valuable because when signage examples were presented using the grid format *(6.8.2.2 Pain points with outdoor direction sign – 1)*, it made it easier to draw out insights regarding inefficient signage graphic design practices in signage examples or guidelines, that would not have been identified otherwise. Participants did not have the opportunity to generate design ideas independently with the use of the developed grid drawing tool in this workshop. However, benefit from the iterative structure of the co-design workshop, this will be changed in the next workshop.

The main challenge of co-design with partially sighted participants is to draw out participants' feedback and involve them in the co-design process (Magnusson et al., 2018, p.426). Based on findings, participants showed interest in and were motivated to contribute to the workshop with their creative contributions, which could imply that the appropriate conditions for partially sighted participants to co-create signage online were created (Segalowitz and Chamorro-Koc, 2018, p.10; Raman and French, 2021, p.13). This indicates that the developed online workshop activities are appropriate to be carried out for co-designing wayfinding signage with partially sighted participants.

6.9 Workshop 4 - Co-design indoor signage

6.9.1 Workshop goal and procedures

This workshop aims to use the developed grid tool to co-design indoor wayfinding signages with partially sighted participants. Indoor wayfinding signage was used as the design subject of this workshop.

The procedures of this workshop follow the structure of the third workshop, with a few changes made to reflect the insights gathered from the previous workshop *(6.8 Workshop 3 – Co-design outdoor signage).* These changes are:

- Providing design examples of wayfinding signage (selected based on the previous online questionnaire study).

- Encouraging participants to create their prototypes independently before creating a prototype together on the shared screen.

Detailed workshop procedures can be found in *Appendix 5 Co-design Workshops Procedures.*

6.9.1.1 Workshop materials – visual examples

The rationale for designing visual examples remains the same as explained in *6.8.1.1 Workshop materials – visual examples.* There were two reasons for choosing indoor wayfinding signage as the co-design subject of this workshop: first, as discussed in *Chapter 2 (2.4.3 The challenge of wayfinding in academic settings),* indoor wayfinding presents challenges not encountered in outdoor environments; these challenges are caused by repetitive physical obstacles such as lifts, staircases, temporary installations, and additional floors; moreover, unlike outdoor navigation, indoor wayfinding relies heavily on signage and landmarks. Second, the previous workshop *(6.8 Workshop 3 – Co-design outdoor signage)* explored the user journey of an outdoor wayfinding scenario. Focusing on indoor wayfinding would provide additional insight into indoor wayfinding and signage graphic design in academic settings.

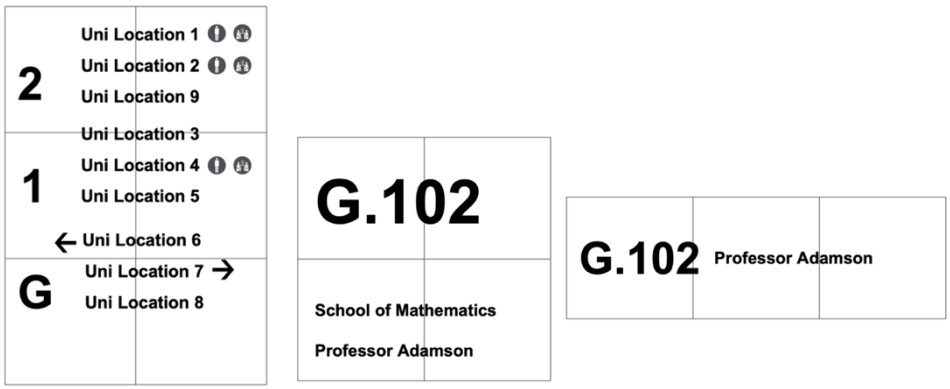

Figure 6-13 Indoor signage design examples

6.9.2 Findings

6.9.2.1 Participant's indoor wayfinding journey

Despite the unique challenges indoor wayfinding imposes (Srinivas and Hirtle, 2015, p.14), partially sighted participants' indoor wayfinding user journey shares similarities to their outdoor wayfinding journey identified in *6.8.2.1 Participants' outdoor wayfinding journey. Participants* initially need to identify the destination information to start the wayfinding journey. Their information needs shift as they get closer to locating the indoor destination, from a more granular level of the direction to the region where the room is located, to eventually finding the room. This adds one more level of information needed compared to an

outdoor wayfinding journey, which echoes the complexity of indoor wayfinding caused by lack of visibility and confinement of physical movement (Srinivas and Hirtle, 2015, p.14). However, this does not suggest differences between indoor and outdoor wayfinding signage in terms of design needs.

Table 6-10 Partially sighted participants' wayfinding journey – indoor

USER JOURNEY			
User journey	**Information**	**Challenges**	**Suggestions**
• **To know the name of the person** • **To know the department/faculty the person is in** • **To find the out where the person is**	• Looking for directories (**Information sign**)	• Good directory (information sign) only available to the main entrance of the building	• Colour-coding • Having a map to help to navigate • Have something to redirect me to the directory
• **To find navigational sign to get to the location**	• Looking for navigational signs (**Direction sign**)		
• **From a more granule level of the direction to identify a specific room** • **To find the room**	• Looking for (Direction) sign specify the direction	• Small room number/ name sign	• Raised lettering • Braille

6.9.2.2 Pain points with indoor information sign

Prior to the idea generation and prototyping, participants were asked to review and evaluate signage examples; common pain points they experienced with this type of signage graphic design were identified.

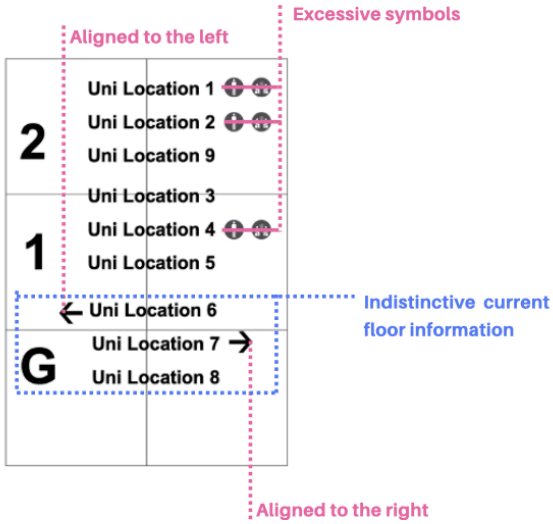

Figure 6-14 Indoor information sign example

Participants identified four pain points with the indoor information sign example. The first pain point consists of the challenge identified in outdoor location signs; anxiety and confusion caused by **inconsistent arrow alignment**.

Participants also raised the **lack of distinction** of the '**current floor**' information **indication**. Colour coding was suggested to be used to differentiate floors. This is considered especially important when there are different entrances at different levels.

The third pain point is the **excessive symbols**, which were not favoured at the stage of making a wayfinding plan. Participants think it is ideal to *"get the maximum amount of information with a little representation"* at this stage of wayfinding. More specific information should be provided when one reaches the next level of information. A participant commented, *"My ability to wayfinding depends on how good the information on the sign has and how good the information I have".* At this level of information, few participants found the symbol could be a bit too excessive; as one participant put it, *"if this is a macro level of a directory (information sign), at and we just got into the building, just to give us a strategic view of what the building contain."* However, one participant disagrees with removing all the symbols. It was raised that sometimes it is convenient to have the bathroom information.

Symbols have been widely used in people's daily lives (Mansoor and Dower, 2004, p.29) because of their adaptability in empowering someone who lacks the language or reading skills to understand the message (Sojourner and Wogalter, 1997, p.963). They are crucial to the inclusion of signage graphic design in community settings such as hospitals, which serve a varied population (Rousek and Hallbeck, 2011, p.771). Participants suggested removing symbols that provide repetitive meaning to the signage message because symbols were not

considered important at this stage of wayfinding. However, this could mean improving the effectiveness of signage graphic design for partially sighted participants as a consequence of decreasing the inclusivity of signage graphic design for people who would appreciate symbols in signage design.

The final solution participants agreed on was to keep only the essential symbols displayed as a facility among the location names rather than add them as an attachment to the location name. There is a need to investigate the use of symbols in signage graphic design for partially sighted participants.

6.9.2.3 Prototypes of the Indoor Information Sign

The prototyping was carried out after participants finalised a discussion of the pain points of the signage example. Suggestions made by participants alongside pain points were gathered in *Table 6-11 Design suggestions for indoor information sign.* Participants were given time to prototype their ideal signage graphic design independently using the grid tool. Participants were encouraged to write and draw on their grid to create a signage prototype in response to the identified pain points. After participants completed their signage prototypes, a collaborated signage prototype was created by the facilitator by compiling participants' inputs. This prototype was evaluated and iterated upon common agreement of participants.

Table 6-11 Design suggestions for indoor information sign

INDOOR INFORMATION SIGN		
Pain Points	**Suggestions**	**Grids**
Arrow on ground floor on opposite sides	• Move arrows to the same side	• Grid 3 • Grid 6
Indistinctive current floor information	• Highlight the ground (current) floor with colour • Colour coding each individual floor • Using the line breaks	• Grid 2 • Grid 3 • Grid 5 • Grid 6
The use of symbols	• The washroom facility should be considered a location instead of added to a location • Adding colour can make it easier to be spotted	• Grid 4 • Grid 5
Excessive symbols	• Only provide sufficient information to construct a wayfinding plan	• Grid 1 - 6

	• Information sign on each floor should provide more specific information about this floor

The participant's prototypes share the similarity of having all the floor numbers on one side and the rest of the information on the other. The arrows were arranged and aligned on the opposite side of the floor number. One of the participants put an arrow on the left side to create consistency with the outdoor direction sign, and others removed arrows because they were not sure which side to place the arrows. However, one participant raised the point that having the floor number on the left is something more familiar, intuitive, and more commonly applied in actual design cases. Therefore, having the floor number on the left is preferred. Colour, outline, and line breaks were used to group and highlight the current wayfinder level. The symbol was only used in one prototype.

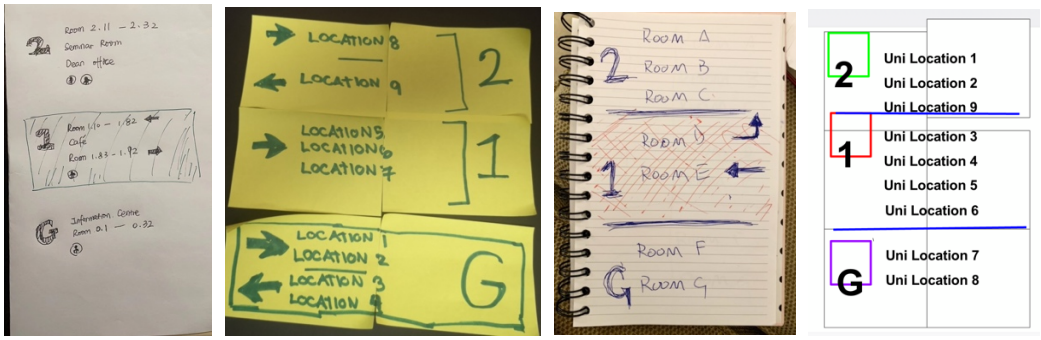

Figure 6-15 Indoor information sign prototypes by participants

Five design differences were identified in co-design indoor direction signage compared to the example:

1) Symbols were removed from the sign.
2) The bathroom symbol is incorporated into the sign as an independent location instead of being added to a specific location.
3) Line breaks were added to separate different levels of information and different groups of locations.
4) Colours were used to highlight the level of information where the wayfinder was at.
5) Arrows were aligned on the right side of the signage.

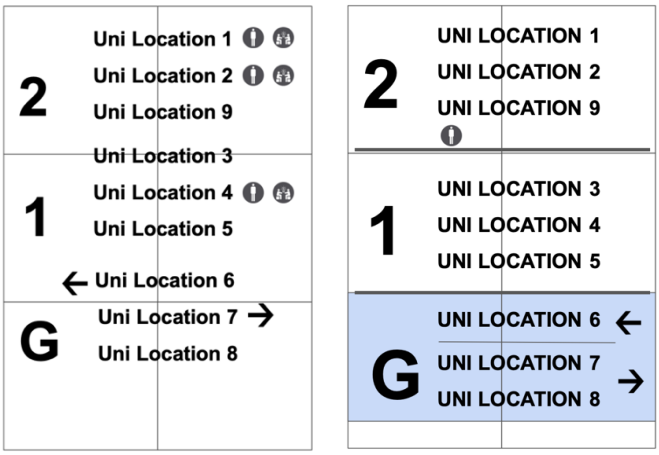

Figure 6-16 Signage example (left) and co-designed indoor information sign prototype (right)

6.9.2.4 Pain points with indoor location/room sign

Prior to the idea generation and prototyping, participants were asked to review and evaluate signage examples; common pain points they experienced with this type of signage graphic design were identified.

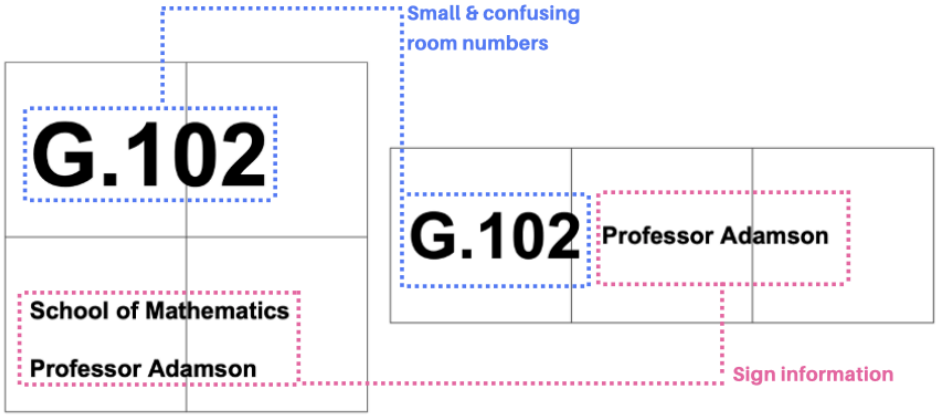

Figure 6-17 Indoor room sign examples

Two types of room sign layouts are commonly used in indoor wayfinding. Participants were provided with both examples to 1) validate participants' preferences for signage layout style identified in *Appendix 9 Preference for Signage Design Elements;* 2) investigate the relationship between participants' preference and design decision. Among the two provided room sign examples, participants prefer the left one (stacked positioning) over the right one (side-by-side positioning). This preference is coherent with the preference identified in *Appendix 9 Preference for Signage Design Elements.* This was also reflected in the later prototype activity. Participants prefer the form factor of a "*more compact format*" layout because it takes less eye movement and is easier for people with tunnel vision to *"read text in block"*.

Based on participants' feedback, the sign example presents four crucial pain points for the indoor location/room sign. These are directly related to the visibility and readability of the signage. The main pain points with the room sign design are the small room number and the meaning of the room number. This affects participants' ability to read and obtain the signage information. Signage placement is also raised as it can challenge the visibility of the signage. Apart from these pain points, participants also suggest using colour to emphasise the meaning of the sign message for a *"quick reassurance".*

6.9.2.5 Prototypes of the indoor location/room sign

The prototyping was carried out after participants finalised a discussion of the pain points of the signage example, suggestions made by participants alongside pain points were gathered in *Table 6-12 Design suggestions for indoor room sign.* Participants were given time to prototype their ideal signage graphic design independently using the grid tool. Participants were encouraged to write and draw on their grid to create a signage prototype in response to the identified pain points. After participants completed their signage prototypes, a collaborated signage prototype was created by the facilitator by compiling participants' inputs. This prototype was evaluated and iterated upon common agreement of participants.

Table 6-12 Design suggestions for indoor room sign

INDOOR ROOM SIGN		
Challenges	**Suggestions**	**Grids**
Small room number	• Enlarge the room number to take up the whole grid 1 and grid 3	• Grid 1 • Grid 3
Confusing room number meanings	• To go with local convention	• Grid 1 • Grid 3
Difficult placement	• To place at eye level	
Sign information	• To provide sufficient information about the room • Emphasis room number for office and room name for lecture/auditorium	
	• Adding colour to reassure at the right section of the building	

Participants' prototypes share similarities in layout with differences in detail. These include enlarged room numbers, emphasising the information of the room occupant. *Figure 6-18 Indoor room sign prototypes by participants* presents the signage prototypes developed by participant 1 (top left), participant 2 (top right), participant 3 (bottom left) and participant 4 (bottom right).

Participant 1 added a *"strong border"* to the entire sign to make it more *"eye-catching",* and it should increase the visibility of the signage. Left alignment was used by participant 1 and participant 2 to make more *"visual sense",* as well as to maintain consistency with the rest of the developed signage prototypes.

Participant 2 added a colour stripe on the left side of the sign to give reassurance that one is on the right building level.

Participants 3 and 4 focused on enhancing the visibility of the room number. Central alignment was used in their design for aesthetic reasons.

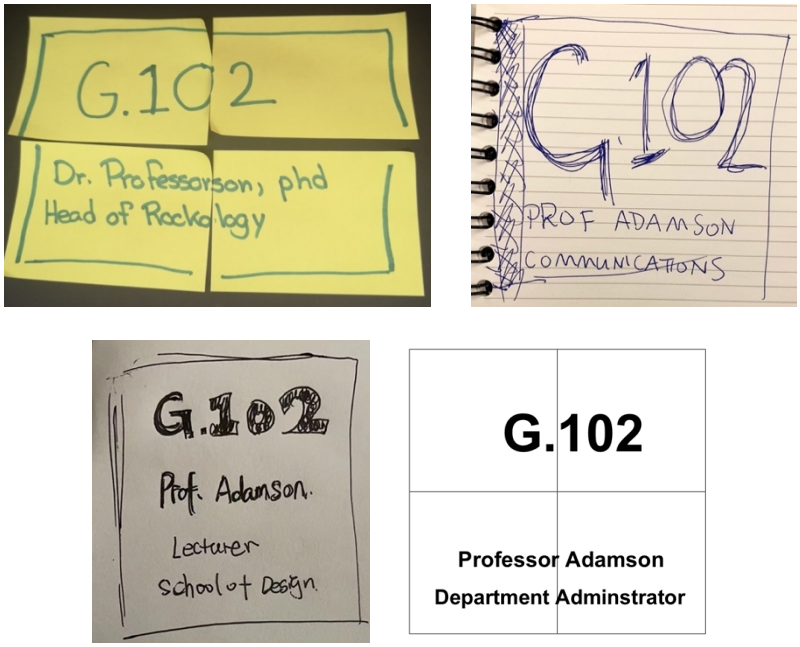

Figure 6-18 Indoor room sign prototypes by participants

The rationale of participants' prototypes emphasises the readability of the room number and the visibility of the signage in general. Therefore, compared to the example, co-design indoor location signage has these differences:

1) The room number on the sign was enlarged.
2) A border was added to the sign.

3) A colour stripe was added to the sign.
4) The title of the person was added to the sign.

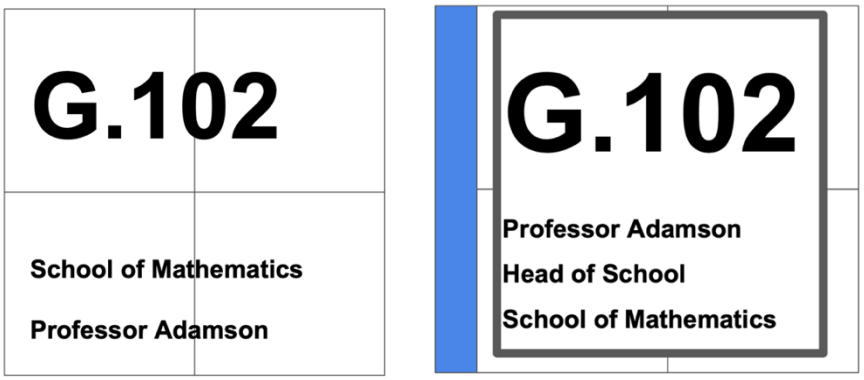

Figure 6-19 Signage example (left) and co-created indoor room sign prototype (right)

6.9.2.6 Feedback about the workshop

Positive responses were received at the end of the workshop. Participants found the last two workshops were more *"smoothly and efficiently"* than the design video call app workshops. This could be the result of two reasons. First, participants found the signage graphic design more concise than the app interface design. One participant even prototyped on the basis of the provided examples on Google Slide.

Second, participants found it easier to produce visualisations when having specific examples to reference than when designing from scratch. Participants commented that they *"prefer to have a foundation"* and can *"modify from there".* In the first two sessions, *"we spend a lot of the time trying to understand different ideas, whereas we can modify one thing to where we might want it to change to, it is easier than just talk about it abstractly"; a*nd it is *"much easier to give feedback on something concrete".* Participants commented again that *"it is very ironic that we are visually impaired, but we are working on something very visual based.",* It makes it much easier to imagine *"which ones are visually successful and which ones are not".*

6.9.3 Discussions

6.9.3.1 Partially sighted individuals' wayfinding journey and information needs

Based on the evidence, partially sighted individuals' information needs during an indoor wayfinding journey shift from macro to micro, granule to detailed. The information presented on the signage should also follow the order from left to right, top to bottom. Literature suggests that the wayfinding journey involves four stages: information processing; decision making; decision execution; and closure (Arthur and Passini, 1992, p.26; Cornell and

Greidanus, 2006, p.203; Vandenberg, 2016, p.20). Finding agrees with the four stages of wayfinding activities involved in a wayfinding journey. Moreover, this finding provides a more in-depth understanding of how the information should be presented on signs based on different stages of the wayfinding journey. For example, at the beginning stage of the wayfinding journey, users require a broad range of precise information to help them understand their surroundings and make a wayfinding decision. As they move into the next level of wayfinding, the information should be more and more detailed to guide participants to their destination. There should be clear information on signage to confirm that the user has reached the correct destination.

6.9.3.2 Co-design and participants' signage design needs

Co-designed signage prototypes

The co-designed signage prototypes were created based on pain points highlighted by partially sighted participants using signage samples as reference. The signage examples were created to provide an example of the type of signage that needs to be co-designed, as well as to serve as inspiration for developing signage prototypes on the grid. As a result, the co-designed prototypes illustrate participants' design solutions to the issues that this type of signage graphic design would present.

The value of co-designed prototypes

Findings support the emotional and practical importance of wayfinding signage *(Chapter 2 2.2.2.6 The importance of wayfinding design).* First of all, it was discovered that wayfinding signage is essential to partially sighted participants' indoor *(6.9.2.1 Participant's indoor wayfinding journey)* and outdoor *(6.8.2.1 Participants' outdoor wayfinding journey)* wayfinding activities. Secondly, when participants experiencing difficulty reading the signage information *(6.8.2.2 Pain points with outdoor direction sign – 1),* negative emotional response emerged.

The design practices identified in the workshops presented a clearer picture of signage graphic design that reflects the design needs of partially sighted participants, which reinforces the findings from the online questionnaire. For example, participants' requirements for effective signage design, as well as participants' emotional needs for signage design, were initially identified via an online questionnaire. Signage prototypes developed during the workshop illustrated how these requirements can be met through design. For example, it was identified that participants would prefer to have colour used in signage; in the workshop, participants used colour on signage to highlight, differentiate, and reassure the sign messages. Participants asked for simplified and stand-out signage in the online questionnaire; in the workshop,

participants used a stronger outline and line breakers to achieve this design goal. It also visually identified types of design that would help to alleviate stress and anxiety caused by the signage graphic design.

Visibility, legibility and readability

The co-designed signage prototypes emphasise the **visibility**, **legibility**, and **readability** of the signage graphic design. **Visibility** measures how easy it is for one sign to be noticed. Visibility in co-designed signage is found to share the characteristics of using a strong border, bold typeface, and strong colour contrast to make the signage 'pop'. **Legibility** measures how distinguishable each group of information is presented on the signage. The characteristics of legibility in co-designed signage are found to share the characteristics of using an all-caps typeface, increasing the spacing between groups of information, and using line breaks and coloured blocks to create an information hierarchy. **Readability** measures how easy it is to read the information on the sign. Readability in co-designed signage is found to share the characteristics of enlarged typeface, using a compact stack layout, consistent arrow alignment, and reducing unnecessary information such as excessive symbols. Participants' suggestions for improving these criteria in signage graphic design may not be the best design practice, as identified in *6.8.2.3 Prototype of the outdoor direction sign – 1*, participants' personal preferences do not always imply usability of the signage. However, these criteria, established from participants' pain points with signage graphic design, highlight, and specify participants' signage design needs.

The inadequacy of available wayfinding signage design guidelines

The findings of this workshop support the inadequacy of available wayfinding signage guidelines in producing signage that meets partially sighted individuals' design needs. Findings of participants' wayfinding journey support reviewed signage planning and practicality guidelines. However, visual outcomes of the co-design workshop suggest the gap between reviewed guidelines (*Chapter 4)* and partially sighted participants' design needs. Evidence shows that participants' preferences influence their design decision-making and co-designed signage outcomes. However, the reviewed guidelines do not consider partially sighted individuals' preferences for signage layout, arrow, symbol styles and colour palette. For example, findings confirm the importance of eye-level placement and increase the visibility of signage (Baker and Fraser, 2000, p.69) for partially sighted wayfinders. However, the importance of a more compact layout style and reversed symbol field style is absent in the literature.

In some cases, the reviewed guidelines contradict participants' preferences. Participants raised the challenge of anxiety caused by the inconsistent alignment of arrows; therefore, arrows on signage should always be aligned on the left side of the signage layout. However, as suggested by (Baker and Fraser, 2000, p.39; Calori and Vanden-Eynden, 2015, p.179), the arrow should never be pointed at the text message and should be aligned on the side of the signage where the direction this arrow indicates. Therefore, the reviewed guidelines fulfil the functional importance of signage in providing direction, but it also sacrifices its emotional importance of promoting a relaxed wayfinding experience to partially sighted individuals.

The functionality of colour in signage graphic design is overlooked in the reviewed guidelines. In the reviewed guidelines, colour is recognised as the tool for distinguishing signs from the environment (O'Grady and O'Grady, 2008, p.108), reinforcing the message, and being decorative (Calori and Vanden-Eynden, 2015, p.163). In developed prototypes, colour is also used to differentiate groups of information.

The available literature does not always provide the most informative guidelines for signage graphic design for partially sighted individuals. It lacks consideration for partially sighted individuals; in some cases, it is against their preferences. This inconsideration of partially sighted individuals' preferences hinders the signage from fulfilling its emotional importance. Hence, they are not satisfied with the current signage graphic design in academic settings. Therefore, the design preferences identified in this workshop are valuable in providing design variables that need to be considered when designing effective wayfinding signage for partially sighted individuals.

The challenge of co-designing visualisation with partially sighted participants online is to draw out participants' inputs. The developed co-design method provides an alternative design approach to gather users' requirements and produce design prototypes that reflect participants' design needs and preferences. This chapter demonstrates the benefit of using the participatory approach to signage graphic design with and for partially sighted individuals.

6.9.3.3 Value of participants-led co-design practice/method

The co-design workshop activities documented in this chapter were developed in response to the lack of developed methodological frameworks that support the achievement of online co-design visualisation with partially sighted participants. Four iterated workshops were carried out to achieve this goal. The first three workshops were designed to be self-contained design workshops, which helped establish the understanding of the appropriate conditions for co-designing signage with partially sighted participants online. The final workshop was to apply

what had been learned and co-design signage with participants. Insights surrounding online co-design visualisation with partially sighted participants were gathered.

The importance of acknowledging participants' experiences

Findings support that user-centred co-design practice cultivates a better understanding of the current design 'problems' and brings value to co-designed outcomes (Cullen and Metatla, 2019, p.369; Raman and French, 2021, p.11). In the traditional design approach, users are the passive objects to be studied; designers then passively receive information and execute it to produce a design outcome (Sanders and Stappers, 2008, p.11). The consideration of user experience is typically carried out as an 'add-on' additional to a well-designed product for the design product/service targeted at mixed-ability user groups, which in most cases makes compromises for both traditional user groups and user groups with various abilities (Newell et al., 2011, p.235).

In the carried out co-design workshops, participants were considered 'experts of their experiences.' Participants' feedback on producing visualisations online and their experience with signage graphic design were acknowledged in the workshop iteration and reflected in the co-designed signage outcome. As a result, the appropriate conditions required for co-designing signage with partially sighted participants online were identified; a better understanding of participants' signage graphic design needs was established.

The appropriate condition to enable online co-visualisation

The aim of co-design is to strive for target users to be active and creative contributors to the co-design process (Magnusson et al., 2018, p.415). In order to achieve that, creating the appropriate conditions to support participation is essential (Raman and French, 2021, p.13). Co-design tools and activities used in workshops were adapted to support participants' visual ideation and expression.

During the first workshop, participants displayed varying levels of interest in contributing to the session. This was later found to be the result of participants' different experiences with the co-design subjects, which led to one participant responding to ideas rather than actively commenting. To facilitate participants' contributions to the workshop, the scenario approach was introduced at the beginning of the second workshop to help participants envision a future that might not exist in their user experience. This shifted perspectives and increased participation and interest in contributing to workshop activities.

In order to produce visualisation in the workshop, a grid tool was developed *(Chapter 6-1 6.2.1.6 The birth of the new workshop tool)* to support participants in contributing to the visual

prototype through speaking, writing and simple drawing. Overall, participants were pleased with the convenience that the grid tool provided them in communicating design ideas over online video call. However, during the second workshop, participants showed little confidence in producing visual prototype. This was found to be the result of a lack of mental image of the expected design outcome.

During the third workshop, carefully designed and selected visual elements and examples that provide an idea of signage graphic design were introduced to participants before the prototyping took place. Participants showed an increase of interest in prototyping as a result of the availability of visual examples. This was validated by participants' feedback to the workshop as well as presented in the developed prototypes.

In the context of this study of co-design visualisation with partially sighted participants online, fostering the appropriate conditions to facilitate participants' creative contribution was credited to: **the accommodating tool that allowed participants to contribute regardless of their abilities; appropriate probe and prime activities, the scenario method which allowed them to contribute regardless of their experience with the design subject; and the knowledge that was needed in order to create a shared visual understanding.** These, together, are critical to the co-designed outcome of the workshop.

A better understanding of participants' signage graphic design needs

A better understanding of partially sighted participants' signage graphic design needs was established through the co-design activities and the outcome of the co-designed prototypes. The importance of signage graphic design in participants' indoor *(6.9.2.1 Participant's indoor wayfinding journey)* and outdoor *(6.8.2.1 Participants' outdoor wayfinding journey)* wayfinding activities was identified through the probing/scenario activities.

Participants' pain points with common types of signage graphic design were identified with the support of the grid tool and visual examples. This was not possible to gather otherwise. In the combination of visual examples presented through the developed grid model, it made communication and idea generation more efficient. Participants were able to provide more specific suggestions for the signage graphic design, compared to the online questionnaire.

A collection of signage graphic design prototypes that reflect partially sighted participants' ideal signage designs were produced. As discussed in *(6.9.3.2 Co-design and participants' signage design needs),* participants' suggestions came from their experience as well as personal preference with signage graphic design. This means the developed prototypes, to some degree, embody the quality that participants desire in a signage graphic design, specifically, **visibility, legibility** and **readability**. The design practices to achieve these qualities

in signage graphic design are not necessarily the best approaches if usability were considered. Nevertheless, this does not devalue the developed online co-design workshop practice, because the developed research methodology provided great insight into using a 'visual' approach to collaborate with partially sighted participants online, to gather design input from them, which was absent when this study was conducted.

6.10 Conclusion

This chapter aims to visualise partially sighted individuals' needs for wayfinding signage graphic design in academic settings. In response to the challenge of lack of methodological support, a grid tool and four workshops were developed *(Chapter 6-1)* and implemented in this chapter. This chapter documented the iteration of four co-design workshops in which participants' feedback on the workshops influenced the workshop activities and outcomes. Insights on co-designing signage with partially sighted participants as well as participants' signage graphic design needs in visualisation were gathered. Through four iterated co-design workshops, the goal of the chapter was achieved.

As discussed in Chapter 6-1, there were two major challenges to achieve the research objective of co-designing with partially sighted participants online. The multi-sensory approach was therefore adapted to the development of workshop design to introduce accessibility in data collection. The reliance on visual elements of the workshop was carefully reduced or substituted with other modalities in order to accommodate participants' varied vision conditions. Unexpectedly, during the workshops, participants were seeking visual design examples to inform and inspire their design decisions, and providing visual examples in the workshop evidently improved participants' engagement and creative contribution. This new 'visual' approach indicated the importance of appropriate conditions in supporting online co-design visualisation with partially sighted participants.

In the context of this study, the appropriate conditions for partially sighted participants to co-design online means to: prioritise accessibility in co-design tool and activity development; create accommodating tools to support participant creative expression; accommodating activities that are tailored to participants' experience with the co-designed subjects; and obtain the information required in order to make an informed design decision.

By fostering this appropriate condition in workshops, a better understanding of the signage graphic design that partially sighted individual design needs in wayfinding signage was established. The co-designed signage reflects partially sighted participants' preferences, pain

points in use and reading behaviour (eye movements). Alone with pain points identified with the visual examples as well as developed prototypes, three qualities that are critical to the effectiveness of signage graphic design for partially sighted participants were identified. These are visibility, legibility and readability. Participants' prototypes do not necessarily provide the best approaches in achieving visibility, legibility and readability. However, it does provide a better perspective to design signage for them, which would be impossible to gather otherwise. This demonstrates the value of the created online co-design methodology for investigating how to increase the effectiveness of wayfinding signage design for the partially sighted.

Because of the novelty of the tool and methodology framework developed to achieve the goal of this chapter, the following chapter will explore the potential of the developed workshop approach.

Chapter 7 The Value and Considerations of Co-Design with Partially Sighted Participants Online

7.1 Introduction

This chapter aims to explore the value and potential of developed online co-design practices. A semi-structured online focus group was carried out with participants from the previous online co-design workshops *(Chapter 6-1 6.2.3 Workshop participants).* The focus group discusses aspects of the participatory experience that influence participation and co-design outcomes.

PD (Participatory Design) is an emerging design discipline that involves the future user of the product in co-design activities throughout the design process (Sanders et al., 2010, p.195). Co-design has become the common practice for developing better products/services that support users' needs (Magnusson et al., 2018, p.414) by designing 'with' the user rather than 'for' the users (Cullen and Metatla, 2019, p.361; Sanders et al., 2010, p.195). However, with a huge body of PD studies traditionally conducted in person, very few studies discuss the application of carrying out PD practice online (Friedrich, 2013, p.3; Tsuda and Sakuragi, 2020, p.502; Kamat, 2021, p.3), and even less are focused on partially sighted individuals (Lee, 2021, p.3).

Most frameworks focus on extreme needs and reduced participation (Raman and French, 2021, p.3); these approaches can be user-involved but non-participatory (Carroll, 1996, p.285; Kensing and Blomberg, 1998, p.169; Van der Velden and Mortberg, 2014, p.19). Studies have developed multi-sensory approaches to co-creating with partially sighted participants (Cullen and Metatla, 2019, p.361; Magnusson et al., 2018, p,411; Albouys-Perrois, 2018, p.1; Kamat, 2021, p.3; Vermeersch and Heylighen; 2021, p.50), most visualisation activities rely on visual communication, such as visual narrative, visual sequencing and writing (Chick, 2019, p.43). It can be difficult to facilitate a shared representation between participants, which leads to the lack of collaboratively designed solutions (Brewer, 2018, p.1).

Because of these two inadequacies of PD methodology, a new approach was developed *(Chapter 6-1)* and implemented *(Chapter 6-2)* to achieve the goal of co-designing signage online with partially sighted participants. The trajectory of the initial research plan should be centred on thoroughly testing and iterating the prototype at this stage of the thesis. However, because the potential value of this developed co-design method was observed in the workshop *(Chapter 6-2 6.9.3 Discussions),* this methodological finding may have a greater

contribution in increasing the effectiveness of wayfinding signage design for partially sighted participants than what was initially anticipated.

This adjustment in research direction does not contradict the research that was done for this thesis; rather, it is a change in perspective that places more emphasis on the methodological findings that came out of the study than the final results. This could make an impactful addition to PD practice when designing visualisation for/with partially sighted participants online.

7.2 Research design

This chapter aims to explore the value and potential of developed online co-design practices through understanding the aspects of participatory experience that influence workshop participation and co-design outcomes. In order to achieve this goal, it is vital to collect feedback on the participation experience. Online focus group is known for its capacity to allow in-depth exploration; nevertheless, compares to interviews, the social element of focus groups can uncover wider insights through participant interaction (Curedale, 2013, p.144). Furthermore, as to what was intended to be discussed in the online focus group - participants' co-design workshop experiences – it would be beneficial to involve all (co-design workshop) participants in the discussion to reflect on their collective experiences.

Because the data from the online focus group could be difficult to analyse (Curedale, 2013, p.226), a question framework was developed centred on the two main aspects of the workshop experiences: 1) The **outcome** of the online co-design workshop; 2) The **development/iteration process** of the online co-design workshop activities.

The **first part** of the online focus group focused on the outcome of the workshop. Signage prototypes developed from the workshop *(Chapter 6-2)* were presented to participants during the discussion. Design decisions made on prototypes and the signage example used in the workshop were reintroduced in the workshop. Participants were encouraged to discuss their design decisions, the rationale of these decisions, and the impact of these decisions on design outcomes.

The **second part** of the online focus group focused on the development/iteration process of workshop activities. This part of the discussion started with a brief of the activities in each workshop. Participants were encouraged to discuss their expectations and experiences with the workshop series; reflect on the tools used and activities carried out in the session; and consider the potential of established workshop practices.

At the end of the focus group. Participants were asked to share their insights on the application of the developed co-design practice. A list of detailed focus group questions can be found in *Appendix 10 Online focus group plan.*

7.2.1 Focus group materials

Signage graphic design examples used during the co-design workshop and the co-designed signage outcomes were provided during the online focus group. These include co-designed outdoor wayfinding signages *(Figure 7-1 Signage example (left) and co-designed outdoor signs (right)* and co-designed indoor wayfinding signage *(Figure 7-2 Signage example (left) and co-designed indoor signs (right).*

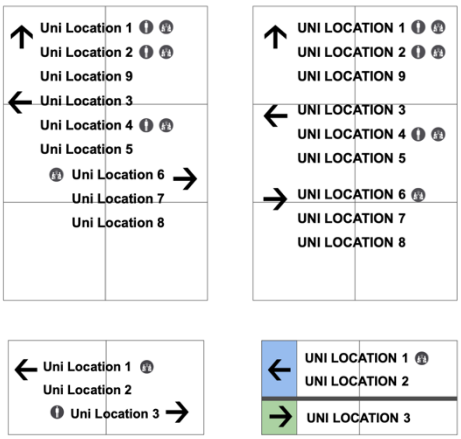

Figure 7-1 Signage example (left) and co-designed outdoor signs (right)

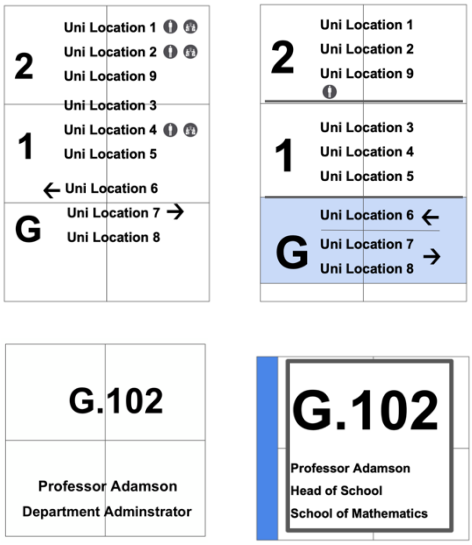

Figure 7-2 Signage example (left) and co-designed indoor signs (right)

7.2.2 Participant

Participants from the previous co-design workshops *(Chapter 6-1 6.2.3 Workshop participants)* were invited to the focus group. Three participants participated in this online focus group. Two female and one male, all participants are native English speakers. All participants are educated to at least an undergraduate degree and have experience using wayfinding signage in academic settings.

7.2.3 Workshop equipment and accessibility consideration

The Focus Group was carried out online through Microsoft Teams. Participants were asked to express their ideas and thoughts verbally. Visual examples for comments were presented through MS Teams shared screen feature. Participants were able to zoom in on the screen to view the visual content. There were non-potential exclusion elements to this study.

7.2.4 Ethical considerations

This study was granted ethical approval from the Faculty of Arts, Humanities and Cultures Research Ethics Committee, University of Leeds. The ethic reference: LTDESN-129. The data collection was carried out in accordance with the ethical protocol of Data protection, anonymisation and storage and sharing of research data, and informed consent. Participants were informed of the focus group procedure, data protection, and potential risks. Participants were offered autonomy to withdraw from this study.

7.2.5 Data analysis

One type of data was collected from the online focus group. This type of data was gathered from participants' discussions within the focus group and was coded, organised, and analysed with NVivo 12[1].

The analysis of the online focus group data follows the procedure of content analysis (Saunders et al., 2016, p.611): 1) devising categories; 2) defining units of analysis; 3) coding; 4) quantitative analysis.

First, the recording of the discussion was transcribed based on the audio recording. Participants' names and any indication of identity were replaced with *"PA"* for *"Participant A", "PB"* for *"Participant B",* and *"PC"* for *"Participant C"* to protect participants' identities.

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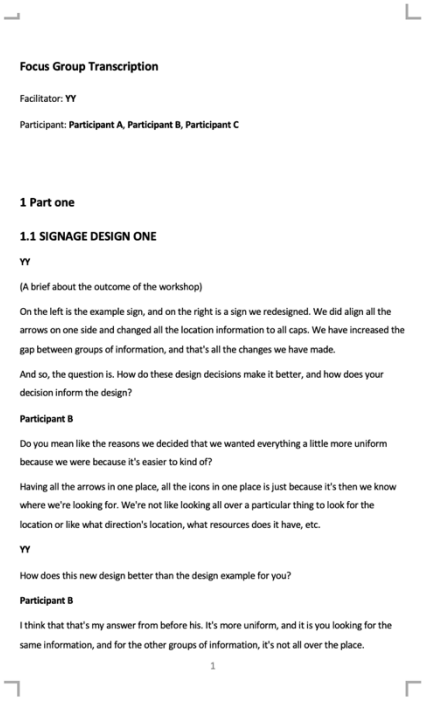
[1] NVivo 12 is a qualitative data analysis software produced by QSR International. NVivo 12 helps to organise, analyse and find insights in qualitative research data.

The unnecessary responses that do not add value to the conversation, such as *"Uhm", "I see", "I hear you",* etc., were removed. The transcription was edited to exclude irrelevant chatting amongst participants that were unrelated to the subjects or theme of this study, such as discussing their day and the weather. As a result of the structure set and followed in the conversation, participants' discussions on various themes were spontaneously separated into sections, and information pertaining to certain themes was divided into sections accordingly. This improved the efficiency of data organisation.

After organising the transcription, it was transferred into Nvivo12 for coding. In response to research question (Saunders et al., 2016, p.611), the broader categories/themes of this analysis concern the outcomes of co-designed signage graphic design and the development/iteration process of the online co-design workshop activities. Two top-level nodes were created to accommodate the themes discussed under the **co-design outcome** and **co-design process**. Themes that emerged from the discussion were coded as sub-nodes and organised under these two top-level nodes. Transcription samples were coded following the five principles of: 1) fitting the purpose of the research; 2) being collectively exhaustive; 3) being mutually exclusive; 4) being independent; and 5) being a single classification (Martin and Hanington, 2012, p.40; Saunders et al., 2016, p.611).

As co-design process and outcome were two primary focuses explored during the data analysis, new ideas and themes that emerged from the discussion were included in its new themes/nodes. Detailed codes for the focus group can be found in *Appendix 11 Online focus group code book.*



Focus Group Transcription

Facilitator: **YY**

Participant: **Participant A**, **Participant B**, **Participant C**

1 Part one

1.1 SIGNAGE DESIGN ONE

YY

(A brief about the outcome of the workshop)

On the left is the example sign, and on the right is a sign we redesigned. We did align all the arrows on one side and changed all the location information to all caps. We have increased the gap between groups of information, and that's all the changes we have made.

And so, the question is. How do these design decisions make it better, and how does your decision inform the design?

Participant B

Do you mean like the reasons we decided that we wanted everything a little more uniform because we were because it's easier to kind of?

Having all the arrows in one place, all the icons in one place is just because it's then we know where we're looking for. We're not like looking all over a particular thing to look for the location or like what direction's location, what resources does it have, etc.

YY

How does this new design better than the design example for you?

Participant B

I think that that's my answer from before his. It's more uniform, and it is you looking for the same information, and for the other groups of information, it's not all over the place.

1

Figure 7-3 Screenshot of the focus group transcription

7.3 Findings

7.3.1 The value of co-designed signage outcome

The developed co-design practice improved the understanding of participants' idea of 'effective' signage graphic design. Based on the discussion, co-designed signage showed improvement to the visual example presented prior to prototyping during the workshop. The improvement in the signage graphic design is mainly reflected in four dimensions; the co-designed outcome was informed by participants' **pain points in use, experiences, preferences** and **cultural convention.** Signage prototypes were developed in response to the pain points identified in the signage example. The identification of these four aspects of improvements indicates that partially sighted participants' needs for signage graphic design are beyond the consideration of pain points in use. These findings extend the list of factors to take into account when designing signage for the partially sighted.

7.3.1.1 Informed by participants' pain points in use

The co-design signage outcome was informed by participants' pain points.

Pain Point 1: One of the problems participants often have is that they find it difficult to *"parse information if it's spread out over a large area (PA)"* or have to *"look back and forth like shake*

things up in my head". Therefore, compared to provided visual example, the information was displayed more *"orderly (PA)"* on co-designed signage. The information on the co-designed sign was *"compartmentalised (PA)"* into the structure of *"the left side of the image (signage) is, where the arrow is, it tells me direction; middle is where the names of locations are, right is where the things at the location, where the icons are located (PA)"*. This saves participants time searching for information on the sign because it is *"much easier … to scan linearly other than vertically or horizontally (PC)"* to know where to look for information (as shown in *Figure 7-4 Outdoor direction sign – signage example (left) and co-designed sign (right).*

Pain Point 2: When different groups of location information are presented in one compacted list, participants found it repetitive and confusing. Therefore, the increased gap between *"straight-ahead locations (PA)"* and *"turn left locations (PA)"* makes the sign much easier for participants to understand the context of the information (as shown in *Figure 7-4 Outdoor direction sign – signage example (left) and co-designed sign (right).*

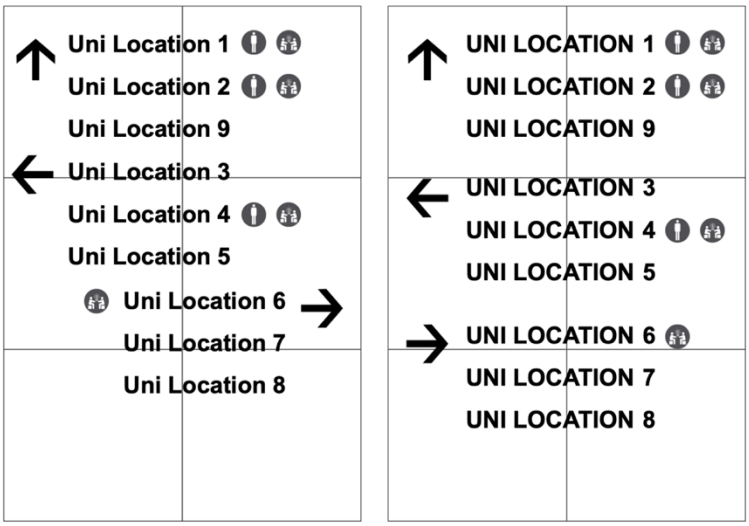


Figure 7-4 Outdoor direction sign – signage example (left) and co-designed sign (right)

Pain Point 3: One participant often *"have to memorise design"* as they are reading the sign because they have an *"extremely small field of vision (PA)",* which means they can only read a *"quarter section"* of the sign at a time. Therefore, having *"things (line break) that break up united items into their fields is extremely helpful (PA)",* it saves time for the user to better associate the arrow with the location it applies to (as shown in *Figure 7-5 Outdoor direction sign 2 - signage example (left) and co-designed sign (right).*

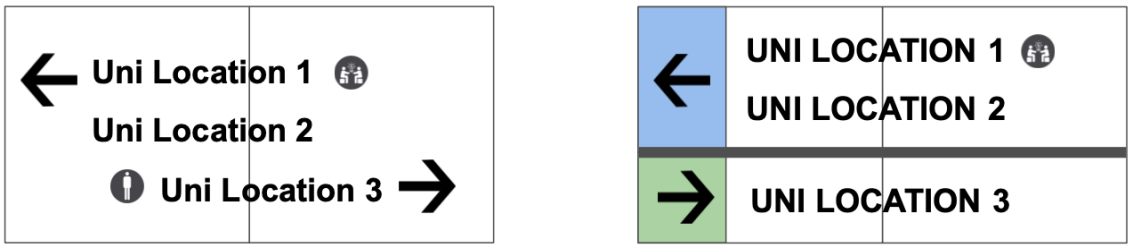


Figure 7-5 Outdoor direction sign 2 - signage example (left) and co-designed sign (right)

Pain Point 4: Participants expressed that *"you wouldn't always necessarily know inside a building what floor you're on (PA)",* especially with buildings with multiple entrances. Therefore, having a highlighting indication for the 'current' floor is beneficial (as shown in *Figure 7-6 Indoor information sign - signage example (left) and co-designed sign (right).*

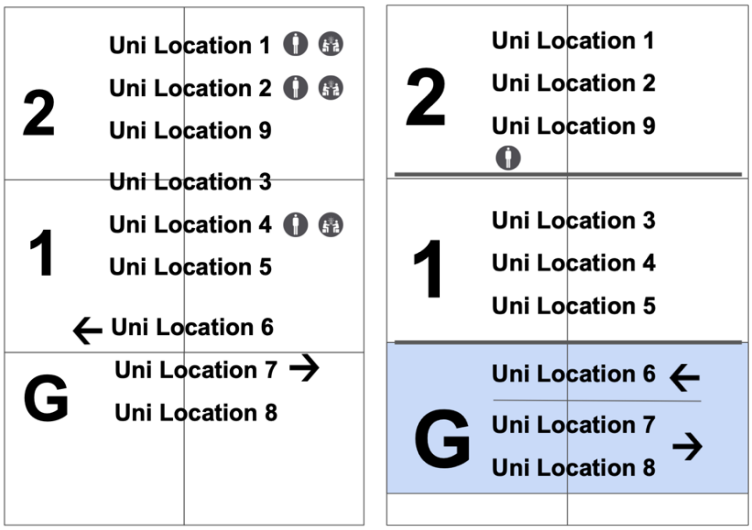


Figure 7-6 Indoor information sign - signage example (left) and co-designed sign (right)

7.3.1.2 Informed by participants' individual experiences

The co-designed signage was informed by participants' individual experiences; this is shown in the indoor information sign prototype. Instead of having the arrow placed on the left side of the signage to maintain consistency with the design of outdoor signage (*Figure 7-4 Outdoor direction sign – signage example (left) and co-designed sign (right),* participants placed the arrow on the right side of the main text body. Based on participants' experience, they tend to *"First want to know what floor you need to go to and then additionally, once you're on a floor then you might need to know (PA)"* the direction (as shown in *Figure 7-7 Indoor information sign - signage example (left) and co-designed sign (right).*

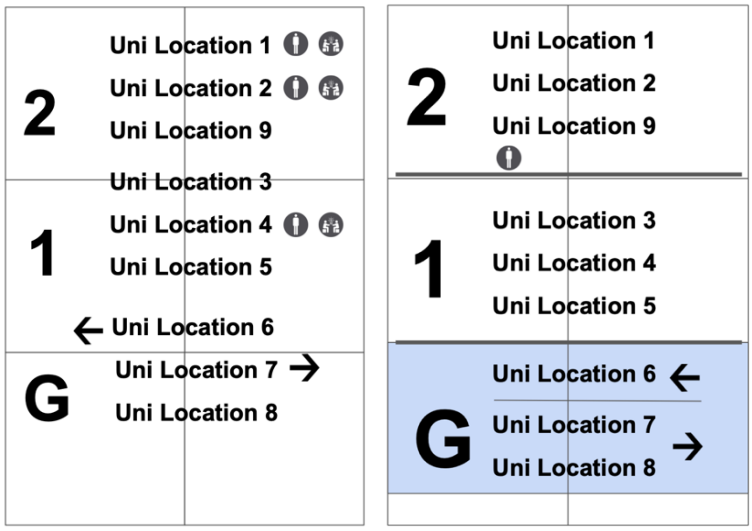


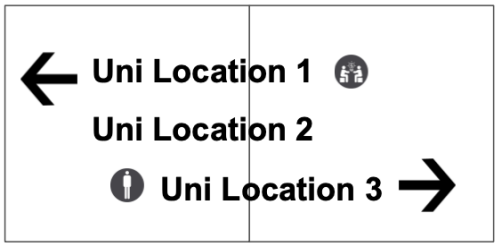
Figure 7-7 Indoor information sign - signage example (left) and co-designed sign (right)

7.3.1.3 Informed by participants' preferences

The co-designed signage was informed by participants' preferences in design; this is shown in the outdoor direction sign. As discussed in *chapter 6-2,* participants' preferences do not necessarily imply the best design practice to achieve the goal of effectiveness. However, it does project participants' ideas of effective signage graphic design, raising new design variables to be considered when developing signage for them.

Participants prefer to "*have all the arrow to be in a vertical column because that's more immediately understandable (PA)".* This is especially important because with *"small field vision",* they often read till the end of the text without noticing the arrow. With all the arrows placed in a predictable place, participants can *"predict"* the signage layout and not miss any information.

Participants prefer to have colour carefully applied on signages; it adds a level of *"association (PB)"* to the signage, and it helps to *"block out information (PC)"* and make the sign "*visible (PA)*". When *"there are layers of differentiation, so people with different forms of vision loss can have safety nets … to help them navigate the sign. (PC)*" This was also considered *"far more sophisticated"* than the provided example.



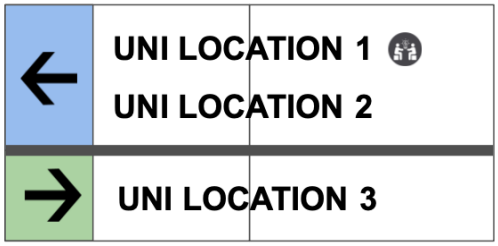


Figure 7-8 Outdoor direction sign 2 - signage example (left) and co-designed sign (right)

Participants prefer "*bold and enlarged (PC)*" text on room number signs; it makes it easier to *"spot the sign (PA)"* and easier to read the information on the sign; it presents a nice *"clean aesthetic (PC)".*

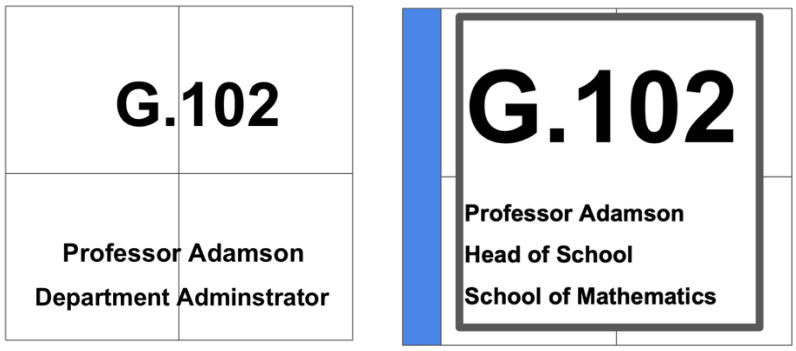


Figure 7-9 Outdoor direction sign 2 - signage example (left) and co-designed sign (right)

7.3.1.4 Informed by culture convention

The co-designed signage was informed by cultural convention; this is shown in the co-designed indoor information sign. Participants expressed the relationship between cultural convention with their design decision, "*The western culture intake information left to right and so we do want to go from macro to micro … It makes more sense, that's how I would find information, and that's how I would organise it internally. (PC)*" Therefore, a more effective signage graphic design for them should accommodate this convention and read from the left to the right, corresponding "*floor we gonna go (PC)*" to the direction arrow that leads to the destination.

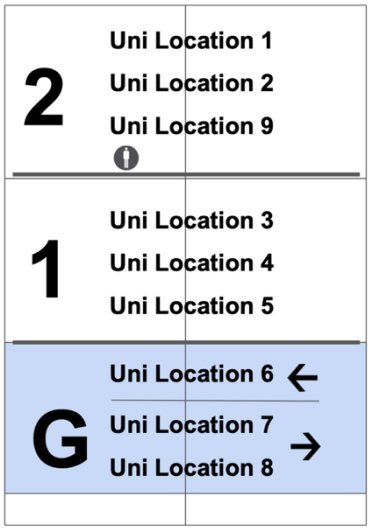
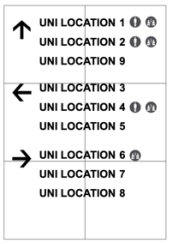
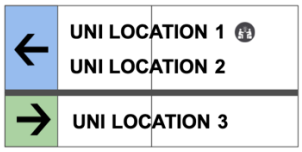
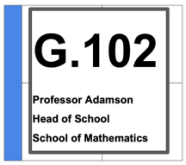
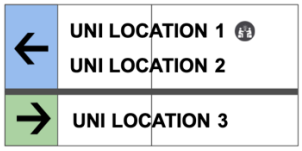


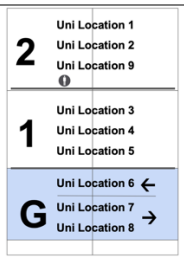
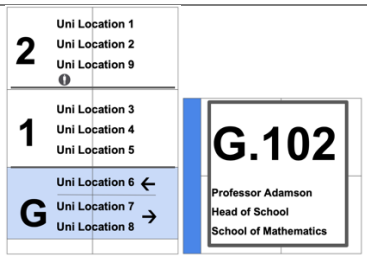
Figure 7-10 Co-designed indoor information sign

7.3.1.5 Definition of 'effectiveness' for partially sighted individuals

The definition of effective signage graphic design for partially sighted participants was identified in the focus group; these were drawn from the keywords surrounding the discussion of the effectiveness of co-designed signage outcome. Specifications were generated and interpreted from participants' discussion about these keywords. The corresponding visualisation/co-designed signage prototypes were gathered based on these specifications.

Table 7-1 Better signage design specification for partially sighted individuals

DEFINITION OF BETTER SIGNAGE DESIGN		
Keywords	**Specifications**	**Visualisation**
Orderly	• Clean aesthetic – only the essential information to provide direction. • Having arrows in one place, text in one place and symbols in one place. • Having a larger gap between regions/groups of information. • Using line breaks between groups of information.	
Predictable	• Compartmentalised design. • Break up sign layout into regions; for example, left side - a column of direction arrows, middle part - all the location names and symbols to be placed on the right side. • For example, in room-sign, the number to be placed on the top with detailed information at the bottom. • Keep all the text left aligned. • Colour-coding the campus.	
Visible	• Distinguishable from adjacent environment with: • Stronger boarder around the sign. • Highlight the important information, highlight the sign with colour.	
Sophistication	• Visually appealing with colour coding. • Layers of differentiation by using colour and line breaks. • Orderly.	
Associations	• Using colour coding for directions or departments. • Highlight the important information such as the floor and directions with colour.	

		
Macro to Micro	• The displayed information from left to right (Top to bottom) correspond to how user process the information (granule to detailed).	
Uniformed Design	• Consistent design language throughout the signage design.	

7.3.2 The developed PD approach enables good co-design experiences

The aim of co-design is to encourage target users to actively contributes to the design process, which might range from actual design to creative input for design (Magnusson et al., 2018, p.415). Three metrics (Segalowitz and Chamorro-Koc, 2018, p.9) of participation are considered essential to evaluate participatory co-design workshops. The first aspect of the metrics is **intrinsic motivation**, which is considered fundamental to the performance of participation. In the context of the workshops, this can be interpreted as the participant's satisfaction with the activity itself. This is addressed in the aspect of *7.3.2.1 The potential of online co-design* and *7.3.2.3 Autonomy in workshop*. The second aspect of the metrics is **self-efficacy**, this refers to participants having confidence in their abilities to execute the required activities to produce outcomes. In the context of the workshops, this is addressed in the acknowledgement of participants' diverse abilities and creativities *(7.3.2.3 Autonomy in workshop),* and access to relevant information to support their creative activities in co-design *(7.3.2.4 Access to knowledge and transparency in co-design workshops).* The third aspect of the metrics is the **positive group effect**, this is addressed in participants' experience in co-design within the workshop groups *(7.3.2.5 Good facilitation led to a better positive workshop experience).*

7.3.2.1 The potential of online co-design

According to the focus group discussion, it was appropriate to carry out PD generative activity online, contrary to what Sanders et al. (2010) advised. However, this was largely attributable

to changes in social phenomena as well as special accommodations that have been explored. Overall, participants suggested a "*positive experience (PC)"* with the workshop; this is as a result of:

1) Participants are familiar with online collaboration. Due to the changing social climate of working from home, participants are familiar with using online collaboration tools such as Google Hangouts and Zoom. They got used to online collaborations.
2) Participants find the workshop works "*particularly well with a smaller group (PA)*" when it is carried out online. However, it might be difficult for larger groups of participants due to the limitation of the online group chats, because that would be easy for participants to speak over others accidentally and only magnifies the active participants in the group.
3) Accommodating (accessible) tools were provided to facilitate the co-design generative activities. Participants usually do not expect any accommodations for accessibility when involved in online collaboration workshops. They often consider it their responsibility to compensate for their disability. The grid tool used in the workshop was considered "*pretty good for describing where things should be. (PA)*" Participants find the co-design workshop to be a "*very freeing (PA)"* experience.

7.3.2.2 The highlights and challenges of the grid tool

Participants' confidence in completing workshop tasks is influenced by the workshop tools and activities. The grid tool was developed with the goal of injecting accessibility into data collection; it played a significant role in the workshop activities. Therefore, participants' feedback about the grid tool, especially concerning accessibility, was gathered. Based on the discussion, there was mixed feeling toward the grid tool being used in the workshop. The grid tool was considered accessible but limiting in some senses. On the one hand, participants find the grid tool accessible and good for communicating the design; on the other hand, participants find the grid tool difficult to use when they need to refer to more than one grid at a time, and it does not provide real spatial representation (with squares) of the actual item being designed.

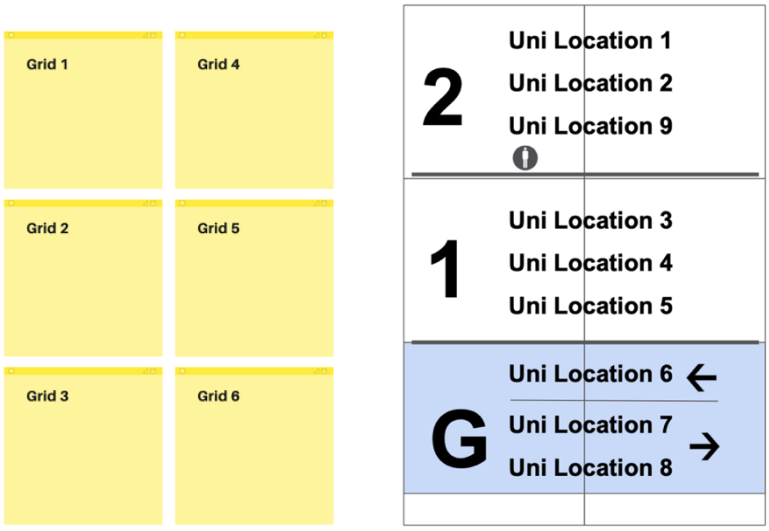


Figure 7-11 Illustration of the grid tool (left) and corresponding signage design on grid (right)

Participants made suggestions to compensate for this limitation of the grid. First, the sign shape on the grid should closely emulate the shape of actual signage. Then, participants suggested, *"divide the sign up asymmetrically into regions or units (PA)"* once the sign shape has been decided; therefore, if one design element crosses more than one grid, participants could refer to, for example, *"text region"* and *"arrow region", "border"* instead of grid numbers.

Overall, participants appreciate the grid tool being accessible, considering it a good basis for co-design activities.

7.3.2.3 Autonomy in workshop

Participants felt autonomy to express their creative ideas in the workshop; this was attributed to two workshop configurations. Firstly, participants had the chance to create their designs individually before returning to share their designs and collaborate on a shared design. This way, participants could make direct changes to the design instead of communicating them verbally.

Second, the availability of the design examples and parameters aided their ability to articulate their design ideas. Participants struggled in the first workshop to be creative due to a "*lack of context (PC)*". As a result, the sign design process, the elements that make up a sign layout design, and examples of signage layouts were introduced in later workshops. Participants found it beneficial for their creative contribution, as *"(to) know the structure that it is within which I can be creative (PC)"* inspired their design.

Diverse Abilities

One participant considers themselves "*more technical than creative (PB)*", who suggested that to *"utilise your group strengths and not necessarily individual (PB),"* and suggested that they are not good at creating *"beautiful designs".* However, this participant did bring constructive perspectives to the workshop, ideas such as providing examples and introducing parameters to the co-design process, making the grid model more spatially representative; these facilitated the iteration of the workshop itself, which essentially aided the "*creative type*" and "*in the middle (of being creativity) (PC)*" participants to better express themselves.

7.3.2.4 Access to knowledge and transparency in co-design workshops

Having access to a clearer goal of co-design outcome and the knowledge of design was considered hugely important to the efficiency of the co-design workshop and participants' creative contribution. This connotation of 'accessibility' was expressed throughout the focus group discussion. Participants found that being able to provide "*direct feedback (PC)*" to the "*design example*" and knowing the context of the desired co-design outcomes greatly enhanced their capacity to co-design. In the last two workshops, participants were introduced to how signage was made, the design elements options they could utilise in their design, and the basic compositions of signage. A significant increase in interest in creating was observed after participants were introduced to design knowledge. It was brought up several times and agreed upon by participants that "*it is easier to give feedback to something that existing (PC)*" than "*to create*" without understanding the context. Participants even suggested that it would be beneficial to have the signage examples be "*sent out ahead of the time of workshop (PA)*".

7.3.2.5 Good facilitation led to a better positive workshop experience

Participants had a positive experience with the workshop and other co-designers, which resulted from good facilitation. Participants suggested that the facilitator played a major role in bringing them together with good leading questions; participants could find their way back to the subject when the discussion deviated too far from the subject.

However, participants suggested that they would appreciate having the opportunity to *"have a quick round table to introduce ourselves (PC)"* at the beginning of the workshop because they don't get many opportunities to meet people with shared experiences.

7.3.3 The application of the developed approach

7.3.3.1 The value of accessibility in signage graphic design

Accessibility is considered hugely important in signage graphic design and the approach that was developed to achieve it. Based on participants, the majority of people can access signage graphic design, and it does not matter much beyond aesthetics, "*the people for whom the differences in sound design can be crucial are the ones for whom we may have to work the hardest to make it possible for them to share their opinions about it. (PA)*"

Designing for accessibility through co-design workshops "*helps a wider audience be more cognizant that there are people who need help around them, and they might not even realise that … there is a way to make signs better, not just for people with disabilities, but for everyone (PC).”* Participants also discussed the areas of their life in which accessibility needs to be considered.

7.3.3.2 The future application

Participants find the developed approach applicable to signage graphic design within smaller institutions such as libraries, hospitals, train stations, office spaces and shops. These organisations only use indoor signage, whereas it would be more challenging for complex environments to use both indoor and outdoor signage.

Apart from signage graphic design, participants expressed the potential of utilising the developed tool for "*app layout, screen layout or (newspaper) page layout (PA)*" because of already have a "*specific space to work within*".

Participants also expressed a huge desire for accessibility to be considered in game design; especially, tabletop card games design was hugely echoed by participants, as participants expressed the feeling of being "*left out*" and "*isolated*". It is difficult for participants to rely on supplementary tools to help them participate. Participants expressed, "*We are playing a lot more games when we're trying to be more social, and yet this is the one area that I feel really isolated in (PC).”* It is "*very difficult to compensate in and to keep up with everybody (PC)*" when participating in playing activities during the COVID time. One participant is in favour of *“opt-out sometimes”* because "*to try and compensate takes away from the fun of it (PC).*"

7.4 Discussion

The aim of co-design is to support target users to be active creative contributors to the design process (Magnusson et al., 2018, p.415), it is essential to ensure the user role is transformed from merely informants to legitimate acknowledged co-designers (Raman and French, 2021, p.2). This means centring participants' experiences during the design development and tailoring the co-design activities to accommodate participants' capabilities in participating and supporting participants to accomplish workshop goals. Based on metrics[2] (Segalowitz and Chamorro-Koc, 2018, p.9) of participation, the co-design workshop had achieved its goal of putting the co-designer at the centre of design development. Participants expressed a positive experience with the implemented co-design workshops, this was partly due to accommodating tools and activities that increased participant confidence and encouraged participation. The **intrinsic motivation** is discussed in *7.4.2 Online co-design with partially sighted participants.* The **self-efficacy** is discussed in *7.4.3 The power dynamic in online co-design with partially sighted* and *7.4.4 Autonomy and freedom to create under 'constraints'.* Based on the experience of carrying out research activities, insights into achieving **positive group effect** are discussed in *7.4.5 Suggestions to co-design with partially sighted participants online.*

7.4.1 The importance of user-centred co-design practice

Findings support that accommodating special considerations (Magnusson et al., 2018, p.427) and tailoring the method to support partially sighted participants' creative contribution in co-design lead to a better workshop experience (Chick, 2019, p.57; Raman and French, 2021, p.11) and more 'effective' design outcome (Thinyane et al., 2018, p.1). Co-design workshops produced high-fidelity signage prototypes compared to the online questionnaire. While the previous online questionnaire produced an initial list of requirements for signage graphic design for partially sighted individuals, the co-design workshops produced a collection of visual representations of participants' ideal design. Despite visualisations produced by participants were influenced by individual preferences; however, the value of the workshop outcome is that it improved the understanding of the effectiveness of signage graphic design for the partially sighted; this supports the importance of user-centred co-design practice in cultivating a better understanding of the current design 'problems' of the surrounding context (Cullen and Metatla, 2019, p.361).

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[2] The three metrics to evaluate participatory workshops are: 1) **intrinsic motivation**, which is considered fundamental to participation performance; 2) **self-efficacy,** which refers to whether participants have confidence in their abilities to execute the required activities to produce outcomes; 3) **positive group effect,** which refers to participants' experience in the workshop.

The co-designed outcome improves the 'effectiveness' of the signage graphic design by making the signage layout more orderly, predictable and visible. Based on participants' feedback, this should hugely reduce their time searching, memorising, and guessing the information on signage, decreasing the chance of developing anxious feelings due to difficulties finding information on the signage. Participants initially identified their pain points in previous workshops and how these pain points should inform signage graphic design. In this reflective focus group discussion, participants expressed further on how these design decisions would benefit their user experience with wayfinding signage graphic design.

7.4.2 Online co-design with partially sighted participants

The finding provides great insight into co-designing with partially sighted participants online, which was considered challenging, especially with generative activities (Sanders et al., 2010, p.197; Brewer, 2018, p.4). Contrary to what the literature suggests, the overall workshop is considered suitable to be carried out online for a variety of reasons.

The workshops benefited from a small group of participants, which, according to (Brewer, 2018, p.2), should encourage more hands-on participation in the session; this was also noticed throughout the workshops. The small group format created a trustworthy and safe environment (Magnusson et al., 2018, p.415); this facilitated engagement and collaboration between participants. This also made the workshop iteration against participants' engagement more manageable.

Participants found it familiar to collaborate online due to the social environment changes introduced in Chapter 6-1; this agrees with (Sanders et al., 2010, p.195; Raman and French, 2021, p.11); introducing participants to a familiar and relaxed social setting encourages engagement.

The workshops benefited from the development of accommodating workshop activities which supports the importance of designing a useful and usable system when co-designing with people with disabilities (Brewer, 2018, p.3). Most low-fidelity prototype tools are considered unsuitable for non-visual use (Magnusson et al., 2018, p.415); adaptation with tactile and sound technologies is the common practice for co-designing with partially sighted participants. This, however, means that participants will no longer be able to build shared representations. The lack of shared representation in co-design could diminish the contributions of sole contributors (Brewer, 2018, p.1), which negates the purpose of co-design.

The developed grid tool activities conform to considerations suggested by (Magnusson et al., 2018, p.428; Raman and French, 2021, p.12), which **support participants sharing information**

through several modalities and allow participants with different visions to engage with design activities. This echoes the importance of avoiding the unintentional exclusion of creativity and ideation (Brewer, 2018, p.1). The grid tool does rely on little to more vision from participants, despite scholars (Magnusson et al., 2018, p.415; Albouys-Perrois, 2018, p.2; Cullen and Metatla, 2019, p.369; Kamat, 2021, p.1; Vermeersch and Heylighen; 2021, p.51) have addressed the challenge and somewhat impractical to use visual means in such workshops, findings of this study support the importance of visual representation in co-design with partially sighted participants. Findings support (Thieme et al., 2017, p.747) that in the context of working with mixed vision ability participants, visual representation plays a significant role in aiding sense-making and engagement for people with vision being a dominant and pervasive sense for someone who has (some) vision. This was initially observed during the co-design workshops and reinforced during the focus group.

The workshop benefited from providing basic knowledge and information about signage graphic design to participants through visual means. Findings support that providing learning opportunities to participants builds up their confidence and reassures their ability to participate (Raman and French, 2021, p.11). This is especially beneficial when working with a mix-ability group (Cullen and Metatla, 2009, p.363). The positive effect of providing information about how signage is made and examples of signage layout was observed during workshops and confirmed by participants' feedback in the focus group. Findings support the importance of acknowledging the role of the researcher/facilitator, to lead, guide, support and encourage (Sanders and Stappers, 2008, p.14).

7.4.3 The power dynamic in online co-design with partially sighted

The workshop approach challenges the traditional role power dynamic between the user and the designer/facilitator in product/service design practices (Sanders and Stappers, 2008, p.11). In the traditional design approach. The designer passively absorbs the user's insights, combines them with understanding and creative thinking to come up with ideas and concepts (Sanders and Stappers, 2008, p.11). In the online co-design workshops *(Chapter 6-2)*, participants were considered active contributors to the co-design workshop process and co-designed outcome, the facilitator was there to provide support for participants to achieve the workshop goal. Findings support the importance of acknowledging and validating participants' experiences, as they are the 'expert of their experience' (Magnusson et al., 2018, p.411; Raman and French, 2021, p.11). The co-designed signage outcomes took into consideration participant feedback on co-design visualisation and experience with signage graphic design. This incorporates user-specific requirements into the design, which is crucial when working with people of various

abilities (Raman and French, 2021, p.11). Therefore, compared to the traditional 'user-involved' signage graphic design approach, this user-centred co-design practice produces a more effective outcome for participants.

Findings challenge the traditional role connotation of researcher/facilitator (Sanders and Stappers, 2008, p.11) in design, which is often considered the translator between 'User' and 'Designer/Developer'. Findings support the importance of acknowledging the different levels of creativity among participants (Sanders and Stappers, 2008, p.14; Raman and French, 2021, p.12), as it is the researcher/facilitator's role to lead, guide, support and encourage participants at different levels of creativity to engage in the creative activities. Therefore, the researcher/facilitator's role is more and beyond 'translator'; This role requires the researcher/facilitator to prepare supportive tools and materials to accommodate participants' abilities to understand the design subject (Magnusson et al., 2018, p.427), a allow and facilitate creative interaction between participants (Sanders et al., 2010, p.197), closely observe the engagement of the workshop, iterate the workshop activities, and therefore empower participants to co-create (Ertner et al., 2010, p.193).

7.4.4 Autonomy and freedom to create under 'constraints'

Autonomy and the freedom to create underpins the democratic principle of Participatory Design practices (Raman and French, 2021, p.3); it is the key to democratic engagement and participation (Thinyane et al., 2018, p.1). Based on the *five enunciations of empowerment in participatory design* (Ertner et al., 2010, p.191), **autonomy** in co-design can be interpreted as **direct democracy** – the enablement of participants to participate democratically and gain direct influence on the co-designed subject through communication and information. In the context of this thesis, the workshop has achieved the goal of helping partially sighted participants visualise their design needs for signage under certain 'constraints'. Based on the evidence, this success inevitably due to a number of factors. Firstly, I disagree with providing participants 100% full autonomy to create. Participants have different levels of experience, passion and creativity to create; as Sanders and Stappers (2008) mentioned, *"all people are creative, but not all people become designers* (Sanders and Stappers, 2008, p.16)*",* giving participants full autonomy and freedom to create hinders participants' prototyping activities, this was observed during the workshops and expressed in the focus group. Participants can be the 'expert of their experiences'; however, the facilitator needs to provide the necessary tools and information to guide participants to express their ideas. In the context of an online co-design workshop, instead of asking participants to create from their imagination, much more

progress was made after participants were introduced to the basic graphic construct of signage graphic design.

Secondly, it is important to appreciate the value of pre-co-design research. Simple languages, minimum text and visuals enable communication, comprehension, and enjoyment for participants (Raman and French, 2021, p.11). To achieve that, the facilitator, researcher, and designer must conduct in-depth research to better understand the subjects and then translate it for co-designers (Sanders and Stappers, 2008, p.13; Magnusson et al., 2018, p.427). The previous guideline review/audit *(Chapter 4)* and online questionnaire *(Chapter 5)* provided me with a good understanding of signage graphic design in the academic setting. These preparations enabled me to create the appropriate condition for the co-design workshop; it helped me to construct wayfinding scenarios in academic settings; it helped me to break down the signage graphic design process to participants; it helped me produce signage examples relevant to the design 'problem'; essentially, it contributed to facilitating partially sighted participants creative contribution to the co-designed signage outcomes.

Together, these two practices created a 'constraint' - a direction for participants to work towards rather than starting from scratch. Additionally, it provided a solid knowledge base from which to conduct co-design activities. This echoes the benefit of providing additional 'training' to participants (Williams et al., 2015, p.4). Overall, based on participants' feedback, this did not impede participants from having autonomy in their creative contribution. Instead, it encouraged participants to create hands-on prototypes.

7.4.5 Suggestions to co-design with partially sighted participants online

Before the workshop: Make sure the information is accessible before, during, and after the workshop (Magnusson et al., 2018, p.427). Digitalise pre-workshop material, send detailed information about the workshop activities, and prep the participants for the activities, especially when they are expected to carry out reflection and creative activities. For partially sighted individuals, this also means ensuring accessibility to all the workshop materials (Image description, screen reader friendly), getting feedback from participants about their concerns of workshop activities, and preparing accommodating tools and information if requested. It also helps ask participants to think about the design problems before the workshop by providing critical using scenarios (Carroll, 1996, p.286; Sanders et al., 2010, p.198; Williams et al., 2015, p.4; Brewer, 2018, p.2) to draw out participants' experiences in scenarios.

During the workshop: Conduct a **pilot study before the workshop**. This gives participants opportunities to get to know each other and boosts the facilitator's confidence in carrying out

the following workshop activities. This helps build a trusting and familiar atmosphere and encourages collaboration (Cullen and Metatla, 2019, p.362; Raman and French, 2021, p.11). For partially sighted participants, this means closely listening to and observing participants' engagement during the pilot study. Prepare and provide necessary information and examples to support participants in understanding the context of the co-design subject and reassure participants' ability to complete the creative tasks. This will build participants' confidence (Chick, 2019, p.57; Raman and French 2021, p.11) and facilitates participants' hands-on engagement (Williams et al., 2015, p.4; Brewer, 2018, p.2).

Preparing accommodating tools for participants with different abilities to collaborate. This includes multi-sensory, multi-modality scenario approaches (Brewer, 2018, p.3; Williams et al., 2015, p.4; Carroll, 1996, p.286; Sanders et al., 2010, p.198). This acknowledges different levels of creativity and abilities to complete the tasks, reduces the participation threshold, and encourages creative contribution. For partially sighted participants, due to mixed vision capabilities, it is crucial to provide more than one modality for participants to work with. This should not be limited to storytelling, but also consider writing or simple drawing to encourage creative contribution.

Draw out different experiences from the participants and expect the unexpected (Magnusson et al., 2018, p.427). Nurturing and respecting participants' creative ideas encourage participants' engagement in decision-making; this brings new perspectives to co-designed outcomes (Raman and French, 2021, p.12). For partially sighted participants, this means constructing a workshop including activities that participants can complete independently and collaboratively.

At the end of the workshop: Consider how you can support sharing information. Participants appreciate being asked for their opinions; this brings social inclusion to the workshop (Cullen and Metatla, 2019, p.361); this gives participants a chance to reflect on their design and facilitate collaboration (Raman and French, 2021, p.11). Make sure all participant's ideas are heard (Brewer, 2018, p.1). This means, in the context of online co-design with partially sighted participants, having a shared screen which all participants are able to access, comment and contribute. Encourage sharing of ideas, and collaboration between participants in terms of the workshop activities and outcomes. Improve the workshop activities based on participants' feedback and observed engagement.

7.5 Conclusion

In this chapter, I presented an online focus group to explore the value and potential of the developed user-centred online co-design practices by discussing aspects of the participatory experience that influence participation and co-design outcomes with workshop participants. The findings suggest that **focusing on tailoring accommodating tools and activities to meet the participant's needs in co-design encourages participants' creative contribution and therefore improves the understanding of partially sighted participants' ideas of more effective signage graphic design.** To place target-users at the centre of the co-design process means adopting a different role-power dynamic between the designer/facilitator and the user; carrying out a range of pre-workshop research activities such as design review/audit and online questionnaire to provide a theoretical foundation for co-design activities; and acknowledging participants' needs during the co-design activities to design and develop accommodating tools to support participants' creative contribution and collaboration. In the context of this thesis, this does not necessarily imply that co-designed signage prototypes are the best design practice for reflecting the challenges partially sighted participants face when it comes to signage graphic design in academic settings; however, the insights generated by the co-design outcome cannot be obtained otherwise.

Co-design with partially sighted individuals is a little explored by scholars; very limited frameworks and tools are available in this field. The nature of the PD approach does not allow one fit for all methods to carry out studies. In this chapter, I explored the benefits of co-design with partially sighted participants; the meaning of co-design in practice; techniques to facilitate co-design workshops with them online; and the appropriate conditions to facilitate participants' creative contributions. I acknowledged the importance of understanding that participants all have different creativity and abilities to complete the task. I found that **focusing on the process and providing information to support participation and creative contribution is crucial to a positive co-design experience.** By embracing different participants' skill sets and creative capabilities in design, more insights on how to make the co-design process more accessible for participants with diverse creative capabilities were gathered. This led to a better approach to co-design with partially sighted individuals online and more informative co-design outcomes. Participants appreciated being asked for their opinion and remembered their good experience with a well-designed product. I believe that the insights and techniques for online participatory design concluded in this chapter will positively impact the design of the product/service for partially sighted individuals as well as contribute to PD practice in general.

Chapter 8 Conclusion and Future Work

This chapter summarises the key findings and highlights the contribution of the thesis. *8.1 Overall discussion* discusses how the research activities in the thesis respond to the five-sub research questions outlined in the introduction *(Chapter 1 1.3 Research questions).* This section investigates how met objectives respond to research sub-questions, as well as the connections between research activities. *8.2 Key Findings* discusses the findings of the thesis and presents insights drawn from completed research objectives. Contributions which validate research questions are presented *8.3 Contribution to knowledge.* Surfaced potential future work and limitations of the study are discussed in *8.4 Limitations and future work.*

8.1 Overall discussion

This study aims to determine the role of user-centred research-based signage graphic design in improving the effectiveness of the wayfinding signage system in academic settings for partially sighted individuals. Five sub-questions were developed to achieve the research aim, and seven objectives *(Chapter 1 1.2.2 Research objectives)* were accomplished through a series of research activities. These research activities include: design review and design audit *(Chapter 4)* to establish an understanding of signage graphic design in academic settings; an online questionnaire *(Chapter 5)* to investigate partially sighted individuals' experience and expectations with signage graphic design in academic settings; online co-design workshops *(Chapter 6-1 and Chapter 6-2)* to visualise the design needs of the partially sighted; an online focus group *(Chapter 7)* to explore the value and potential of the developed co-design approach in improving the effectiveness of signage graphic design for the partially sighted.

The following five-sub questions are answered in chronological order following the research structure *(Chapter 1 1.2 Aims and objectives).*

1) **What graphic design factors are essential to wayfinding signage design in academic settings?**

This sub-question corresponds to **objectives a** and **b**, which were set to define the graphic design factors essential to wayfinding signage design in general and in academic settings. This question helped establish an understanding of signage graphic design in academic settings. In **Chapter 4**, a design review *(4.3 Research design – The guideline review)* and a guideline audit *(4.8 Research design – The guideline audit)* were conducted to achieve these two objectives. During the review of available signage design guidelines and the audit of signage design

standards of 58 academic campuses, a framework of signage design guidelines *(Appendix 1 Wayfinding Signage Design Guideline Framework)* and a list of signage graphic design factors *(Chapter 4 4.9 Results)* that are primarily considered in academic settings were produced.

Three main themes among reviewed guidelines have emerged: *Signage (System) Planning*, *Signage Design* and *Signage Practicality*. *Signage (System) Planning* addresses where and when to assign signage on a wayfinding network and the types of signage needed. *Signage Design* addresses the graphic layout of the signage. Gathered guidelines address: *language, wording, punctuation, typeface, type size, layout, information hierarchy, colour* and *other design factors* such as *symbol, arrow, map, embossed, lift* and *braille*. *Signage Practicality* addresses the practical factors such as maintenance that need to be considered during and after the signage installation. Gathered guidelines address: *illumination and glare* on signage, *positioning* of the signage, signage *alteration* and *common maintenance*.

Primarily considered design guidelines across audited campuses are signage design factors of *Typeface, Type size*, *Colour* - especially on *Branding Colour*, *Symbol,* and *Arrow*. This indicated the importance of these design factors in delivering wayfinding signage messages in academic settings.

This chapter started with the goal of exploring commonalities among audited university signage design standards. However, during the review and audit activities, issues and the need to improve the effectiveness of signage graphic design were also identified.

2) What are partially sighted individuals' experiences with signage graphic design in academic settings?

This sub-question corresponds to **objective c**, which was set to investigate the experiences and opinions of the partially sighted with regard to current wayfinding signage design in academic settings. This question helped define the initial user requirement for signage graphic design and identify the importance of effective signage graphic design in academic settings. In **Chapter 5**, an online questionnaire was conducted to answer this sub-question. Despite the fact that it has been shown on the Likert scale *(Chapter 5 5.3.1.3 User satisfaction and signage effectiveness)* that participants are somewhat neutral about the effectiveness and satisfaction with the signage design in academic settings due to central tendency bias. More participants suggested that wayfinding signage in academic settings needs improvement. Findings *(Chapter 5 5.3.1.3.1 Justified user satisfaction)* suggest that dissatisfaction with the signage is associated with the effectiveness of the signage, and thus justifying and confirming the overall

ineffectiveness of signage in academic settings *(Chapter 5 5.3.1.3.2 Signage ineffectiveness)*. Qualitative evidence suggests little satisfaction towards the *design* aspect of the signage compared to the *planning* and *practicality* aspects. Ineffective signage graphic design in academic settings challenges navigation of the location, the ability to read the signage information, and independence.

3) **What are partially sighted individuals' design needs for signage graphic design in academic settings?**

This sub-question corresponds to **objectives c** and **d**, which were set to investigate partially sighted individuals' experiences and opinions with current wayfinding signage graphic design in academic settings and prototype users' signage graphic design needs through co-design. In **Chapter 5,** issues with signage graphic design in academic settings were initially identified through the online questionnaire *(Chapter 5 5.3.2.2 Issues with design),* and assumptions of 'effectiveness' of signage graphic design were made based on participants' feedback *(Chapter5 5.3.3.2.2 Assumption of effective design)*. Findings *(Chapter 5 5.3.3 Redefining good signage practice)* suggest participants require wayfinding signage to fulfil both functional and emotional needs in wayfinding. Therefore, an effective wayfinding signage system must reflect both of these needs. The functional need in design requires the presentation of the information to be readable to partially sighted individuals. In order to support the emotional needs of this user group and alleviate stress and anxiety, the signage graphic design must reduce the difficulty of reading the signage. The fulfilment of their functional needs does not guarantee the fulfilment of their emotional needs, therefore, readability alone in signage graphic design is not enough to fulfil both functional and emotional needs. As discussed in sub-question 2, participants' satisfaction with the signage is greatly associated with the effectiveness of the signage graphic design; this signifies the potential to improve the effectiveness of the signage system for them by acknowledging both their functional and emotional needs in signage graphic design.

Furthermore, it was discovered that the essential graphic design factors have a significant impact on the effectiveness of signage graphic design. The accessible features such as Braille and Tactile are critical to signage accessibility; nevertheless, based on evidence, participants have more issues with the fundamental graphic design factors than accessible features. A framework of effective signage graphic design and factors that induces satisfactory wayfinding experiences was produced during the online questionnaire (*5.3.3.1 Definition of satisfactory wayfinding experience for the partially sighted).* The effectiveness of signage graphic design is

determined by the *type, colour, layout* and *other design factors* and whether these choices are consistently well executed.

Chapter 5 provided initial insights into the surrounding context of partially sighted individuals' experiences with signage graphic design and their design needs. However, these findings were insufficient for producing high-fidelity signage graphic design prototypes. In **Chapters 6-1** and **6-2**, four online co-design workshops were developed and conducted to specify as well as visualise partially sighted individuals' expectations of effective signage graphic design. There was no developed methodological framework to support the data collection – co-create visualisation with partially sighted participants online. Four interrelated workshops were developed *(Chapter 6-1)* to achieve this goal. A collection of visual prototypes of effective signage graphic design against identified pain points in three types of wayfinding signage were co-created by the end of co-design workshops *(Chapter 6-2 6.9 Workshop 4 - Co-design indoor signage).* The co-design signage prototypes emphasise the **visibility**, **legibility**, and **readability** of the signage graphic design, which supports the assumption of effective signage graphic design made during **Chapter 5,** the online questionnaire. This was further discussed with the participants in **Chapter 7**, the online focus group. The definition of 'better' signage graphic design for partially sighted individuals is drawn from participants' discussions about what makes the co-designed outcome more effective signage. A list of keywords corresponding design specifications and visualisations of designs were obtained during the online focus group *(Chapter 7 7.3.1.5 Definition of 'effectiveness' for partially sighted individuals)*. These can be concluded as *Orderly, Predictable, Visible, Sophisticated, Associations, Macro to Micro* and *Uniformed Design.*

4) **How to design effective wayfinding signage graphic design for partially sighted individuals in academic settings?**

This sub-question corresponds to **objectives d, e** and **f**, which were set to prototype partially sighted participants' signage graphic design needs through co-design; reflect on the co-designed outcome; and reflect on developed signage graphic design practice.

The challenges of improving the effectiveness of signage graphic design for partially sighted individuals lie in the prediction of design needs, together with acquiring the feedback required for enhancement of the current design (Alnawaisri, 2019, p.18). However, the generic design process which the design consultancies follow, has little input from partially sighted users. This is due to a lack of experience working with people of different capabilities, along with time and money constraints (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289). Participants are

the ‘expert of their experience’; findings *(Chapter 5 5.4.2 Effective signage design for partially sighted users)* of **Chapter 5** indicate that participants are able to clarify the issue with signage and provide feedback for better design. The participatory design approach acknowledges participants’ ‘expertise’ and produces design outcomes that support users' needs through co-design activities (Cullen and Metatla, 2019, p.369; Sanders et al., 2010, p.195). Findings of **Chapter 6** and **Chapter 7** provided evidence to support the benefit of adopting a research-based participatory design approach to design with partially sighted participants.

There was a lack of a developed methodological framework to support co-creation visualisation with partially sighted users online, as mentioned in sub-question 3. As a result, learning how to co-design with partially sighted participants online was critical, in order to co-design with them without compromising accessibility. The online design workshops were developed in response to that.

In **Chapter 6-1** and **Chapter 6-2**, a series of iterative online co-design workshops were designed *(Chapter 6-1)* and implemented *(Chapter 6-2)*. Four interrelated workshops were developed with the aim to assist in the co-creation of signage graphic design prototypes which reflect the signage graphic design needs of partially sighted participants. Each workshop was iterated in response to participant feedback and observed participation during the workshop, with the goal of learning how to co-design visualisations online before co-designing signages with partially sighted participants through online workshops.

During the workshops, participants’ 'expertise' with their experiences was recognised. The prime activities were carried out to assist participants in comprehending the signage graphic design. For inspiration, the signage graphic design process, design elements, and signage graphic design examples were introduced. Participants were asked about their design preferences with essential signage graphic design factors in academic settings. Participants were given tools to support them in contributing creatively to the design process by using verbal expression, writing, simple drawing, and sophisticated drawing. A collection of signage graphic design prototypes was co-created with participants, which was later validated in **Chapter 7.** The developed Participatory Design approach improved the understanding of how to design more effective signage for partially sighted individuals. Additionally, it assisted in identifying four design criteria—reflecting *users' use-related pain points, preferences, experiences,* and *cultural conventions*—which are crucial to the effectiveness of signage graphic design for the partially sighted.

5) **What is the value of the developed signage graphic design practice in this thesis for improving the effectiveness of wayfinding system in academic settings for partially sighted individuals?**

This sub-question corresponds to **objectives e, f** and **g**, which were set to reflect on the co-designed signage outcome and design practice outcomes in order to conclude the design practice which improves the effectiveness of the signage graphic design for partially sighted individuals.

This thesis adopts a user-centred design approach to 1) Understand and specify the context of use, 2) Define the user requirements, 3) Produce design solutions and 4) Evaluation. In **Chapter 4**, a design guideline review and audit were carried out in order to identify the essential graphic design variables that contribute to signage graphic design in academic settings. The identified key design variables of signage graphic design in academic settings provided a better understanding of signage on campuses and later contributed to the online co-design activities in **Chapter 6-2**.

In **Chapter 5** and **Chapter 6-1**, online questionnaire and online co-design were designed to define the user requirements. The online questionnaire helped in understanding the partially sighted individual's user characteristics, pain points with current signage graphic design in academic settings, and concerns about inefficient signage graphic design. The results of the online questionnaire indicates the need for more effective signage graphic design in academic settings for the partially sighted *(Chapter 5 5.4.1 Partially sighted wayfinders)*. It helped build an initial understanding of participants' needs in signage graphic design *(Chapter 5 5.4.2 Effective signage design for partially sighted users).* This initial understanding of user characteristics contributed to the development of co-design workshop activities, which facilitated the visualisation of user needs to be achieved in later thoroughly developed co-design workshops.

The online co-designed outcome and design practice were validated in **Chapter 7** *(7.4 Discussion).* The co-design workshop approach challenges the traditional role power dynamic between the user and the designer/facilitator in product/service design practices. The developed approach supports the users' autonomy and freedom to creatively engage in the signage graphic design process. Nonetheless, it has been demonstrated that this method improved the 'effectiveness' of signage graphic design for partially sighted participants. The co-designed wayfinding signage better meets the functional and emotional needs of partially sighted participants. The co-designed signages reflect partially sighted individuals' pain points in use, preference, cultural convention and experiences. This approach was also suggested by

partially sighted participants as applicable to signage graphic design in other public settings or 2-dimensional visual graphic designs for partially sighted individuals. Through research, this thesis developed a methodological framework *(Chapter 6-1 6.2.1.8 Workshop Plan)* for online co-visualization with partially sighted participants. This developed design practice is not only valuable for improving the effectiveness of wayfinding signage for partially sighted in academic settings but also has value for generalisation.

8.2 Key Findings

8.2.1 The importance of signage graphic design for partially sighted individuals

There has been discussion amongst scholars over whether people who are blind or partially sighted may develop their spatial-cognitive abilities for wayfinding. From the early rejection of such ability (Fletcher, 1980, p.381) then to later confirming their ability to carry out navigational tasks, such as, exploration, obstacle avoidance, turning angles and understanding the configurational environment (Passini and Proulx, 1988, p.247; Passini et al., 1990, p.114; Golledge et al., 1996, p.242). Eventually, these findings (Passini and Proulx, 1988, p.247; Passini et al., 1990, p.114; Golledge et al., 1996, p.242; Kitchin et al., 1997, p.225; Fortin et al., 2008, p.3001) validate the ability of blind and partially sighted people to navigate.

Wayfinding signage is one of the essential pieces of information for wayfinding decision-making (Arthur and Passini, 1992, p.28) since it determines the mental difficulty of the navigational task (Vandenberg, 2016, p.26). Based on findings gathered in **Chapter 5** online questionnaire *(5.3 Findings)* and **Chapter 6-2** co-design workshops *(6.9.3 Discussions),* partially sighted individuals rely on their wayfinding spatial-cognitive abilities to find their way on academic campuses. Moreover, evidence gathered in the online questionnaire suggests that partially sighted individuals rely on wayfinding signage to carry out their wayfinding commute, explore, and quest activities. Partially sighted participants expressed the desire for signage improvement in the online questionnaire. This finding supports the significance of route-type information (Verghote et al., 2019, p.9) in partially sighted wayfinders' wayfinding performance (Noordzij et al., 2006, p.321; Hölscher et al., 2006, p.284). This supports the importance of effective signage graphic design in resolving the *"situational confusion* (Kitchin et al., 1998, p.45)" imposed by the unfamiliar environment for partially sighted individuals.

This finding was later reinforced in **Chapter 6-2,** co-design workshop scenario activities. In the scenario of participants using signage to navigate through an unfamiliar academic campus, the ineffectiveness of signage graphic design impedes their progress and frequently causes anxiety

due to difficulty understanding and acquiring information on signage. Although participants may be able to use devices like GPS to aid navigation in outdoor areas in real life, the lack of visibility and the restricted movement would still make indoor wayfinding difficult (Karimi, 2015, vii; Srinivas and Hirtle, 2015, p.14). Together, these findings signify the importance of signage graphic design to the independence of partially sighted individuals in wayfinding. This also indicates the significance of effective signage graphic design for partially sighted individuals in academic settings.

8.2.2 Defining effective signage graphic design for partially sighted individuals

Academic campuses have an impact on students' overall well-being, safety, and even academic success (McDonald-Yale and Birchall, 2021, p.13), wayfinding signage system plays a role in promoting safety and accessibility on academic campuses (Arthur and Passini, 1992, p.10; Lawton, 1996, p.137; Gibson, 2009, p.14; Hunter et al., 2016b, p.4; Kanakri et al., 2016, p.255; McDonald-Yale and Birchall, 2021, p.13). However, based on previous studies (Rousek et al., 2009, p.531; Khattab et al., 2015, p.157; Obeidat and Rashid, 2017, p.8), the current built-in environment standard is not fulfilling the partially sighted individual's wayfinding signage needs.

A series of potential issues related to signage graphic design, such as the size of the signs, illumination, placement and obstructive decorative elements are pointed out by Rousek et al. (2009). With a huge body of partially sighted individual related wayfinding research focuses on navigational technologies (Liu et al., 2007, p.1655; Dakopoulos and Bourbakis, 2008, p.1; Stewart et al., 2008, p.332; Swobodzinski and Radubal, 2009, p.1315; Söderström and Ytterhus, 2010, p.303; Xiao et al., 2015, p.303), there is a lack of updated and unified definition of effective signage graphic design for partially sighted individuals. This was further confirmed in **Chapter 4** - the guideline review. Based on evidence gathered in the review, there is a lack of updated and comprehensive signage graphic design guidelines for partially sighted individuals. Issues such as inconsistencies and confusion were identified amongst reviewed guidelines. Accessibility is found to be addressed under different connotations. Institutions such as the *Americans with Disabilities Act (ADA)* provides the basic guidelines for improving the overall accessibility in wayfinding. Still, the aspect of signage graphic design for partially sighted individuals is not prioritised.

In **Chapter 5** – the online questionnaire, the requirements for designing wayfinding signage for partially sighted individuals were initially defined. The effectiveness of signage graphic design must accommodate their functional and emotional needs in wayfinding. The effectiveness of signage graphic design is significantly influenced by the essential graphic design elements,

based on evidence *(Chapter 5 5.4.2 Effective signage design for partially sighted users).* Assumptions of effective signage graphic design were made based on participants' feedback and opinions on the current signage graphic design in academic settings. This definition was later strengthened in **Chapter 5** and **Chapter 6-2,** the online co-design workshop and online focus group. A clearer 'picture' of effective signage graphic design for partially sighted individuals was defined.

8.2.3 The importance of acknowledging partially sighted individuals' experience in design

In the traditional designer/user power dynamic, users are considered the passive object to be studied by researchers. The designer passively absorbs the user's insights, combines them with understanding and creative thinking, in order to ascertain ideas and concepts that add up to existing products (Sanders and Stappers, 2008, p.11). This is found significant in these wayfinding research surrounding partially sighted individuals (Liu et al., 2007, p.1655; Dakopoulos and Bourbakis, 2008, p.1; Stewart et al., 2008, p.332), where participants' experience is considered at the later stage of design development to give feedback on the developed wayfinding products.

In this thesis, partially sighted individuals' experience with signage graphic design was acknowledged from the earliest stage of defining user requirements. In **Chapter 5,** the online questionnaire, evidence showed that the participants were able to clarify the problem with the signage graphic design they had experienced with and then provide recommendations for better design; participants' experiences were acknowledged at the problem identification stage of the research. In **Chapter 6-1 and 6-2,** participants were involved in both the online tool development for co-design visualisation and the subsequent co-design of their ideal effective signages. Users/partially sighted participants contributed to the identification of the design tools and procedure that would provide accessibility for both the workshop and the design outcomes. By acknowledging participants' experience and incorporating it into the design practices, a better understanding of the current design 'problems' was formed, and signage graphic design prototypes that reflect user needs were produced. Therefore, when designing for partially sighted individuals', the acknowledgement of their experience in the context of the design should not merely be reflected at the later stage of producing a design outcome, but throughout the design process - as outset as defining the design 'problem'.

8.2.4 Considerations for online co-designing with partially sighted participants

In traditional participatory design research, co-design activities are often carried out in person, very little research discusses the application of carrying out PD practice online (Friedrich, 2013, p.3; Tsuda and Sakuragi, 2020, p.502; Kamat, 2021, p.3), and even less is focused on partially sighted individuals (Lee, 2021, p.3). This led to a lack of developed frameworks to support co-design with partially sighted participants online and even less support for the development and implementation of co-design data gathering.

Chapter 6-1 documented the process of co-design activities development and, later, this was reflected and further discussed with partially sighted participants in **Chapter 7**. A pilot study was conducted with partially sighted participants to gather insights into facilitating online co-design workshops with them at the start. Subsequent workshops gradually began to tackle the goal of the online co-design workshops. Each workshop was then iterated based on the feedback collected at the end of the previous workshop and observed workshop engagement. Positive feedback from participants was received by the end of the co-design workshops. The insights and considerations to conducting online co-design workshops with partially sighted participants were initially addressed in **Chapter 6-2** *(6.9.3.3 Value of participants-led co-design practice/method)* and further developed in **Chapter 7** *(7.4.5 Suggestions to co-design with partially sighted participants online).* The framework developed in **Chapter 6-1** *(6.2.1.8 Workshop Plan),* along with considerations when carrying out online co-design activities with partially sighted participants online, provides a theoretical foundation to support online co-design activities with partially sighted participants.

8.2.5 The importance of visual examples in co-design with partially sighted participants

To ensure accessibility in data collection, one of the biggest challenges during this thesis was to develop a new co-design tool that does not solely rely on visuals to help partially sighted participants to co-create visualisation. Scholars developed the multi-sensory approach in order to avoid having to rely on visuals when researching with partially sighted participants. As storytelling is considered the primary tool (Andrews, 2011, p.133; Lee, 2021, p.32; brewer, 2018, p.2) for co-designing with partially sighted participants; practices were also found in making simple and accessible cross-sensory prototypes using simple materials in participants' homes (Schiafone et al., 2015, p.13; Cullen and Metatla, 2019, p.361), mood boards/collage (Andrews, 2011, p.126), card sorting (Andrews, 2011, p.138), modelling with Styrofoam (Andrews, 2011, p.152), focus group (Lee, 2021, p.32), mock-up with wax sticks and create 3D models with playdough (Kamat, 2021, p.29). These approaches enable participants'

involvement in the design process. However, because it would increase the threshold to participate online, a grid tool was developed based on a computer drawing software for blind users (Kamel and Landay, 2002, p.39) to support their visualisation. The grid tool was developed with accessibility in mind and used alongside verbal expression, writing, and drawing to assist participants in visualising and co-designing their ideal signage graphic design. Workshop activities were configurable to suit different participants' vision conditions to co-create.

With all the effort put into removing the reliance on visual elements in the online co-design tools, unexpectedly, during the online workshops, participants were seeking visual design examples to inform and inspire their design decisions. Providing visual examples in the workshop noticeably facilitated participants' engagement and contributions.

The majority of partially sighted individuals who have 'functional vision,' which refers to what a person can see, e.g., they might have peripheral vision or tunnel vision or may find it easier to see in certain light conditions; this varies amongst individuals' condition (RNIB, 2014). Findings of the workshop support the finding of (Thieme et al., 2017, p.747), that in the context of working with participants with mixed vision abilities, visual representation plays an important role in aiding sense-making and engagement for people with vision being a dominant and pervasive sense for someone who has (some) vision. This evidence suggests the importance of visual examples in facilitating partially sighted participants' participation in online co-design activities.

Therefore, visual examples should be considered as one of, but not the only, modalities to be used in co-design activities with partially sighted participants, especially when the goal is to co-create visual prototypes.

When developing co-design tools and activities for mixed vision participants, it is important to detach from the common perception of participants. Because of their diverse vision ability, there is no one size fit for all approach to co-design with them. Instead of following common practices from available studies, it is critical to adopt and establish a strategy that recognises participants' various capabilities and experiences which then tailors the tool and activities to these qualities.

8.2.6 The potential of online co-design

Choosing types of co-design activities in research is determined by the purpose of the co-design workshop, the form it takes and the context of the design problem (Sanders et al., 2010, p.196). Therefore, it is difficult to identify a one for all sets of activities in co-design.

Because the traditional Participatory Design emphasises the collaborative aspect of the process, most traditional co-design activities are carried out in person. Online co-design is only suggested to be used for probing and priming. It is considered challenging to conduct all the co-design activities online, especially enacting activities in which participants come together to create (Sanders et al., 2010, p.197). However, the co-design workshop carried out in this thesis signifies the possibilities and potential to carry out co-design workshops online.

Based on evidence gathered in **Chapter 6-2** *(6.9.2.6 Feedback about the workshop)* and concluded in **Chapter 7** *(7.3.2.1 The potential of online co-design),* partially sighted participants were comfortable co-designing online and appreciated the online collaborative experience. With the shifting social climate of working from home, participants are familiar with using online collaboration tools such as Google Hangouts and Zoom. They are used to participating in online collaboration within projects. The success of online co-design workshops also benefited from the developed accommodating (accessible) tools provided to compensate for different vision capabilities and the shared screen feature that enabled real-time collaboration and shared visual representation.

Co-design is an effective tool for better understanding the design 'problems' (Cullen and Metatla, 2019, p.361), and it is beneficial when working with mixed-ability user groups (Brewer, 2018, p.1; Magnusson et al., 2018, p.415; Raman and French, 2021, p.11). Online co-design has huge potential by allowing the research to be carried out beyond the constrain of geography and reducing the disadvantages of co-design, such as participant recruitment, confidentiality, finding a venue for co-design activities, travelling, and participants' safety.

8.2.7 Novel workshop approach for signage graphic design

In 2020, COVID-19 led to social environment change - working from home impacted my ability to carry out research in person. Therefore, there was a need for research methodology to be adapted for online research activities. At the stage of prototyping partially sighted individuals' ideal signage graphic design, a participatory design approach was chosen due to its ability to capture and incorporate user-specific requirements and insights into the design process (Thinyane et al., 2018, p.1); which would be beneficial due to partially sighted participants having varied vision capabilities. During the research tool development, two challenges preventing the accomplishment of this research objective were identified: the challenge of a lack of **online co-design methodology** and the **consideration of accessibility**. In order to achieve the research goal, a novel workshop approach was developed. This new workshop approach, which incorporates a multi-sensory approach (storytelling, writing and drawing), alongside a low-fidelity (post-it note) grid as a canvas, provided partially sighted participants a

range of creative channels to participate in the signage graphic co-design. It was learned that **to develop an online workshop that would be accessible to partially sighted participants, accessibility needs to be prioritised at the centred of the workshop tool and activity development.** Despite the fact that the workshop was carried out online via video conference call, the fixed structure of the grid canvas liberated participants to contribute creatively to build shared visual representations of their 'effective' signage graphic design. The workshop outcomes not only improved understanding of the partially sighted's signage graphic design needs, but the developed workshop approach provided a new methodology framework for the signage graphic design community to conduct online participatory research, particularly when conducting remote workshops with partially sighted participants.

8.3 Contribution to knowledge

Firstly, this thesis **contributes to the knowledge in the field of wayfinding signage design methodology**. By involving users in the thoroughly developed research and design process, a better understanding of partially sighted individuals' signage graphic design needs is established, and more effective design prototypes are produced. This effectiveness is reflected in four dimensions; the design prototypes reflect partially sighted individuals' pain points in use, experiences, preferences, and cultural conventions *(Chapter 7 7.3.1 The value of co-designed signage outcome)*. This improvement saves them time when trying to read, remember and guess the signage message. This reduces partially sighted participants' anxiety developed during wayfinding caused by difficulty reading the signage information. The finding supports the importance of signage design in helping wayfinders maintain the sense of direction and locomotion movement in the wayfinding process (Montello, 2010, p.257; Garip, 2011, p.1771).

Furthermore, the importance of signage graphic design in supporting **partially sighted individuals** in their wayfinding information processing, decision-making, decision execution, and closure **is identified**. To the best of my knowledge, this is the first study that investigates the benefit of the user-centred design approach in improving the effectiveness of signage graphic design for partially sighted individuals. The traditional design approaches followed by generic design organisations merely acknowledge the importance of user experience in design development. As one of the barriers is the lack of experience working with people of different capabilities (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289), this thesis is important in providing insight and a methodological framework to support design with partially sighted individuals.

Secondly, this thesis **contributes to the knowledge in the field of inclusive environmental graphic design, specifically signage graphic design.** The specialisation of environmental graphic design was driven by the demand for effective wayfinding information to navigate complex physical spaces (Gibson, 2009, p.13). Complementing the fixed physical structure of a built environment, environmental graphic design brings order to wayfinding by reinforcing and explaining the circulation in detail (Arthur and Passini, 1992, p.56; Gibson, 2009, p.16; Vandenberg, 2016, p.20). In this thesis, partially sighted users were involved and participated in the design and research processes to identify challenges with signage graphic design in academic settings. **New specifications of effective signage graphic design for partially sighted individuals** were identified in **Chapter 4** *(4.5.1 The lack of updated comprehensive signage guidelines).* With a huge body of work has been done concerning the inclusivity of the *"Architectural information* (Arthur and Passini, 1992, p.56)*"*/physical environment design, there is an inadequacy in updated and comprehensive design guidelines for signage graphic design in academic settings or public spaces for partially sighted individuals. Signage guidelines produced by institutions such as the *Americans with Disabilities Act (ADA)* provide the basic guidelines for improving the overall accessibility of wayfinding. Nonetheless, the aspect of signage graphic design for the visually impaired is not prioritized.

This thesis identified a set of design specifications that could lead to effective signage graphic design for people who are partially sighted. This is derived from participants' user experiences with signage graphic design and developed with them through co-designing activities. These design specifications embody participants' pain points, experiences, preferences, and cultural conventions, which are considered essential to the effectiveness of signage graphic design. Because guidelines issued by governmental/policy entities are frequently tasked with covering as many diverse abilities as is feasible, the design specifications identified in this thesis can be used as complementary considerations when designing inclusive environmental graphic design for partially sighted individuals.

Moreover, design prototypes which reflect these values were produced. To the best of my knowledge, this is the first study that provides a scope view of partially sighted users' design needs and expectations in environmental graphic design, specifically, signage graphic design. This thesis is significant in terms of incorporating inclusivity into signage graphic design.

Thirdly, there is a lack of **a developed methodological framework to empower partially sighted participants to contribute to visualisation in participatory co-design activities.** Findings support the challenge of using traditional visual tools such as post-it notes, drawings, cards and low-fidelity tools to prototype with partially sighted participants (Cullen and

Metatla, 2019, p.361; Williams et al., 2015, p.4; Magnusson et al., 2018, p.415). This thesis involved partially sighted participants in the co-design methodological development process before co-designing signage. Accessibility was embedded throughout the development of the co-design tools and activities in **Chapter 6-1**. Multi-sensory approaches were adopted in the co-design tools and activities development to accommodate the different vision capacities of participants. Based on the findings of **Chapter 7** *(7.3.2 The developed PD approach enables good co-design experiences),* partially sighted participants felt comfortable with, and empowered by, the developed grid tool and co-design activities to contribute to the co-design process creatively. To the best of my knowledge, this is the first study that **supports partially sighted participants to creatively contribute to the online co-design activities with visual tools.**

Fourthly, the majority of co-design workshops with mixed ability participants are carried out in person (Sanders and Stappers, 2008, p.5; Chick, 2019, p.39; Cullen and Metatla, 2019, p.361; Williams et al., 2015, p.4; Brewer, 2018, p.1; Magnusson et al., 2018, p.411). The thesis accomplished its goal of **co-designing with partially sighted participants by conducting all the workshop activities solely online.** Based on **Chapter 7,** this was hugely benefited from having a small group of participants; participants were familiarised with online collaboration due to the social environment changes of working from home; the development of accommodating workshop activities; providing basic knowledge and information about signage graphic design to the participants through visual means. This thesis is important in identifying the potential of online co-design as an effective tool to solve design 'problems' for partially sighted individuals. The insights generated from this study would benefit future scholars to tap into this research field.

Fifthly, this thesis contributes to **a new perspective on designing/co-designing visual products for/with partially sighted demographics.** Based on insights gathered in **Chapter 7,** the design of an inaccessible product could make partially sighted users feel "*left out*", which led to social exclusion. A product's design might be inclusive or exclusive to individuals with disabilities, depending on the designer (Clarkson and Coleman, 2015, p.235). Partially sighted participants appreciate being asked for their opinion and remember their good experience with a well-designed accessible product. As the generic design process that the design consultancies follow has little input from partially sighted users due to a lack of experience working with people of different capabilities (Dong et al., 2003, p.112; Carroll and Kincade, 2007, p.289). With online research/collaboration becoming a norm, techniques and tools introduced in this thesis could provide a time-efficient and effective approach to facilitate partially sighted participants to contribute to the development of a product/service.

8.4 Limitations and future work

This thesis provides insight into the importance of a research-based user-centred participatory design approach in improving the effectiveness of signage graphic design in academic settings for partially sighted individuals. With key learnings, emerging principles, and an open framework for user-centred co-design practice shared in this thesis, there is abundant room for future research to explore.

Firstly, generalisation of developed design practice for signage graphic design in other public settings apart from academic settings can be investigated. As identified, there is an inadequacy of available signage design principles and methodological frameworks to improve the signage graphic design in academic settings for partially sighted participants. Other public spaces can also be researched as participants suggested the potential of applying the approach to co-design signages within smaller institutions such as libraries, hospitals, train stations, office spaces and shops. These organisations only use indoor signage, whereas it would be more challenging for complex environments which use both indoor and outdoor signage. Moreover, it is required by law for the service provider to ensure accessibility to mixed abilities users.

Secondly, the effectiveness of a wayfinding signage system is influenced by planning, design, and practicality. This study focuses on the graphic design aspect of wayfinding signage, whereas there are more aspects that influence the effectiveness of signage than just design. During the research, it was found that *planning* and *practicality* aspects of signage all have significance to the ability of the partially sighted when completing a wayfinding task. Future research can investigate and resolving these pain points to increase the overall wayfinding system effectiveness. A more effective signage design reduces partially sighted participants' frustration and anxiety from reading, remembering, and guessing the signage messages**. More can be investigated in the wayfinding system to provide a satisfactory wayfinding journey for partially sighted individuals.** As much as an effective signage graphic design itself improves the accessibility of the academic setting to some degree, environmental configuration, individual experience, and intelligence also play significant parts in the success of a wayfinding journey. **Future research can look into the signage planning and practicality aspect of signage design. More can be done to improve the academic campuses' environmental configuration to improve the effectiveness of the wayfinding system for partially sighted individuals.**

Thirdly, future research can look into online co-design with mixed ability participants or further development on the grid tool for partially sighted individuals. With the social climate change of more and more people working from home and collaborating online, it lowers the

threshold for online collaboration. It creates a comfortable, familiar environment for co-design workshops to take place online. Online co-design has huge potential by allowing the research to be carried out beyond the constrain of geography and reducing the disadvantages of co-design such as participant recruitment, confidentiality, finding a venue for co-design activities, travelling, and participants' safety.

With techniques for facilitating online co-design workshops with partially sighted participants concluded in **Chapter 7**. More research can be done to explore the potential of the grid tool developed for online co-design with partially sighted individuals. In the context of this thesis, the grid was validated by partially sighted participants to be flexible, accessible and effective for co-design visualisation activities for partially sighted participants. The grid tool was tested and deemed to be effective when used alongside traditional co-design activities such as prime, understanding, and generative activities. With these advantages in mind, however, the grid tool can also be challenging in representing complex spatial space as it presents a miniature version of the two-dimensional static design. For example, participants found it difficult to visualise mobile app gestures and interactions on the grid. **More studies can be done to improve the versatility of the grid tool for other traditional co-design activities.**

Fourthly, future research can also be done in game design or other design aspects for partially sighted individuals. As most of the products/services are designed by and for able-bodied users, partially sighted individuals are left out of space to engage with the activities that able-bodied individuals might sometimes take for granted. Participants raised the feeling of being *"left out"* when participating in board games and expressed their desire for more inclusivity in tabletop board game design. **Future studies can look into the design of products/services to include partially sighted individuals, making the product/service accessible for more.**

Fifthly, the co-design workshop in this thesis was carried out online; therefore, the developed prototypes provide a good outlook on the layout aspect of an effective signage design for partially sighted individuals. However, as co-design activities were carried out on screen through enlargeable visual representations, the developed design prototype might not match all the signage design physical specifications, shape or form. **A more detailed application to the wayfinding signage system in academic settings requires further involvement with partially sighted participants to investigate the actual size of the signage to produce the most effective signage graphic design outcomes.**

Sixthly, this study was carried out with the majority of North American participants; the findings are generic but might not have geographical representativeness. Participants indicated the importance of cultural conventions in the effectiveness of signage graphic

design. Western culture is familiar with reading from left to right, top to bottom, macro to micro. This influenced the co-designed signage outcome. However, this should have little influence on applying the developed methodological framework to develop signage prototypes for partially sighted individuals from other cultural backgrounds. **Future research can investigate the impact of cultural conventions on the effectiveness of signage graphic design.**

Seventhly, the study was carried out with a small group of participants with qualitative methods; as one of the significant challenges of participant recruitment, I am aware that a larger sample would add more credibility to the finding. **Future research can be done with more groups of participants to co-design wayfinding signage.** However, based on findings from **Chapter 7**, maintaining a small group of participants would benefit the workshop engagement.

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Appendices

Appendix 1 Wayfinding Signage Design Guideline Framework

PLANNING

Sign Location

a. Signage should be placed at the beginning, key decision point, and end nodes along each route to inform navigation decisions and indicate the decision point (Baker and Fraser, 2000, p.24; Calori and Vanden-Eynden, 2015, p.101).
b. The destinations' maximum distances should appear on **directional signs** based on the travel model the wayfinder is using (Alta Planning + Design, 2019, p.36).
c. Consistent placement of the signs is essential to create a reliable path for travel. Signage should be placed in the same relative location and facing so that the wayfinder can easily locate and read the signs (Baker and Fraser, 2000, p.24; Alta Planning + Design, 2019, p.38).
d. Signage should always be located perpendicular to the viewer's line of movement and direct sight. Parallel located signage requires head-turning, which might cause hazards, particularly when a viewer is driving (Calori and Vanden-Eynden, 2015, p.103).
e. Signage should be placed within the wayfinder's visual field. Sightlines should not be blocked with any obstructions (Calori and Vanden-Eynden, 2015, p.104).
f. The location of the signage should have sufficient illumination, avoid areas are gloom or lack of supplementary lighting (Baker and Fraser, 2000, p.68).
g. **Turn signs** such as **directional signs** and **information signs** (i.e., maps) should always be placed at the decision point (intersection) to mark turns and to confirm the directions (Baker and Fraser, 2000, p.25; Calori and Vanden-Eynden, 2015, p.101; Alta Planning + Design, 2019, p.36).
h. **Confirmation signs** must be placed to assure wayfinders and reduce doubt when the route to a destination is too long (Baker and Fraser, 2000, p.25; Calori and Vanden-Eynden, 2015, p.105; Alta Planning + Design, 2019, p.37, p.37).
i. In the situation where reaction time is required as a factor of the wayfinding journey (i.e., Exit Next Left), the **advance directional sign** is required to give the wayfinder enough time to move to the decision point. Use an **advance directional sign** in pair with a **confirmation sign** at the decision point to affirm the wayfinding decision (Calori and Vanden-Eynden, 2015, p.103; Alta Planning + Design, 2019, p.36).
j. The installation of **location signs** at the destinations to which a wayfinder has been directed can confirm wayfinder's arrival at the destination (Calori and Vanden-Eynden, 2015, p.101).
k. **Location Signs** indicate room identification and should be placed at eye level on the wall next to the latch side of the door (Baker and Fraser, 2000, p.27).

l. **Location Signs** can also be placed on the door where there is not enough space on the wall (Baker and Fraser, 2000, p.27).

DESIGNING

Language, wording and punctuation

a. **Clarity**: To utilise words that are easy for wayfinders to understand and relate to their information needs. Avoid technical and complicated wording (Baker and Fraser, 2000, p.34).
b. **Consistency**: The words used in the wayfinding directories should be consistently applied throughout the signage programme (Baker and Fraser, 2000, p.34).
c. **Conciseness**: Only provide enough information at any given time to enable the user to achieve their wayfinding goals (Baker and Fraser, 2000, p.34).
d. **Case**: Characters shall be upper case or lower case, or a combination of both (ADA, 2010).
e. **Title case treatment**: Improving signage legibility by beginning each keyword with capital letters followed by lowercase letters, it is found to improve the legibility by 12 per cent compared to all caps (Arthur and Passini, 1992, p.168; Baker and Fraser, 2000, p.35; Calori and Vanden-Eynden, 2015, p.138).
f. **Sentence case treatment**: The case style of only capitalising the first word of the sentence is commonly reserved for detailed information in signage design (Calori and Vanden-Eynden, 2015, p.138).
g. **All Cap**: Messages indicating emergencies are preferred in all cap (Arthur and Passini, 1992, p.168).
h. **Punctuation**: Avoid the use of punctuation. Avoid full stops after the end of each message (Baker and Fraser, 2000, p.36).
i. **Abbreviation**: Avoid abbreviations (Baker and Fraser, 2000, p.36).

Type

Typeface

a. **Typeface**: It is recommended that the best practice of letters for signage purposes have a **ratio** of larger than **3:4** between x-height and cap-height (Arthur and Passini, 1992, p.150). Moreover, the sans serif fonts *Helvetica medium* and *Helvetica light* are equally legible for both sighted and partially sighted people. The sans serif font is recommended for signage use (Arthur and Passini, 1992, p.218 Baker and Fraser, 2000, p.41).

b. **Character proportions**: character font shall be where the width of the uppercase letter “O” is 55 per cent minimum and **110** per cent maximum of the height of the upper letter “I” (ADA, 2010).
c. **ADA guidelines**: characters on the signage should have a width-to-height ratio of between **3:5** and **1:1** (ADA, 1992).
d. **Exaggerated typeface**: with overly long ascenders and descenders are considered illegible (Baker and Fraser, 2000, p.43).
e. **Style**: Characters should be conventional in form. Not be italic, oblique, script, highly decorative, or other unusual forms (ADA, 2010).
f. **Italic**: is considered illegible (Baker and Fraser, 2000, p.43).
g. **Script**: is considered illegible (Baker and Fraser, 2000, p.43).
h. **Bold**: letterform with white space inside the letter disappears is considered illegible. However, it can also work as a breaker when there is too much information in one single sentence (Baker and Fraser, 2000, p.43).
i. **Letter case**: words with both capital and lower-case letters are deemed to be more recognisable even with blurred vision (Baker and Fraser, 2000, p.52).
j. **Things to avoid**: **exaggerated typefaces** with overly long ascenders and descenders are considered illegible; italics or scripts are considered illegible; too many type sizes on any single sign; bold letterform with the white space inside the letter disappears (Baker and Fraser, 2000, p.43).
k. **Embossed:** the serif typeface is not appropriate for embossed signs. It should always be produced in a simple sans-serif such as *Helvetica* (Baker and Fraser, 2000, p.45).

Type size

a. **Type size**: the larger the type size, the better, especially for regular older viewers (O'Grady and O'Grady, 2008, p.136).
b. **50ft/inch rule**: Arthur and Passini (1992) proposed that the minimum letter cap height should follow the rule of **50** ft/inch (**15** m/**25** mm) to be legible for a fully sighted wayfinder (Arthur and Passini, 1992, p.165).
c. **Character height:** shall comply with and measure the viewing distance and height to the floor (ADA, 2010).
d. **Long-distance reading**: **150** mm minimum letter size (cap-height) is recommended for long-distance signage reading for the partially sighted, such as signs at the building entrance and level house numbers (Baker and Fraser, 2000, p.44).
e. **Medium-distance reading**: **50** mm to **100** mm is the recommended letter size (cap-height) for signage medium distance reading for partially sighted. Arthur and Passini (1992) suggest **1.75** inch (**45** mm), such as location signs in reception or direction signs in corridors (Arthur and Passini, 1992, p.166; Baker and Fraser, 2000, p.44).

f. **Close-up reading**: **15** mm to **25** mm is the recommended letter size (cap-height) for signage close-up reading for the partially sighted, such as the directories on the freestanding information signs (Baker and Fraser, 2000, p.44).
g. **ADA guidelines**: an increase of **72** points is required for every **25** ft (**7.6** m) of viewing distance. Correspondingly, **25** ft—**72** point; **50** ft—**144** point; **100** ft—**288** point (ADA, 1992; Arthur and Passini, 1992, p.165; Calori and Vanden-Eynden, 2015, p.166).
h. **Angular distortion**: angular distortion occurs when signage is not perceived by the wayfinder directly ahead. A legible signage letterform only retains **75** per cent of its legibility when distorting by **45** degrees. Therefore, in this situation, one inch (**25** mm) is legible at **35** ft (**10.7** m) instead of **50** ft (**15** m) (Arthur and Passini, 1992, p.168).
i. **Hierarchy**: Where letters are used to inform the hierarchy of the building to wayfinders, the minimum reading distance should be used for the least important information (Baker and Fraser, 2000, p.44).

Layout

Spacing

a. **Space between letters and words**: increase the space between letters and words by **20** and **30** per cent. Shall be **10** per cent to **35** per cent maximum of character height (ADA, 2010).
b. **Space between lines**: It is essential to have consistent line spacing. For partially sighted individuals, it is suggested that it must have a **15-20** per cent increase in line spacing. Distance between separated baseline of two lines shall be **135** per cent minimum to **170** per cent maximum of character height (ADA, 2010).

Letter per line

a. It is recommended that **12-14** letters per line (including spaces), or **2** to **3** words per line, is the most legible solution for both reading and touching (embossed letters) (Baker and Fraser, 2000, p.54).

Alignment

a. Left alignment: Aligning on the left-hand side of the signboard.
b. Right alignment: Aligning on the right-hand side of the signboard.
c. Centred alignment: Aligning on the centre of the signboard horizontally.
d. **For Directional Signs**: The text should align with the direction the arrow indicates (i.e., right direction sign should be ranged right). (Baker and Fraser, 2000, p.51).

Margin

a. A properly sized margin is helpful to increase the contrast between the message and the signboard. A good starting point is to use the equal size of the cap height of the sign message as the margin. The proportion could be slightly enlarged as **1.3** cap height or **0.7** cap height (Calori and Vanden-Eynden, 2015, p.173).
b. When sign languages use a centred layout, it is important to leave the bottom margin slightly larger than the top margin to give the visual balancing (Calori and Vanden-Eynden, 2015, p.173).

Border

a. The width of the border should not overpower the sign letters; **10** per cent of the lower case letter height is suggested (Baker and Fraser, 2000, p.52).

Directional Sign positioning

a. There are two options for arranging the information on the signboard with text, symbols and arrows. Once the style is chosen, it should be consistently adapted throughout the system (Calori and Vanden-Eynden, 2015, p.179).
b. **Side-by-side positioning:** Arrows and symbols are positioned in line with typography.
c. **Stacked positioning:** Arrows and symbols are positioned above the typography.

Information Sign grouping/Readability

a. **Information grouping**: Signs should contain no more than **three** or **four** messages in each group and no more than **five** or **six** groups on each sign (Arthur and Passini, 1992, p.180). Information hierarchy is important to be built on signages to enhance the effectiveness of communication and save up space on signboards (Calori and Vanden-Eynden, 2015, p.98).
b. **Information Hierarchy**: The LATCH (Location, Alphabet, Time, Category, Hierarchy) system (Calori and Vanden-Eynden, 2015, p.98).
c. **Location** structure is based on physical spatial geography.
d. **Alphabetical** structure based on the sequence order of the letters.
e. **Time** structure is based on the development of the sequence of the events based on the timeline (i.e., cooking instruction).
f. **Category** structure is based on the similarity of the attributes.
g. **Hierarchy** structure is based on the perceived importance of the information.

Symbol / pictogram

a. Symbols acquire a more complex visual complexity than arrows. Where the space allows, symbols should be at least **100** mm in height overall (Baker and Fraser, 2000, p.37). The proportion relationship between symbols, arrows, and typography should be consistently applied throughout the design once it's decided (Calori and Vanden-Eynden, 2015, p.110).

b. Pictograms shall have a field height of **6** inch (**150** mm) minimum. Characters and braille shall not be located in the pictogram field (ADA, 2010).
c. **Text descriptions:** should be below the pictogram field (ADA, 2010).
d. **Finish and contrast for both pictogram and symbol:** non-glare finish, the contrast between pictograms and their background (ADA, 2010).

Arrow

a. Symbols of arrows can be used to communicate or augment certain typographic messages. Moreover, arrows are well understood worldwide as a directional device to replace lengthy verbal indications of directions (Calori and Vanden-Eynden, 2015, p.143). Arrows can be found commonly in directional signs and some information signs.
b. Arrows should be differentiated from the text and on lines by themselves. (Arthur and Passini, 1992, p.175).
c. Arrows can be adopted from several available symbol vocabularies or typefaces that include arrows, such as DOT symbol vocabulary or Zapf Dingbats (Calori and Vanden-Eynden, 2015, p.143). It is recommended that the ISO (International Standards Organisation) 7001 standard requires that the arrow's ends to be parallel with the main stem (Baker and Fraser, 2000, p.38).
d. **Alignment**: For the arrow used for directional signs, the text messages should be arranged according to the direction of the arrow. Arrows should always be aligned on the right or left side of the sign based on the indicated direction. When the arrow indicates the right direction, the arrow should be on the right-hand side of the sign, next to the first message. When the arrow indicates the direction of left, straight, or down should be placed on the left side of the sign, on the left of the first message (Baker and Fraser, 2000, p.39).
e. **45-degree arrow**: To reduce miscommunication, **45**-degree arrows should always be reserved for diagonal rout across an open area, ramps or stairs and escalators only (Baker and Fraser, 2000, p.39).
f. Avoid pointing arrows to the main text message (Calori and Vanden-Eynden, 2015, p.143).

Map

a. **Heads-up Orientation**: It is suggested to align the top of the map with the direction the wayfinder is facing. It is logically easier for the wayfinder to comprehend the locations on the map (Gibson, 2009, p.52; Montello and Sas, 2010, p.8; Calori and Vanden-Eynden, 2015, p.153).
b. **North Orientation**: The North Orientation map is usually used on paper-based maps because it is more flexible than the map on information signs. It is usually printed with 'North' on the top (Calori and Vanden-Eynden, 2015, p.153).
c. When only the North Orientation map is available on the Information Sign, ***You Are Here*** map -- A prominent graphic indication of the location of the wayfinder on the map is suggested (Calori and Vanden-Eynden, 2015, p.153).

Embossed

a. Serif typefaces should be avoided in the use of the embossed sign. A Sans serif typeface should be adapted (Baker and Fraser, 2000, p.45; ADA, 2010).
b. The embossed character's minimum height (Cap-height) should be more than **15** mm for reading from touch alone (Baker and Fraser, 2000, p.45; ADA, 2010).
c. Uppercase should be used (Baker and Fraser, 2000, p.45; ADA, 2010).
d. The embossed characters should rise from the signboard by **1** mm - **1.5** mm, and the minimum height of each character could vary from **15** mm to **50** mm. The stroke width should be recognised by the figure with one pass (i.e., between **1.5** mm and **2** mm for a **15** mm letter height). In ADA 2010 is **0.8** mm minimum (Baker and Fraser, 2000, p.45; ADA, 2010).
e. **Character Proportions:** Characters shall be selected from fonts where the width of the uppercase letter "O" is **55** per cent minimum and **110** per cent maximum of the height of the uppercase letter "I" (Baker and Fraser, 2000, p.45; ADA, 2010).
f. An embossed sign always requires close-up reading. The height of the sign must position between **1400** mm to **1700** mm above the floor (Baker and Fraser, 2000, p.45). **1200** mm minimum apart from elevator sign (ADA, 2010).
g. **Character Height:** Character height measured vertically from the baseline of the character shall be **5/8** inch (**16** mm) minimum and **2** inches (**51** mm) maximum based on the height of the uppercase letter "I" (Baker and Fraser, 2000, p.45; ADA, 2010).
h. **Stroke Thickness:** The stroke thickness of the uppercase letter "I" shall be **15** per cent maximum of the height of the character (Baker and Fraser, 2000, p.45; ADA, 2010).
i. Inter-letter spacing should be increased between **20**-**30** per cent, and the inter-word spacing should be increased by **25** per cent (Baker and Fraser, 2000, p.45).
j. **Character Spacing:** Character spacing shall be measured between the two closest points of adjacent raised characters within a message, excluding word spaces. Where characters have rectangular cross-sections, spacing between individual raised characters shall be **1/8** inch (**3.2** mm) minimum and **4** times the raised character stroke width maximum. Where characters have other cross-sections, spacing between individual raised characters shall be **1/16** inch (**1.6** mm) minimum and **4** times the raised character stroke width maximum at the base of the cross-sections, and **1/8** inch (**3.2** mm) minimum and **4** times the raised character stroke width maximum at the top of the cross-sections. Characters shall be separated from raised borders and decorative elements **3/8** inch (**9.5** mm) minimum (Baker and Fraser, 2000, p.45; ADA, 2010).
k. **Line Spacing:** Spacing between the baselines of separate lines of raised characters within a message shall be **135** per cent minimum and **170** per cent maximum of the raised character height (Baker and Fraser, 2000, p.45; ADA, 2010).
l. Rounded and chamfered edges are recommended for embossed characters (Baker and Fraser, 2000, p.45).

m. ADA requires that all the Location Signs (Name of the room and the space display the name) must be only embossed in capital case accompanied by **Grade 2** Braille (ADA, 1992; Calori and Vanden-Eynden, 2015, p.141).

Colour

a. **Role of Colour**: The adequacy of the signage system relies heavily on the wayfinder's ability to recognise and read the sign. Colour can be used in signage to distinguish from or fit into the sign system, reinforce the message, and be decorative (Calori and Vanden-Eynden, 2015, p.157).
b. **Colour selection**: It is suggested to select the colour combination having the differential (contrast) of the brightness no less than **70** per cent (ADA, 1992; Arthur and Passini, 1992, p.179). It could be the differentiation between the background and the signboard or between the message and symbols and the signboard.
c. **Identifiable colours: Twelve** easily identifiable colours are recommended for signage design purposes. Only one shade of each nameable colour is included to reduce confusion (Baker and Fraser, 2000, p.56).
d. **Twelve colours***: Red, Orange, Pink, Grey, Yellow, Green, Brown, white, Blue, Purple, Black, and Beige (Baker and Fraser, 2000, p.59).

Lift

a. **Lift bottom**: The lift bottom should be placed next to the door frame instead of the lift frame (Baker and Fraser, 2000, p.62).
b. **Embossed indication**: Is required to be provided (Baker and Fraser, 2000, p.62).
c. **Control panel**: The control panel should be placed in the range of **900-1200** mm above the floor inside or outside the lift (Baker and Fraser, 2000, p.62).
d. **Floor number:** The floor number needed to be repeated on the wall opposite the lift (Baker and Fraser, 2000, p.62).

PRACTICALITY

Illumination and glare

a. **Adequate illumination**: When lighting is installed to illuminate the floor and walls, extra illumination is needed for the signage to accommodate partially sighted and older wayfinders (Baker and Fraser, 2000, p.68).

b. **Minimise glare**: Glare occurs when one part of an interior is much brighter than the surrounding areas. It can be the major cause of discomfort in the interior environment. To minimise the negative effect of glare, it is suggested to use matt finish materials that do not place signs against direct lighting sources or external lighting (Baker and Fraser, 2000, p.68; ADA, 2010).
c. **Lighting and colour**: Lighting can be a substantial factor affecting the perception of colour. Dramatic colour and contrast are suggested to mark the edge or stairs in spatial spaces (ADA, 2010).

Positioning

a. **Height from finish floor:** visual characters must be at least **40** inches (**1015** mm) above the finish floor (ADA, 2010).
b. **Signs for close-up reading**: A person's average viewing eye level is in the range of **1400-1700** mm above floor level. Directional Signs, Information Signs and some Location Signs are intended to be read at a close range and should be positioned as close to eye level as possible. (Baker and Fraser, 2000, p.68).
c. **Signs for medium-distance reading**: Ceiling mounted signs should be positioned high enough to avoid causing a blockage. The lower side of the signage should be positioned **2300** mm above the floor. Flat-wall-mounted signs (i.e. Information Signs) must be positioned high enough to not be obstructed by pedestrians and raised from the wall by less than **100** mm (Baker and Fraser, 2000, p.69).
d. **Signs for long-distance reading**: The sign must be positioned high enough to be obvious and avoid obstruction by intervening objects (Baker and Fraser, 2000, p.69).
e. **Signs with a control element**: The sign attached to the control panel should be positioned above the floor at a height of **900-1200** mm to fulfil the needs of people in a wheelchair together with those standing (Baker and Fraser, 2000, p.69).
f. **Braille and embossed signs**: The position of Braille and embossed sign should be considered in relation to the accessibility of a person to approach and touch the message on the sign. The Braille and embossed room location sign must be positioned on the wall side of the latch side of the door to prevent the door from opening from inside to outside while the wayfinder is reading the sign. One exception: in the UK, Braille and embossed toilet and washroom signs are positioned on the door (Baker and Fraser, 2000, p.69; ADA, 2010).

Organising sign system

a. **Maintenance**: In parallel with signage design, it is important to ensure signs are in good condition and visible. A routine cleaning and maintenance programme should be adopted to

complement the visual signs. Good maintenance includes cleaning and physical adjustment if needed (Baker and Fraser, 2000, p.72).

b. **Alteration**: Keep the sign information updated and reduce inaccuracies and misleading information. A standard document regarding the signage specification is recommended. A good sign system should still look good after 6 months of installation without having handwritten notes stuck on obsolescent signs (Baker and Fraser, 2000, p.73).

Appendix 2 Academic Setting Wayfinding Signage Inclusivity Survey 2020 – Online Questionnaire

Academic Setting Wayfinding Signage Inclusivity Survey 2020

Page 1: Instructions

INSTRUCTION:

You are invited to participate in this study which contributes to understanding the inclusivity of **wayfinding signage*** within the academic setting (for sight loss individuals). This study conducted by **Mr Yuan Yuan** at the School of Design under the supervision of **Prof Maria Lonsdale** and **Dr Paul Wilson**, University of Leeds, to gather information on the public feedback concerning the inclusivity of the English language based wayfinding signage design in the academic setting. This research is part of the PhD research project. This research is supported and reviewed by the **CNIB** research team lead by **Dr Mahadeo Sukhai**.

Wayfinding signage*: Wayfinding signage is the visual tool people use to orient oneself through the physical world.

This study aims to assess the usability and the inclusivity of the wayfinding signage design in the academic setting for sight loss users. The questionnaire consists of two parts. The first section covers general information; the second section (broken down into two parts) relates to your personal experience and opinions with the wayfinding signage system in an academic setting.

The survey information collection complies with the Data Protection Act. The answers you provided in the questionnaire will only be used for research purposes and remain confidential, only anonymised data will be published. Any unique identifying personal details will be unassociated with your answers. We take steps to ensure that the personal data we hold is secure; only the researcher in this study will have access to the records.

There are no associated risks with this study. However, if any issues arise, please bring them to the attention of the researcher. Participants also have the right to withdraw within 2 weeks of the test being conducted without prejudice and without providing a reason. In the event of withdrawal, data already provided will be deleted.

We would like to thank you very much for taking part in this project. Your input is making

a difference to the community and the world! **If you have any difficulties concerning completing this questionnaire, please contact:**

Mr Yuan Yuan - sd17yy@leeds.ac.uk

If you are interested in participating in this study, please click "Yes" to continue. If you are not interested in participating in this study, you can close the browser and no data will be saved.

1. I agree to take part in the above research project.

- Yes

Page 2: General Information

In this section, there are 11 questions relating to your general information.

2. What is your age?

3. What is your Gender?

- Male
- Female
- Other
- Prefer not to say

4. Which country have you lived in the majority of your life?

5. What is your first language?

6. What is the highest level of education that you have completed?

- Primary school
- High school / secondary school or equivalent
- Vocational / technical school or college
- Undergraduate / university graduate
- Some postgraduate education
- Postgraduate or professional degree (e.g. PhD, MD)
- Other

6.a. Other:

7. Do you wear glasses?

- Yes
- No
- Prefer not to say

7.a. Do you have difficulty seeing, even when wearing your glasses? Would you say:

- No difficulty
- Some difficulty
- A lot of difficulty
- Cannot do at all
- Prefer not to say

7.b. Do you have difficulty clearly seeing the picture on a coin, even when wearing your glasses? Would you say:

- No difficulty
- Some difficulty
- A lot of difficulty
- Cannot do at all/ Unable to do
- Prefer not to say

8. Are you familiar reading text-based signages? (such as the example shown below)

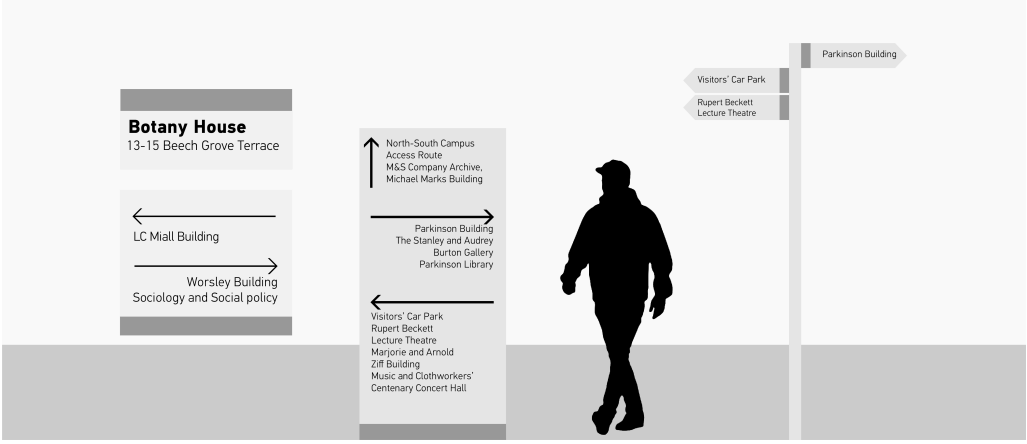
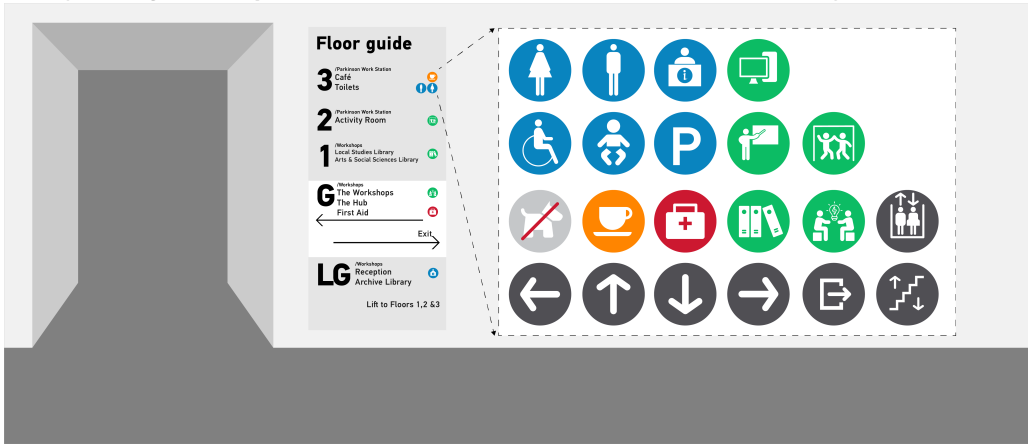


***Image description**: 4 signage examples are presented above, with a human figure in the middle to indicate the size of the signage. - The signage on the left top reads "Botany House, 13-15 Beech Grove Terrace"; - The signage on the left bottom signage reads "LC Miall Building" with a direction arrow indicates to go left and the bottom part reads "Worsley building, Sociology and Social Policy" with a direction arrow indicates to go right. - The signage in the middle reads "North-South Campus Access Route, M&S Company archive, Micheal Marks Building" with a direction arrow on the left indicates to go straight. The middle part of the signage reads "Parkinson Building, The Stanley and Audrey Burton Gallery, Parkinson Library" with a direction arrow on top indicates to go right. The bottom part of the signage reads "Visitors' Car Park, Rupert Beckett Lecture Theatre, Marjorie and Arnold Ziff Building, Music and Clothworkers' Centenary Concert Hall" with a direction arrow on top indicates to go left. - The signage on the right reads"Visitors' Car Park, Rupert Beckett Lecture Theatre" with the indication of to go left, and "Parkinson Building" with the indication of to go right.

- Yes
- No

9. Are you familiar reading signages containing symbols? (such as the example shown below) ***Image description**: the illustration above demonstrates the "Floor guide"



signage in a real-life corridor placement, and the icon box on the right indicates the detail of the icons used in the signage. The signage in the middle reads "Floor guide"; - The first-row has an enlarged number "3" on the left, and on the right reads "/Parkinson work station", "cafe" "Toilets", three icons representing cafe and toilets are placed on the right of the text. - The second-row has an enlarged number "2" on the left, and on the right

reads "/Parkinson work station", "Activity Room", one icon representing activity room is placed on the right of the text. - The third-row has an enlarged number "1" on the left, and on the right reads "Workshops", "Local Studies Library", "Art & Social Sciences Library". - The forth-row has an enlarged letter "G" on the left, and on the right reads "/Workshops", "The workshops", "The Hub", "First Aid" and an arrow below indicates the direction to go left. And reads "Exit" with an arrow below indicates the direction to go right. Two icons are placed on the right of this row representing the workshops and first aid. - The last-row has enlarged letters "LG" on the left, and on the right reads "/Workshops", "Reception", "Archive Library", "Lift to Floor 1,2, & 3" with an icon placed on the right of the text representing reception.

- ○ Yes
- ○ No

10. Which type of signages do you encounter more often?

- ○ Text-based signages
- ○ Signages containing symbols

11. Which type of signages do you find more helpful when looking for information?

- ○ Text-based signages
- ○ Signages containing symbols

11.a. Why? ✱ *Required*

Page 3: Experience and opinion - part 1

In this section, there are 6 questions relating to your personal experience with the wayfinding signage system on the university campus.

12. Please name a post-secondary education campus you are most familiar with (i.e. university, college, trade and vocational school). * Required

13. On this campus, which of these facilities have you visited the most? Please select all that apply. * Required

- ☐ Workspace/Workstation facilities
- ☐ Laboratory facilities
- ☐ Lecture facilities
- ☐ Recreational facilities
- ☐ IT facilities
- ☐ Library facilities
- ☐ Faculty offices
- ☐ Other

13.a. Other:

14. Please rank the frequency of you using wayfinding signage during these activities.

	Never	A few times	Sometimes	Very often
Use signages to travel between locations that you have visited previously	☐	☐	☐	☐
Use signages to explore the campus with no specific destination in mind	☐	☐	☐	☐
Use signages to finding a certain destination	☐	☐	☐	☐

15. On a scale from 1 to 5, how would you rate the effectiveness level of the wayfinding signage you have used on this campus? * Required

	1 very low	2	3	4	5 very high
effectiveness	☐	☐	☐	☐	☐

15.a. Why? ✱ *Required*

16. On a scale from 1 to 5, how satisfied are you with the wayfinding signage you have used on this campus? ✱ *Required*

	1 very low	2	3	4	5 very high
satisfaction	☐	☐	☐	☐	☐

16.a. Why? ✱ *Required*

17. On a scale from 1 to 5, how much do you think the current wayfinding signage on this campus could be improved? ✱ *Required*

	1 not at all	2	3	4	5 very much needed
needs to be improved	☐	☐	☐	☐	☐

17.a. Why? ✱ *Required*

Page 4: Experience and opinion - part 2

In this section, there are 7 questions relating to your opinion with the wayfinding signage system on the university campus.

18. Which one of these information order would you find most helpful when searching for a location on signage? * Required

- In the order of alphabetical order
- In the order of required traveling time
- In the order of departments
- In the order of campus zones
- It does not make any differences to me
- Other

18.a. Other:

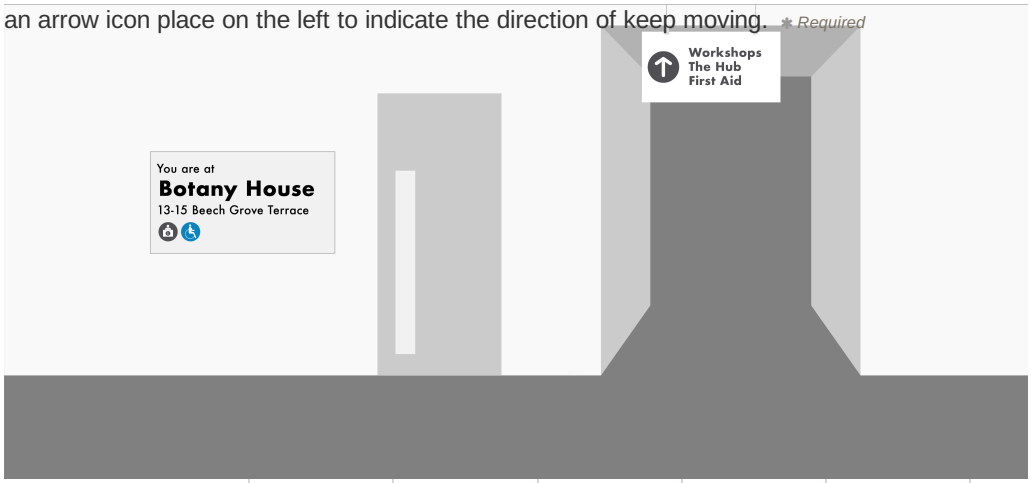
19. Does the use of colours in wayfinding signage help you find, read or understand the information? * Required

- Yes
- No

19.a. How does it (the use of colour in wayfinding signage) affect you?

20. **Confirmation sign** is the type of signage that confirms your journey and confirms your arrival on a wayfinding trip. How would you rate the importance of having both signages to confirm your journey and arrival during wayfinding? (such as the example shown below) ***Image description**: the illustration above demonstrates two signage placement in a real-life corridor placement. The signage on the left is placed next to a grey door reads "you are at" "Botany House" "13-15 Beech Grove Terrace" with two icons on the bottom representing reception and wheelchair friendly. - The signage on the right is hanging on the ceiling of an entrance reads "Workshops, The Hub, First Aid" with

an arrow icon place on the left to indicate the direction of keep moving. *Required



	1 very low	2	3	4	5 very high
Importance of having the signage on the left	☐	☐	☐	☐	☐
Importance of having the signage on the right	☐	☐	☐	☐	☐

20.a. Why? *Required

20.b. How would you rate the placement of the confirmation signage shown above?
Optional

	1 very low	2	3	4	5 very high
Your satisfaction with the signage placement on the left	☐	☐	☐	☐	☐
Your satisfaction with the signage placement on the right	☐	☐	☐	☐	☐

20.b.i. Why? *Required

21. In general (indoor or outdoor wayfinding), which of these problems have you encountered when using the wayfinding signage on this campus? Please select all that

apply. * Required

- ☐ Problems with finding signage when needed
- ☐ Problems with inconsistent signage placement
- ☐ Problems with distracting signage colour schemes
- ☐ Problems with adequate illumination on the signage
- ☐ Problems with bad signage condition
- ☐ Problems with bad signage viewing angle
- ☐ None
- ☐ Other

21.a. Other:

22. What do you expect from using the wayfinding signage while navigating on this campus? Please select all that apply. * Required

- ☐ It provides prompt information about the direction
- ☐ It clarifies the structure of surrounding environment
- ☐ It promote a relaxing wayfinding experience
- ☐ Other

22.a. Other:

23. In general (indoor or outdoor wayfinding), what do you find challenging when reading the wayfinding signage on this campus? Please select all apply. * Required

- ☐ The signage is not noticable and recognisable
- ☐ The signage is not big enough for reading
- ☐ The information you are looking for is hard to be located on signage
- ☐ The information you are looking for is hard to understand
- ☐ The information you are looking for is difficult to read
- ☐ The disturbance from decorative elements around signage
- ☐ Other

23.a. Other:

24. What do you think would be helpful to improve the accessibility of the signage on campus? * Required

25. If you are interested in our research and would like to hear more about the study, please feel free to leave your email address below: Optional

Page 5: Final page

We would like to thank you very much for taking part in this project. Your collaboration is very much appreciated.

Appendix 3 Co-design Workshop Procedure, Script, and Time Arrangement

Co-design workshop "How to co-design with partially sighted participants?"

A series of four interdependent workshops will be carried out to learn:

- 1) How to facilitate online co-design workshops with partially sighted participants.
- 2) Testing the grid tool implication in design
- 3) Improving the grid tool for signage design
- 4) Utilising the grid tool for signage design

Design subject: redesign the MS Teams/ video conference call app interface for partially sighted users

Objectives:

- Storytelling about target users' experiences.
- Identifying the pain points in current design – through vocalisation on the grid – Think aloud.
- Idea generation of a better design – through simple visualisation (easy drawing or writing on the grid).
- Prototyping together to make a better design – through facilitator act as a visualisation assistant.

Time: 60-90 min

Beginning: Brief the workshop 10 min

- During the past 18 months, the majority of work and communication moved online. Partially sighted individual challenges to remote work and communication (Ginley, 2020). In today's workshop, we are going to explore and identify the challenges of your experience with remote communication apps, specifically the interface of the video call app. This workshop aims to work with you to come up with a better solution to make the virtual call app interface more accessible.
- **Today's workshop is divided into four sessions.**
- **In the first session, we are going to take turns discussing the challenges we experienced when using the existing online call app.**
- **In the second session, we are going to identify the pain points in these experiences on the grid everyone has in hand.**
- **In the third session, we are going to brainstorm and try to visualise solutions for these pain points on the grid we created.**
- **In the last session, we are going to create an easy prototype of the app interface together.**

- **Before we start the workshop, I will take 5 minutes to explain to you the tools we are going to use today*** - at the end of this document

Session one and two: 4 participants Approximate 30-40 minutes

- The goal of these sessions is to identify the pain point on the video call app interface through vocalisation on the grid
- What do you find most challenging when using online video call apps?
- Where on screen does this challenge occur?
- **Now we are going to use the gird system, I will need you to speak about the challenges that correspond to the grid I have just told you**
- Can you tell us on which grid you think is most challenging to use?
- Can you tell us which parts on grids you wish to be redesigned?
- Do you think this can be improved by app interface redesign?
- Could you rate each grid from A-C, by telling me, as A is the good design and least needed to be redesigned; B is the average design and could use some redesign, and C is the bad design and most needed to be redesigned.
- Does this make sense to you? do you understand what we need to do now?
- how are we getting on with the grid?

Session three: 20 minutes of simple visualisation

- The goal of this session is to use brainstorming to visualise solutions for these pain points on the grid we created through drawing or writing
- Since we have identified the pain points on the grid and understood where the redesign is most needed, now I will need you to propose your design solution to the grids from grid 1 to grid 6 through drawing or writing on the corresponding grid.
- You will need to make the changes on the grid where it represents the place on the interface that you would like to redesign.
- Does this make sense to you? do you understand what we need to do now?

Session four: 20 minutes of sophisticated visualisation

- The goal of this session is to create an easy prototype of the app interface together
- We will go through each grid and conclude all your ideas about the design and I will make quick drawings to confirm with you if I am illustrating the idea you have in mind
- Let's go to grid 1, starting from participant one, we will all take turns to speak about this grid (the issue and the design proposal you made), and while you are speaking could you please also raise your grid 1 to the camera so I can take a screenshot and work on these ideas?
- Does this make sense to you? do you understand what we need to do now?
- After making a simple design: Talk about the changes I have made … is that what you have had in mind?
- If yes, Excellent! shall we move to grid two?

Grid tool explained:

To create a grid for this workshop, we will need to use 6 square-sized post-notes/or six palm-size square papers.

The basic idea is that we place 6 post-notes on the table or any flat surface to simulate a mobile phone screen.

First, let's imagine that if we divide a mobile phone screen into six equal size squares, we will get a grid of 6 spaces, these 6 spaces should correspond to the 6 post-notes you have on the table.

The post notes shall be placed in these six places, let's place 6 post notes **in two columns** and edge to edge, starting from the right column and then the left column. The grid 1, grid 2 and grid 3 are on the left column, corresponding to the top left to bottom left of the screen. Grid 3, grid 4 and grid 5 are on the right column, this corresponds to the top right to the bottom right on the screen. Now we are getting a long square which is the grid space we are going to use in this workshop, please keep the placement and their corresponding number in mind during this workshop.

If you find this difficult, you can think as this is a mobile phone braille keypad, and the organisation grid is inspired by that.

How to use the Grid:

Now I am going to tell you how this grid is going to be used in the workshop.

In session one, when we discuss the current app interface design, I need you to talk about the challenges you found based on the grid we have just created. For example, if you find something on the top left part of the interface, you should reference it as "in grid 1 I found … challenging".

In the second session, when we are making design suggestions, I need you to write or draw on the grid we created, corresponding to the placement of the interface on the screen. For example, if you want to redesign the left bottom part of the interface, you can simply make changes on grid 3.

In the third session, I will go through each grid with you and make design changes from grid to grid, from grid 1 to grid 6.

So, to recap everything, grids 1, 2, and 3 are on the left column, and grids 4, 5, 6 are on the right column.

Is that clear to you? Do you understand how does the grid work now? Do you have any questions about how to create the grid or use the grid?

Appendix 4 Co-design Workshop Recruitment Questionnaire (Information Sheet & Consent Form)

Co-design workshop participant information

Page 1: Information Sheet

Research Topic

The role of research-based signage design in providing effective wayfinding information in academic environments to individuals with sight loss – co-design workshop

Researcher: Yuan Yuan

Thank you so much for attending this research study, which is part of my PhD project at the University of Leeds. Before you accept to participate it is important for you to understand why the research is being done and what it will involve.

This study aims to outline and visualise the user expectation of wayfinding signage in university/post-secondary academic environment. A series of four co-design workshops will be conducted via video conference call, to help to visualise the inclusive signage design that partially sighted users need. Four workshops are expected to be carried out during four video calls.

- **Workshop one:** you are invited to a pilot study of the following workshop two
- **Workshop two:** you are invited to Co-design a mobile video call app interface with the tool we introduced at the beginning of the workshop.
- **Workshop three:** you are invited to co-design wayfinding signages with the tool we introduced at the beginning of the workshop.
- **Workshop four:** you are invited to co-design a series of wayfinding signages with the tool we introduced at the beginning of the workshop.

If you decide to take part, please read this information sheet and complete the following

consent section and fill in the participant information section. All the information collected will be kept strictly confidential, and you will not be able to be identified in any reports or publications.

One workshop will take at least **60** minutes of your time. All the workshops follow a similar structure of tasks. In the first task and second task, you will be asked to identify the pain point within the current design. In the third task, you will be asked to visualise your idea of a better design with the tool introduced at the beginning of the workshop. In the final task, a facilitator will work with you and other participants to complete the design.

There are no disadvantage or risks for participating during this research. And there will be reimbursement at the end of the appointment for your time (£40 amazon gift card).

Data from this study will be kept anonymous, confidential and secure. The researcher, Yuan Yuan, can answer any further questions and can be contacted at: sd17yy@leeds.ac.uk

Thank you very much for taking part in this study. Your collaboration is very much appreciated.

Page 2: Participant Consent Form

Title of Research Project

The role of research-based signage design in providing effective wayfinding information in academic environments to individuals with sight loss – co-design workshop

Name of Researcher(s)

Yuan Yuan

Please click "YES" to the relevant boxes to confirm your consent to the following:

1. I confirm that I have read and understood the information explaining the above research project and I have had the opportunity to ask questions about the project.

- Yes

2. I understand that my participation is voluntary and that I am free to withdraw at any time during my participation without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. I can withdraw my data within two weeks after my participation by contacting Yuan Yuan (sd17yy@leeds.ac.uk).

- Yes

3. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.

- Yes

4. I agree that the data collected from me can be used in future research.

- Yes

5. I agree to take part in the above research project and will inform the principal investigator should my contact details change.

- Yes

Page 3: Participant information

6. What is your name? ✱ *Required*

7. What is your age? ✱ *Required*

8. What is your Gender? ✱ *Required*

- Male
- Female
- Other

9. Which country have you lived in the majority of your life? ✱ *Required*

10. What is your first language?

11. What is the highest level of education that you have completed? * Required

- Primary school
- High school / secondary school or equivalent
- Vocational / technical school or college
- Undergraduate / university graduate
- Some postgraduate education
- Postgraduate or professional degree (e.g. PhD, MD)
- Other

11.a. Other: Optional

12. Do you wear glasses? * Required

- Yes
- No
- Prefer not to say

12.a. Do you have difficulty seeing, even when wearing your glasses? Would you say: * Required

- No difficulty
- Some difficulty
- A lot of difficulty
- Cannot do at all
- Prefer not to say

12.b. Do you have difficulty clearly seeing the picture on a coin, even when wearing your glasses? Would you say: * *Required*

- No difficulty
- Some difficulty
- A lot of difficulty
- Cannot do at all/ Unable to do
- Prefer not to say

12.c. Do you know your vision acuity if possible? * *Required*

13. Please provide an email address for receiving your gift card? * *Required*

Page 4: Thank you

Thank you for submitting your information, your time is very much appreciated!

Appendix 5 Co-design Workshops Procedures

WORKSHOP 1 PROCEDURE AT A GLANCE

Sessions	Goals	Activities
1	• To identify pain points during using the mobile video call app interface.	• Participants were asked to discuss the challenges they have experienced when using the existing video call app. • Questions were asked, “What do you find most challenging when using this online video call app?”, “Where on the screen do these challenges occur”.
2	• To identify the pain points of design on the grid.	• Questions were asked, “Which grid cell position on the design do you find most challenging to use?”, “Do you think this challenge can be resolved by redesigning the interface?”.
3	• To brainstorm and visualise solutions for identified pain points.	• Participants were given time to propose their design solution on the grid through speaking, writing or drawing. • Participants were asked to make design proposals on the grid where it represents the position on the interface.
4	• To evaluate prototypes.	• Participants were asked to present (on camera) and explain what they have designed in each grid from grid 1 to grid 6, then all the grid cells together. • Participants were asked to talk about the changes they have made and why they proposed such design changes.

WORKSHOP 2 PROCEDURE AT A GLANCE

Sessions	Goals	Activities
1	• To identify pain points during using the mobile video call app interface.	• Participants were asked to imagine a scenario that needed to use a video call app to join a work-related meeting with their phone. • Participants were asked to discuss the challenges they might encounter when using this video call app interface. • Questions were asked, “What do you find most challenging when using this online video call app?”, “Where on the screen do these challenges occur”.
2	• To identify the pain on the grid.	• Questions were asked, “Which grid cell position on the design do you find most challenging to use?”, “Do you think this challenge can be resolved by redesigning the interface?”.
3	• To brainstorm and visualise solutions for identified pain points.	• Participants were given time to propose their design solution on the grid through speaking, writing or drawing. • Participants were asked to make design proposals on the grid where it represents the position on the interface. • Participants were informed of the 10-15 minutes time limit for this task.
4	• To create a prototype of the app interface together.	• Participants were asked to present and explain what they have designed in each grid from grid 1 to grid 6, then all the grid cells together. • Participants were asked to talk about their design changes and why they proposed such design changes. • The facilitator will go through the design ideas in each grid with participants to evaluate the final prototype.

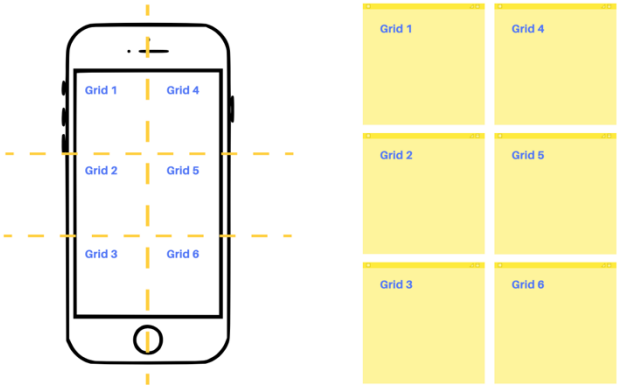
WORKSHOP 3 PROCEDURE AT A GLANCE

Sessions	Goals	Activities
1	• To identify the user journey and challenges during wayfinding.	• Participants were given a scenario: "You are at the entrance of a campus. Please walk us through the process of finding a specific building (i.e., School of Mathematics) on campus using only signage". • Participants were asked to discuss the information and signage they would need to find the building and the challenges they might encounter based on their experience. • Questions were asked, "What would be the initial information you look for?" "How would you get to this location?"
2	• To introduce participants to basic signage design elements and examples. • To help participants learn about the basic design elements they can use in their idea generation and prototype.	• A shared google slide was used to present all the examples; participants were given time to zoom up to view examples in detail. • Participants were introduced to the variation of signage design layout, the variation of symbols, the variation of arrows and different types of signage designs. • Participants were asked to give feedback on the design elements.
3	• To identify the pain points in a series of examples of signage design.	• Design factors such as layout, type case, information organisation, and symbols were evaluated. • Participants were asked to review a series of common signage designs.
4	• To create signage prototypes together on the shared screen.	• Participants were asked to contribute to the design by justifying their ideas and instructing the facilitator to make real-time changes on the shared screen. • Questions were asked, "would you say that design change improves the signage for you?" "Is that what you mean?". • Each example was modified until the group was satisfied with the design. • At the end of each modification, participants were offered the opportunity to give feedback on the final prototype.

WORKSHOP 4 PROCEDURE AT A GLANCE

Sessions	Goals	Activities
1	• To identify the user journey and challenges during wayfinding.	• Participants were given a scenario: "you are at the entrance of an unfamiliar building. Please walk us through the journey of finding a specific office in the building using only signage". • Participants were asked to discuss the information and signage they would need to find the office and the challenges they might encounter based on their experience. • Questions were asked, "What would be the initial information you look for?" "How would you get to this location?"
2	• To identify the pain points in a series of signage design examples.	• A shared google slide was used to present all the examples; participants were given time to zoom up to view examples in detail. • Participants were asked to review a series of common signage designs. • Design factors such as layout, type case, information organisation, and symbol were evaluated. • Questions were asked, "What do you think about the design of this signage?", "Does this signage provide all the information you need in the scenario?" "Would you find these signages challenging to use?"
3	• To create a few signage prototypes.	• Participants were given time to write or draw their ideas on the grid they had created. • Participants were informed of the 5-10 minutes time limit for this task.
4	• To co-create/evaluate prototypes of the signage design on the shared screen.	• Participants were asked to help evaluate what the facilitator has created based on the discussion in previous activities and participants prototypes. • Questions were asked, "would you say that design change makes the sign better for you?" "Is that what you mean?". • Each example was modified until the group were satisfied with the design. • At the end of each modification, participants were offered the opportunity to give feedback on the final prototype.

Appendix 6 Data from Co-design Workshops 2 - Prime Activities

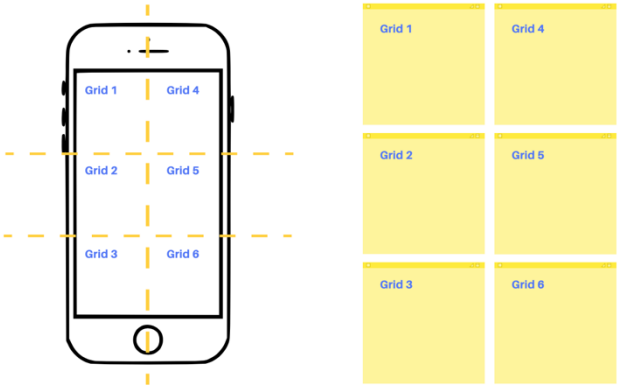


PAIN POINTS AND IDEAS OF THE CURRENT VIDEO CALL APP ON GRID

Grid	Pain Points	Ideas
1	• Difficulty in identifying the current speaker	• Make the speaker full screen • Audio feedback on who is speaking • A blue highlight box/boarder with an audio wave symbol
2	• Difficulty in identifying the current speaker	• Make the speaker full screen • Audio feedback on who is speaking • A blue highlight box/boarder with an audio wave symbol
3	• Difficulties with on and off the microphone and camera	• Make the speaker full screen • Differentiate the colour with hand up red colour • Tactile feedback/buzzing when the button switched • Audio feedback when the button switched (would interrupt the thought when speaking) • A screen flash with a big microphone icon • Have the button at four corners of the screen • Audio for me and video for other people, the whole screen use as a control panel
	• Difficulty with centralised control panel	• Tap/gesture control to summon a control screen

4	• Difficulty to see if I am holding the phone the right angel through the small images (preview oneself)	• Upload an image or create an avatar • Screenshot of myself today • Graphic feedback/a flash on screen to let me know I am not focused in camera
	• Difficulty in identifying the current speaker	• Make the speaker full screen • Audio feedback on who is speaking • A blue highlight box/boarder with an audio wave symbol
	• Difficulty to change which screen(speaker) I want to have on my main screen	
5	• Difficulty to see if I am holding the phone the right angel through the small images (preview oneself)	• Upload an image or create an avatar • Screenshot of myself today • Graphic feedback/a flash on screen to let me know I am not focused in camera
	• Difficulty in identifying the current speaker	• Make the speaker full screen • Audio feedback on who is speaking • A blue highlight box/boarder with an audio wave symbol
	• Difficulty to change which screen(speaker) I want to have on my main screen	
	• Difficulty with centralised control panel	• Tap/gesture control to summon a control screen
6	• Difficulties with on and off the microphone and camera	• Make the speaker full screen • Differentiate the colour with hand up red colour • Tactile feedback/buzzing when the button switched • Audio feedback when the button switched (would interrupt the thought when speaking) • A screen flash with a big microphone icon • Have the button at four corners of the screen • Audio for me and video for other people, the whole screen use as a control panel

Appendix 7 Data from Co-design Workshops 2 – Understanding Activities

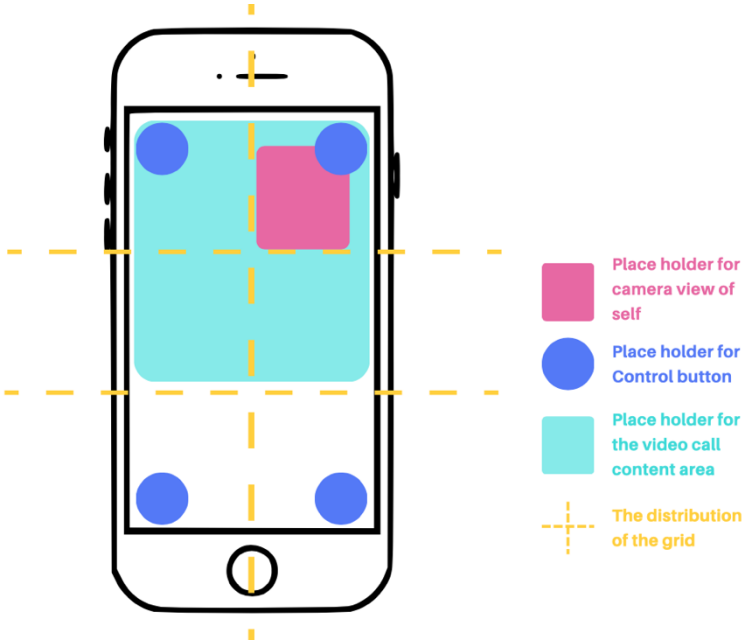


DESIGN IDEAS BASED ON THEME

Theme	Ideas	Grids
Video feedback of oneself	• Upload an image or create an avatar of myself • Graphic feedback/a flash on the screen to let me know I am not focused on the camera	• Grid 4 • Grid 5
Identify the current speaker	• Make the speaker full screen • Audio feedback on who is speaking • A blue highlight box/border with an audio wave symbol to indicate the current speaker on the screen	• Grid 1 • Grid 2 • Grid 4 • Grid 5
Mute & camera control	• Make the speaker full screen • Differentiate the colour between the hand up button and mute/camera control button • Tactile feedback/buzzing when the button switched • Audio feedback when the button switched (would interrupt the thought when speaking) • A screen flash with a big microphone icon when unmuted • Have the button at four corners of the screen • Audio for me and video for other people; the whole screen is used as a control panel	• Grid 3 • Grid 6
General control/Centralised control	• Have the button at four corners of the screen	• Grid 1 • Grid 4

		• Grid 3 • Grid 6
	• Tap/gesture control to summon a control screen • Utilising other mobile physical buttons	• Grid 1-6

Appendix 8 Data from Co-design Workshops 2 – Generative Activities



THE EVALUATED PROTOTYPE ON THE GRID

Grid 1

Control
- Hang up/disconnect button (important button so not easy to close)
- Other people's faces

Content
- Shortcut to the gesture
- Content screen
- Have zoomed initials

Grid 2

Content
- Content screen
- Have zoomed initials

Grid 3

Control
- Camera on/off x 2
- Mute on/off

Grid 4

Control
- Hang up/disconnect button (important button so not easy to close)

Content
- Self image
- Content screen
- Have zoomed initials

Grid 5

Content
- Content screen
- Have zoomed initials

Grid 6

Control
- Mute on/off x 2
- Camera on/off

Appendix 9 Preference for Signage Design Elements

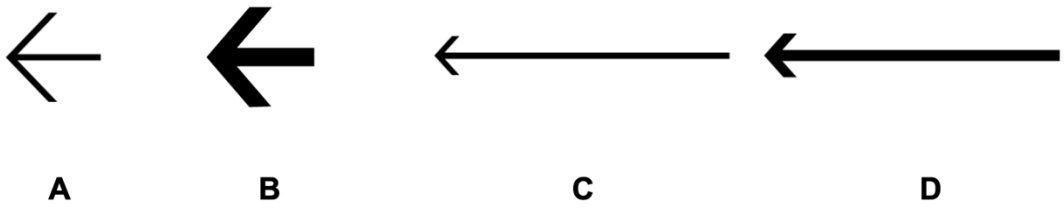
Participants prefer a stack-positioning layout over a side-by-side positioning layout based on collected data. A participant mentioned that with a "restricted visual field", it is difficult to relate to the information when presented "linear" on the sign with a "restricted visual field". Participants mentioned that this difficulty relates the information from "one side" to "the other side". Hence, it is considered more practical in use.

Side-by-side positioning

Stacked positioning

Participants prefer Reversed Symbol Field symbol style among the provided five variations (Calori and Vanden-Eynden, 2015, p.146). Participants found the reversed symbol field style symbol is the most legible symbol for two reasons. 1) the black background has sufficient contrast; 2) having a rounded square symbol field makes the symbol looks like an icon instead of just a graphic shape. Participants expressed that the Reversed Circular Symbol Field symbol style does not differ much from the Reversed Circular Symbol Field symbol style. However, the second reason is also the reason participants prefer Reversed Symbol Field Symbol style rather than the other. The Without Symbol Filed symbol style is the least favourable symbol style because it is considered “least clear to me it is a symbol”, as it can be easily “mistaken as an arrow”.

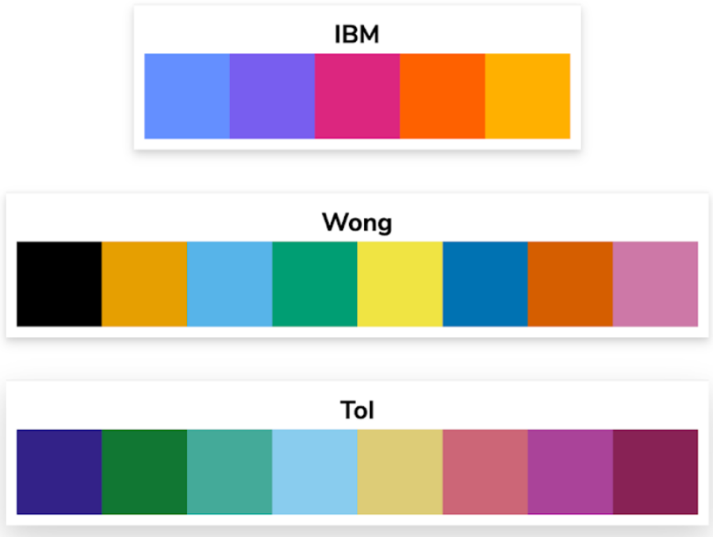
Participants prefer the short and bold styled arrow (option “B”) amount the four provided arrow designs. The long and slim arrows are the least preferred style (option “C”).



Feedback on three colour-blindness-friendly palettes developed by established research institutions (Nichols, 2022) was collected. These examples were used to help us understand the criteria for a colour palette accessible to partially sighted individuals. Among provided examples, Wong and IBM colour palettes were preferred over Tol. With IBM colour considered the most energetic, Wong was considered the most practical colour palette.

Both IBM and Wong were considered great for colour coding. Wong’s palette was considered to have the *“most room for strong contrast”* and *“easy to identify”*. As raised with the IBM palette, it might be hard to differentiate the *“blue”* and *“purple”*, the *“orange”* and *“bright orange”*. The *“washed out”* colour in Tol was considered *“has the least contrast”* and *“would not be good with either white or black text printed on it”.*

Readability, eye comfort, easily identifiable (people are familiar with), and aesthetics are the four primary criteria for an accessible signage colour palette for partially sighted individuals.



Appendix 10 Online focus group plan

The focus group is divided into two parts:

-Intro: a brief of the aim of the workshop, the process of the workshop and what thoughts were put into that

-Part 1: Discussion of the outcome of the workshop

-Part2: Discussion of the workshop development

Part 1: the value of the outcome

- **Briefing about what we have created in the workshops**
- In each workshop, we created different prototypes by the end of workshops. How do you find the relationship between your decision-making and the final design?
- **Show the new and old design**: Here are the original design examples, and the design incorporated everyone's thoughts, in the first design, we have changed …
- Talk about the final design outcome (with pictures); how do these design decisions make it 'better' for you? How does your design decision inform the design outcome?

Part 2: the value of the co-design practice

- **Briefing about how the workshop was evolved**
- Before we started the workshop, have you had any expectations of the workshop? What were the challenges you thought you might encounter? Are these activities suitable to be carried out online?
- You have expressed that "it is ironic that we are visually impaired, but we are visual learners, it would be helpful to have a visual template… so we can jump in a little bit faster, I can provide feedback better rather than react to comments, better than adding comments on the abstract grid." I am glad to learn that providing examples helps you with your design.
- Apart from design examples, what else do you think would be necessary for preparing such workshops?

- **Briefing about the Grid model development:** The grid model offers options of storytelling, simple visualisation and sophisticated visualisation. How do you find it in general? Do you find the grid model accessible? Is there anything we can add to the tool to make it better/more accessible and user-friendly?
- The grid model was developed with accessibility and inclusion in mind. What do you think is the importance and the value of accessibility/inclusion in such co-design workshop?
- During the workshop: Do you find that the workshop tools supported your autonomy to make creative decisions and express design ideas? If so, how?
- Do you find yourself well engaged through the design process? If so, in what way?
- How do you find the social elements in this workshop?
- Do you think this design approach is good enough to be adapted in other areas of design for partially sighted users? Such as the place are busy and lack predictable organisation, for example, signage design for hospitals, museums, libraries, etc. If so, can you provide examples?
- One of us mentioned that the grid model seems suitable for designing things with a concise layout. Is this design process flexible enough to be used with other designs with partially sighted users?

Appendix 11 Online focus group code book

Codes Name	Files	References
Co-design outcome	0	0
[Definition] Better signage design	1	10
[Effectiveness] Local convention	1	1
[Effectiveness] Pain points in use	1	5
[Effectiveness] Participants' experience	1	4
[Effectiveness] Participants' preference	1	9
The importance of effective signage design	1	11
Co-design process	0	0
[Grid tool] Feedback	1	8
Accessibility	1	6
Application in game design	1	4
Applications	1	5
Autonomy and creativity	1	4
Challenges	1	3
Experiences	1	3
Facilitation	1	3
Online collaboration	1	2
Parameters and constrains	1	4
Preparation	1	4
Responding to the developed tool	1	1
Value of accessible tool in co-design	1	3